FEDERAL-F: A multi-regional multi-sectoral dynamic model of the Australian economy

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by

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ABSTRACT

This thesis is concerned with the construction, implementation, and application of a large-scale bottom-up multi-regional multi-sectoral dynamic CGE model of the Australian economy, FEDERAL-F. This model traces its lineage to the multi-regional comparative-static FEDERAL model and the national dynamic MONASH model. Like the latter model, FEDERAL-F links a sequence of single-period equilibria via stock-flow relationships. However unlike MONASH, it features bottom-up modelling of regional activity, detailed fiscal modelling, and accounting for changes in household capital ownership. Unlike FEDERAL, FEDERAL-F is dynamic, it features more plausible modelling of inter-regional migration, and it includes a complete set of regional and national accounts.

A version of FEDERAL-F focussing on the economies of Tasmania and the rest of Australia is implemented. This model is used for five sets of illustrative applications.

The first set of simulations (the historical simulations) derive values for certain otherwise unobservable variables (such as productivities, household tastes, positions of export demand schedules, and various government policy instruments) for the period 1992/93 to 1998/99. The results from these simulations then form part of the input to the second set of simulations. These simulations evaluate the individual contributions of these variables, in addition to the other exogenous shocks to which both economies were subject over the period, to a range of economic indicators. This allows the causes of Tasmania's relatively poor growth experience to be identified and evaluated.

The third set of simulations (the forecasting simulations) extrapolate into the future the structural and other changes derived in the historical simulations, thereby generating forecasts for the economic prospects of both the Tasmanian and Mainland economies. These forecasts project a continuation of Tasmania's relatively slow growth rate, and hence a continuation in the state's historical trend of accounting for a declining share of national activity.

Finally, the results of both the historical and forecasting simulations provide the base case against which two policy scenarios are evaluated. The first examines the impact on the Tasmanian and Mainland economics of microeconomic reform in the utilities sector. The second investigates the potential scope and efficacy of possible Tasmanian government policies aimed to redress the state's declining share of national economic activity.

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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I have made presentations of earlier versions of this model at a number of workshops, conferences, and seminars. Presentations of the theoretical structure and results of an historical simulation from an early version of the model were presented to both the Regional CGE Modelling Workshop (Brisbane) in June/July 1997, and the 15th Pacific Regional Science Conference (Wellington) in December 1997. Results from later versions of the model were presented at the ANZRSAI Annual Conference (Adelaide) in September 1998, and 38th Annual Meeting of the WRSA (California) in February 1999. I also presented an earlier equation structure to a workshop at the Centre of Policy Studies in November 1998. I wish to thank all the participants at these presentations who gave helpful comments, and particularly Professors Peter Dixon and Alan Powell at the latter presentation.

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1 INTRODUCTION

1.1 OVERVIEW

National computable general equilibrium (CGE) models, and more recently regional models[1], have been used for almost a quarter of a century to elucidate the sectoral (and later regional) effects of changes in technologies, tastes, policy variables, and foreign markets (Powell and Snape 1993, Partridge and Rickman 1998, Madden and Giesecke 1999). In Australia, the application of CGE models has made an invaluable and on-going contribution to the formulation of government policy and the quality of public debate on policy and structural issues, both at the national level, and increasingly at the state level. Powell and Snape (1993) provide a review of the extensive range of applications of national CGE models to national level problems. Partridge and Rickman (1998) undertake a review of multi-regional CGE models in the international literature. Madden and Giesecke (1999) provide a review of CGE models and applications at the regional level in Australia. The latter paper addresses a stark omission from the review by Partridge and Rickman. The latter paper, while providing an otherwise wide-ranging international survey of regional CGE models, nevertheless omits the entire Australian history of regional CGE modelling.

Partridge and Rickman note that there has been a rapid growth in both the number of regional CGE models and the range of their applications in recent years. Considering the models reviewed by Partridge and Rickman, it is clear that the international regional CGE literature is dominated by models that are comparative static, and small scale. The number of producing sectors in the model's they review ranges from only 1 to 28, with the average being just under 10. In contrast, the Australian experience with regional CGE modelling has been characterised by large-scale models, containing both detailed industrial and commodity disaggregation and often detailed modelling of government taxation and expenditure. The large size of Australian models has followed from a general philosophy of building models that have sufficient inherent generality and flexibility to allow them to be turned repeatedly to a wide range of different applications with a minimum

[1] The terms "regional models" and "multi-regional models" are used in this thesis to refer exclusively to models which feature explicit modelling of economic activity within one or more sub-national regions. That is, multi-country models are excluded from this definition.

redevelopment effort. The past decade has witnessed the development in Australia of dynamic models, firstly at the national level and lately at the regional level, a trend that has been little followed in international regional modelling[2]. This work has found that multi-period models can elucidate dimensions to economic issues that otherwise would not be amenable to investigation using earlier comparative-static models. These include the adjustment costs to policy change and the causes of changes in observed economic outcomes. They have also allowed an important limitation of comparative-static models to be overcome: namely the absence of a properly specified base case against which the effects of policy change can be compared.

It is against this background that the FEDERAL-F model has been developed. FEDERAL-F is a bottom-up multi-regional dynamic CGE model. As will become clear in Chapter 2, which deals with the construction of the model, FEDERAL-F traces its lineage to the multi-regional comparative-static FEDERAL model (Madden 1992) and the national dynamic MONASH model (Adams et al. 1994, Dixon and Rimmer 1999a). Like the latter model, FEDERAL-F links a sequence of single-period equilibria via stock-flow relationships. Flows in one period (such as savings, investment, migration, and government net financing requirements) change stock variables in the next, and hence subsequent periods. A new solution to the model is computed for each period. The equilibria thus computed change through time as the values for the model's stock variables change. Unlike the MONASH model however, FEDERAL-F features detailed bottom-up modelling of regional economic activity and government finances.

Chapter 3 addresses the construction of the model's database. The starting point for the FEDERAL-F database was an existing 1992/93 database for the FEDERAL model. A number of changes were made to this database, prior to it forming the starting point for the development of the FEDERAL-F database. Thereafter, the implementation of the FEDERAL-F model required the addition of a number of new parameters and data items, and the calculation of the values for these is discussed.

[2] An exception is McGregor et al., who incorporate the basic features of dynamic modelling (namely capital and population accumulation), first in a three-sector single-region model of Scotland (McGregor et al. 1996) then in a three-sector two region model of Scotland and the rest of the UK (McGregor et al. 1999).

Four sets of illustrative applications of the model are undertaken. The first of these (Chapter 4) derives values for certain otherwise unobservable variables (such as productivities, household tastes, positions of export demand schedules, and various government policy instruments) for the period 1992/93 to 1998/99 (hereafter, the "historical simulations"). The second set of simulations (also Chapter 4) evaluate the individual contributions of these otherwise unobservable variables, in addition to the other exogenous shocks to which both economies were subject over the period, to a range of economic indicators (hereafter, the "decomposition simulations").

The third set of simulations (Chapter 5) extrapolate into the future the structural and other changes derived in the historical simulations, thereby generating forecasts for the economic prospects of both the Tasmanian and Mainland economies (hereafter the "forecasting simulations"). In Chapter 6, the results of both the historical and forecasting simulations then provide the base case against which two policy scenarios are evaluated (hereafter, the "deviation simulations"). Chapter 7 concludes with a discussion of the major contributions of the model, suggestions for future development work, and a range of possible future simulations with the model.

In the remainder of this chapter I first review the status of multi-regional CGE modelling, both as it is undertaken overseas and within Australia. Unlike Australian regional CGE models, the international models are typically small-scale comparative static models, generally built with the analysis of a specific issue in mind. In contrast the Australian models are large-scale and general purpose, with a recent emphasis on the development of dynamic models. Dynamic computable general equilibrium models can be classified as one of two types depending on the their treatment of expectations. The two types of dynamic CGE models are briefly discussed, before moving on to consider the policy and analytical insights that have been made possible by recent Australian work on national dynamic CGE models. I conclude by considering the contributions of the FEDERAL-F model within the context of the existing literature.

1.2 REGIONAL CGE MODELLING - INTERNATIONAL EXPERIENCE

Partridge and Rickman (1998) provide a comprehensive review of the international regional CGE literature. Their review reveals a field of models that are comparative-static, generally small scale, and often constructed for the analysis of a specific issue. An overview of their review of the theoretical structures of these models is presented below. These structures are then compared with the theoretical assumptions common in Australian regional CGE models.

Partridge and Rickman describe the production structure of a typical regional CGE model as consisting of a system of nested production functions. At the top levels of such nests a composite value-added input and a composite intermediate input are typically combined to produce a unit of output. Partridge and Rickman note that the top level of the nest is generally characterised by fixed-proportions technology, ruling out substitution possibilities between primary factors and intermediate inputs. The value-added input on the other hand is typically characterised by either a Cobb-Douglas (CD) or Constant-Elasticity of Substitution (CES) technology. Further nesting of the latter functions may be undertaken to circumvent the problem of identical elasticities of substitutions between primary factor inputs within any given CES nest. The Armington assumption (Armington 1969) is often employed to model imperfect substitution between sources for a given intermediate input.

The modelling of regional household consumption typically begins with a linkage between regional factor demands and prices and regional household incomes. Many models feature differences in interregional patterns of capital ownership. Being static models, many of the regional CGE models reviewed by Partridge and Rickman omit savings and investment. Those that do not, typically assume that savings flow into a national pool with investment determined exogenously. Regional utility is typically modelled using CD and CES functions, although several studies employ the Stone-Geary utility function. The Armington assumption is typically employed to model the assumption of imperfect substitution possibilities between differing sources for the same consumer good.

Inter-regional export demands in the models reviewed by Partridge and Rickman are typically a function of the Armington relationships prevailing in other regions. Some models feature Constant Elasticity of Transformation (CET) functions governing the capacity of local producers of a given commodity to switch between production of that commodity for sale in the domestic or export market.

The international regional CGE literature as described by Partridge and Rickman is characterised by a wide variety of specifications for regional government. At the most basic level of modelling, many regional CGE models aggregate regional government and federal government levels. More detailed models, focussing on regional fiscal policies, distinguish two levels of government, and some link regional government spending with regional household income. However many of these studies assume that the expenditure patterns of regional governments mirror those of regional consumers. This means that the level of taxation does not affect the commodity composition of regional final demand. The most detailed fiscal model reviewed by Partridge and Rickman features three types of revenue linked to six expenditure flows, and includes among the expenditures of regional government such outlays as rental payments to factors, intergovernmental transfers, and savings.

Partridge and Rickman note that most regional CGE models in the international literature feature perfectly competitive factor and product markets. With respect to factor markets, the models are characterised by a wide variety of assumptions regarding both the types of factor inputs explicitly identified within the models, and the mobility of those factors. Capital and labour inputs feature almost universally in the models. The degree of factor mobility is typically related to the time horizon of the analysis. Shorter time periods are characterised by a greater degree of factor immobility, while assumptions of perfect factor mobility and equalisation of factor returns across sectors and regions characterise longer time horizons.

Partridge and Rickman's review suggests that there are many similarities between the comparative static multi-regional CGE models in the international literature, and the multi-regional CGE's models in common use in Australia. Where the models are most similar is in the prevalence of the assumption of perfect competition in factor and product markets, and factor mobility being largely a function of the time horizon of the analysis. The features of the production functions within the inter-regional CGE models described by Partridge and Rickman are also representative of such models in Australia. One exception however is the greater use in Australia of the CRESH function to model substitution possibilities for commodities available from more than two sources.

With respect to household consumption, and in contrast to the models reviewed by Partridge and Rickman (the majority of which use CES or CD functions), all the major Australian CGE models model household utility using the LES system. Either CES or CRESH nests then govern substitution possibilities between differing sources for each of the composite commodities that are inputs to this function. The household budget constraint in Australian models is typically determined as a fixed proportion of household disposable income, with gross fixed capital formation being determined independently of the level of household savings. This treatment is similar to that which Partridge and Rickman describe as characterising the models they review.

Like many of their international counterparts, inter-regional exports in Australian models are determined by the Armington assumptions governing source-specific demands within the importing regions. Unlike their international counterparts however, no use is made of CET functions to distinguish between production for domestic and foreign / interstate markets.

On the basis of Rickman and Partridge's review, it is apparent that the treatment of government in Australian regional CGE models, particularly FEDERAL and FEDERAL-F, is significantly more detailed than that of their international counterparts. Starting with the FEDERAL model in 1990, Australian regional CGE models have distinguished many outlays (current consumption, capital creation, transfer payments, inter-governmental transfers) and allowed the composition of these expenditures to differ not only from the pattern of household consumption, but also between regions and between levels of government. The treatment of taxation flows in Australian models has been characterised by explicit modelling of many of the major tax instruments, linking revenues from these instruments directly to the bases upon which they are levied.

1.3 Regional CGE modelling - Australian experience

1.3.1 History of the development of Australian multi-regional CGE modelling

A notable feature of Partridge and Rickman's review is a near absence of reference to the Australian contribution to regional CGE modelling. Madden and Giesecke (1999) address this omission with a review of both the structures of the major Australian multi-regional

CGE models, and the many applications to which these models have been put in the past two decades.

In general, the progress of development of regional CGE modelling in Australia has tended to be linked to that of developments in the national CGE models of the Australian economy. Pre-eminent among these was the ORANI model (Dixon et al. 1982). The first illustrative simulations with the ORANI model were published in 1977 (Dixon, Parmenter, Ryland and Sutton). The following year saw the first introduction of a regional dimension into ORANI (Dixon, Parmenter, and Sutton 1978). This was a top-down[3] spatial disaggregation of results across Australia's six states using a regional disaggregation facility based upon a method devised by Leontief et al. (1965) for disaggregating results from a national input-output model into regional results. The first Australian bottom-up multi-regional CGE model appeared three years later (Liew 1981). However development work on bottom-up models was frustrated by data deficiencies and computing limitations, so that top-down regional modelling was the prevailing form of multi-regional CGE modelling in Australia for much of the 80's. Today, while top-down regional models still play a role in Australian policy analysis, the past decade has seen bottom-up models take over as the main form of multi-regional CGE modelling, particularly for shocks originating at the regional level.

A feature of Australia's bottom-up multi-regional CGE models is that, like the ORANI model, and is successor MONASH, they are large scale general purpose models. The major Australian regional models have followed this tradition. This is borne out by the fact that the bulk of Australia's regional policy analysis that has employed multi-regional CGE models has been undertaken with either one or the other of the country's two main models of this type (FEDERAL and MMRF). As general-purpose models, these two models contain many features which are generally introduced in regional CGE models in other countries only for specific types of applications.

[3] The expressions top-down and bottom-up are used in the terminology of Klein and Glickman (1977). A top-down method decomposes results from a national model to regions using base-year shares and local multiplier effects. The bottom-up method explicitly models the economic behaviour of agents at the regional level.

Australia's five main bottom-up multi-regional CGE models are shown in Table 1.1. Liew developed the first of these models (MRSMAE) for the purpose of his doctoral thesis. While he demonstrated the capabilities of the model (Liew 1984), his efforts were hampered by data deficiencies that resulted in a mechanically constructed database. As a result, MRSMAE was not used beyond the initial illustrative applications.

After Liew, development of bottom-up multi-regional models in Australia stalled until near the end of the decade. Instead, in the early 1980's, various top-down methods were used to undertaken the multi-regional CGE analysis conducted in Australia. Madden, Challen and Hagger (1983) employed the device of adding shift variables to ORES[4] to allow a regional shock to be formed by decomposing it, in a prior calculation, into a shock at the national level and shocks to regional-share parameters. Prior to this it was generally held that ORES was not amenable to analysing shocks originating at the regional level. Higgs, Parmenter and Rimmer (1988) constructed a hybrid model (ORANI-TAS) which retained much of ORANI-ORES' parsimonious use of data, while introducing limited regional dimensions into ORANI to gain some of the advantages of bottom-up modelling.

The essential method of ORANI-TAS was to disaggregate, within the national CGE model, a selected number of industries and commodities. These disaggregated sectors were distinguished on the basis of the regions in which they were located, and were chosen for exhibiting significant inter-regional differences in costs and sales patterns. The ORES method was still used to generate results for all regional industries. However the results for a selected number of these (that is, the disaggregated industries) were computed at the national level, before being allocated (uniquely) to the region in which they were located. This was an improvement over a standard ORES decomposition, however the ORES method was still required to compute results for the majority of the regional industries, which were not regionally disaggregated.

[4] "ORANI Regional Equation System".

Table 1.1: Australian bottom-up multi-regional CGE models

Model name	MRSMAE	FEDERAL	FEDERAL-F	MMRF	QGEM
Model type	Comparative-static	Comparative-static	Dynamic (year-on-year recursive)	Minimal dynamics	Comparative-static
Model builders	Liew (1981)	Madden (1990)	Giesecke (1997)	Meagher, Han, Horridge, Parmenter, et al (1993)	John Fallon and Associates (1993)
Maintained by:	No longer in use.	Centre for Regional Economic Analysis (University of Tasmania)	Centre for Regional Economic Analysis (University of Tasmania)	Centre for Policy Studies (Monash University)	Queensland Treasury
Chief publications describing the model	Liew (1981)	Madden (1990)	Giesecke (1997) and (2000)	Peter et al. (1996)	Fallon (1993)
Model overview	Liew (1984)	Madden (1996)	Giesecke (1999c)	Naqvi and Peter (1996)	-
Period	1968/69 database	1992/93 database	Historical annual 1992/93 - 1998/99, annual forecasts to 2003/04	1993/94 data base	1992/93 data base
Regions	Six state of Australia	Two or more states of Australia (plus decomposition to sub-regions)	Two or more states of Australia (plus decomposition to sub-regions)	Eight regions (six states and territories of Australia)	Two regions (Queensland and rest of Australia)
Number of producing sectors	31 industries	Up to 104 industries (WA / rest of Australia version)	37 industries	Up to 50 industries (for 8 region version)*	32 industries
Production technology	IO / multilevel CES	IO / multilevel CRESH	IO / multilevel CRESH	IO / multilevel CES	IO / CES
Household utility	LES / CES	LES / CRESH	LES / CRESH	LES / multilevel CES	LES / CES

* Note that some two region version of MMRF exist with many more industries; E.g. M2R (NWS) has 130 industries (see Han, Madden and Pant 1997) and MMRF (Qld-Wood) has 38 industries (see Giesecke and Madden 1999)

In the mid 1980s Madden (1985a) proposed a modelling strategy to gain the advantages of bottom-up modelling without the data problems encountered with the development of MRSMAE, by limiting the number of regions to two. In many regional modelling exercises in Australia, economists wish to focus on results for one region (typically a state or territory) within a national economic framework. Provided a satisfactory input-output table exists for the state of interest, a two-region input-output database can easily be created. Madden (1985b and 1989a) developed procedures for spreading interstate exports and interstate imports from the region of focus across demanders and suppliers respectively in the rest of Australia, allowing intra-region flows in the rest of Australia to be calculated as residuals from national input-output data.

These developments led to the construction of the multi-regional CGE model FEDERAL, which up until recent times has been implemented in the form of a two-region model (Madden 1990). The first version of the model had Tasmania as its region of focus, with the other region being the Australian mainland. The computerisation of the database procedures, discussed above, allowed for the relatively easy construction of new versions of FEDERAL focussing on other Australian states. Models have subsequently been constructed focussing on Victoria/New South Wales, South Australia, Western Australia, and Victoria/Tasmania.

The starting point for developing FEDERAL's theory was the ORANI model (Dixon et al. 1982). The modelling of only two regions and diminishing computing constraints by the end of the 1980's meant that the ORANI theory could be extended in FEDERAL into its full multi-regional complexity while also adding the key features of a detailed treatment of two tiers of government and of regional household income. The main features of the model are described in Section 1.3.2.1. As discussed there, the multi-regional characteristics of FEDERAL are particularly evident in its very detailed treatment of transport and other margin commodities, and of state and Commonwealth commodity taxes.

Almost immediately after its construction, FEDERAL was used to examine a policy issue facing a regional government. In a study commissioned by the Tasmanian Employment Summit, the model was used to examine the efficiency of budget-neutral policies for stimulating employment in that state (Madden 1989b). Since then, as evidenced by the selection of FEDERAL studies reported in Madden and Giesecke (1999), the model has been in continual use by a number of researchers. However, in a 1990 study for the Australian Commonwealth Grants Commission, Dixon, Madden and Peter (1993) examined, with the aid of FEDERAL and ORANI-NT (a single region model of the Northern Territory), the efficiency effect of inter-governmental grants designed to alleviate horizontal fiscal imbalance. In this study the authors noted that to examine fully Federal/State public finance issues, a model was needed that was medium term, dynamic and explicitly treated all states and territories. Such a model, the Monash Multi-regional forecasting model (MMRF) was subsequently constructed (Peter et al. 1996), providing an operational model which allows policy questions relating to all or several Australian states and territories to be examined.

The major differences between MMRF and FEDERAL are outlined in Section 1.3.2. As noted above, MMRF represented an improvement on FEDERAL in terms of an increased number of regions, although this came at some cost to the scope for disaggregation of industry structure[5]. MMRF also has a less extensive treatment of transport margins than FEDERAL, and a less sophisticated modelling of state revenues. Since MMRF was developed from ORANI-F, the first forecasting version of the national ORANI model, it contains minimal dynamics that permit annual average forecasting. However, this feature of MMRF has been rarely used, and has now been overtaken by FEDERAL-F. FEDERAL-F has the capability of undertaking year-on-year forecasts. It employs a regionalised version of the recent developments made at the national level in CGE forecasting, which are incorporated in the MONASH model. The latter model has taken over from its predecessor ORANI as Australia's premier national CGE model.

1.3.2 Overview of the major Australian multi-regional CGE models

There are three large-scale CGE models of the Australian economy capable of producing results at the regional (state and sub-state) level which are in regular use by researchers and policy analysts in Australia. These are the FEDERAL model, developed in the late 1980's, the Monash Multi-Regional Forecasting Model (MMRF), developed in the early 1990's, and the MONASH model, developed in the mid 1990's. Each of these models, as they relate to

[5]While the first version of MMRF with 12 industries was slightly larger than the early 9-industry FEDERAL, computing constraints have prevented MMRF versions that have the 104-industry structure of FEDERAL. Indeed in recent times MMRF has been aggregated to two regions to allow for a greater range of industries and occupations. See, for instance, Madden (1998a) and Giesecke and Madden (1999).

regional modelling, is reviewed briefly below. A little more attention is given to FEDERAL in this review, since it is the starting point for the development of FEDERAL-F described in Chapter 2.

1.3.2.1 The FEDERAL model

FEDERAL is a bottom-up multi-regional CGE model of the Australian economy designed to allow comparative-static analysis of regional (state) and national economic shocks within a federal economic system. The model traces its lineage to the single region 1982 version of ORANI, but extends this to include both the explicit modelling of economic behaviour within regions, and a detailed fiscal dimension. A full description of the FEDERAL model is contained in Madden (1992). The initial implementations of the model featured two regions. The two regions in the first (Madden 1989c) version of FEDERAL were Tasmania and the Australian mainland. A second version concentrated on New South Wales/ Victoria (Dixon, Madden and Peter 1990), and the third (Madden and Pant 1994) features South Australia as its region of focus. The latest two-region implementation of the model features Western Australia as the region of focus (Giesecke, Madden and Pant 1998). Recently, a three region version of the model was implemented, featuring bottom-up modelling of economic activity in Tasmania, Victoria, and the rest of Australia (Giesecke 1999b). The key features of the model are reviewed below, drawing on the summary of the model contained in Madden and Giesecke (1999).

Production activity in FEDERAL is governed by the modelling of individual industries within each region. These industries are assumed to operate in perfectly competitive output markets, and minimise production costs subject to constant returns to scale production functions. These production functions have three levels. At the top level, effective inputs of intermediate inputs, primary factors, and other cost tickets are combined in fixed proportions to produce a unit of output. Nested into this top-level Leontief production function are a number of second level non-linear functions, which allow substitutability between sub-types of inputs within the broader input types. For example, an effective input of intermediate commodity i into the Leontief function is a combination of source-specific inputs of i from $r + 1$ sources (r domestic regions and 1 foreign source). Substitution possibilities between these sources are governed by a CRESH (constant ratio of elasticities of substitution, homothetic) function. Similarly, effective units of the primary factor input are a CRESH combination of three primary factors: labour, capital, and land. For labour, there is a third level of technology, again modelled with a CRESH function, defining substitution possibilities between labour of different occupational types. The model's production theory allows for multi-product industries, in which producers choose the commodity composition of a given level of output so as to maximise profit subject to a convex transformation function. However, few of the implemented versions of the model contain multi-product industries.

A representative, utility maximising household is assumed to exist in each region. The utilities of these households are modelled by Stone-Geary utility functions. Regional households are assumed to maximise this utility function by choosing between effective units of commodities, subject to an aggregate expenditure constraint. Effective units of commodities are modelled as CRESH combinations of the commodity from the $r + 1$ geographic sources. The model contains detailed modelling of regional household incomes. Hence, the regional household budget constraint is determined by the sum of all factor incomes earned by residents, plus all transfer incomes (such as unemployment benefits, social security payments and interest receipts), less all direct taxes (such as income taxes and fines), interest payments, and savings. Explicit account is kept of the share of each regional industry's capital rentals that accrue to households within each region.

A typical closure for real private investment links the percentage change in this variable to the percentage change in real consumption. Private investment is then allocated across regional industries so as to equate expected rates of return. Investors are assumed to act under an expectation that an expansion of a regional industry's capital stock will reduce its future rate of return below the current rate of return. The capital stock in regional industries is unaffected by investment decisions by private and government investors, although the process of installing new capital has a direct effect on economic activity in the current period by stimulating activity in sectors supplying inputs to gross fixed capital formation. Once the level of regional industry investment is determined, units of capital are formed by combining effective units of commodities in fixed proportions. Effective units of commodity inputs to capital formations are CRESH combinations of the commodity from the $r + 1$ sources.

Changes in aggregate government consumption are typically modelled as being linked to changes in aggregate real private consumption in their jurisdiction, along with the possibility of exogenous changes via shifts in policy variables. The quantity of foreign export demands for each commodity is a function of foreign currency export commodity prices, and are determined via constant elasticity demand functions.

The model distinguishes basic (ex-gate) prices, and purchasers' prices. Basic prices are calculated as being dependent on production costs (which includes the margin and sales-tax inclusive prices of material inputs, payments for primary factors, and other costs), and production taxes. Basic prices of foreign imports are their landed-duty-paid domestic currency prices.

Prices paid by individual regional purchasers and foreigners (at the port of exit) are equal to the basic price plus markup services and sales taxes. Full regional possibilities are provided for in the provision of markup services and the levying of sales taxes. That is, the flow of each commodity from each source of supply can be facilitated by markup commodities supplied from either region. Similarly, commodity taxes can be levied by the Commonwealth Government and by either regional government (provided the commodity originates from or is sold in their region) with the rate varying according to the type of commodity, source of supply, and type of purchaser.

The model contains very detailed modelling of two tiers of government. For each government, the expenditure and revenue raising activities (both in relation to linkages with all other private agents and inter-governmental linkages) and a set of income and outlays accounts, are modelled in extensive detail.

1.3.2.2 The MMRF model

MMRF is an eight-region CGE model of the Australian economy, modelling the behaviour of economic agents in each of Australia's eight states and territories. The model can be employed to undertake either comparative-static or forecasting simulations. The model contains sufficient accumulation relationships linking investment flows and capital stocks, and current account deficits and foreign debt, to produce limited annual-average forecasts over broad medium-run time periods. The model does not contain any relationships allowing for major changes in the model closure to facilitate either historical or forecasting simulations. To date, public use of the model has been confined to comparative-static simulations. A full description of the MMRF model can be found in Naqvi and Peter (1995) and Peter, Horridge, Meagher, Naqvi, and Parmenter (1996).

MMRF can be thought of as being comprised of five modules (Madden and Giesecke 1999): a core module, a government finance module, a capital and investment module, a foreign debt accumulation module, and a labour market module.

The core module determines regional industry outputs, demands for intermediate inputs and primary factors, international and inter-regional exports and imports, regional household demands, commodity demands for nine governments (eight regional governments and one federal government) and commodity and factor prices. Broadly, the theory governing the MMRF core is similar to that in FEDERAL. There are however some important differences between these parts of the two models. First, in MMRF, inputs to both the top level utility and production functions are CES combinations of an effective domestic commodity and the imported commodity. Effective domestic commodities are CES functions of the commodity from each domestic source. The MMRF method thus allows for different elasticities for intra-national substitution possibilities to that employed for domestic / import substitution. However it does not allow for variation in Allen elasticities between each pair of domestic commodities. This contrasts with FEDERAL's use of a CRESH function to model substitution possibilities between source-specific commodities, which does allow for variation in elasticities of substitution between commodities within the same nest. Other important differences between the CGE cores of the two models are that: (i) unlike FEDERAL, MMRF does not distinguish between federal and state sales taxes within the CGE core; (ii) MMRF only allows for destination margins whereas FEDERAL allows for both origin and destination margins; and (iii) MMRF does not allow for interstate ownership of capital or land, or government ownership of business, all of which are important features of FEDERAL.

The government finance module computes revenue and outlay accounts for the federal government and each of the state governments. Sales tax revenues are allocated between governments on a fixed share basis. The latter treatment can be contrasted with FEDERAL, in which each level of government's sales tax receipts are directly linked to the rates of such taxes which they levy, and the prices and volumes of the transactions on which they are levied. MMRF's government finance module also determines the gross domestic products of the eight regions from the income and expenditure side using variables determined in the CGE core, together with regional household incomes.

The capital and investment module determines the relationship between changes in the capital stock and annual investment. Two sets of equations cover the comparative static and forecasting versions of the model respectively. The forecasting closure allows for the endogenous determination of current capital stocks (i.e capital stocks at the beginning of the solution year) over a medium term forecasting period. Capital stocks at the end of the solution year are then determined via an assumption that the growth of the capital stock over the solution year is equal to the annual average growth rate over the forecast period. The short-run comparative static closure sets regional industry capital stocks exogenous. Regional industry investments and future capital stocks are then typically indexed to current period capital stocks, which effectively sets the values of these variables at zero change.

The foreign debt accumulation module relates the change in the level of foreign debt (relative to its base value) in the solution year to changes in the annual trade deficits over the forecast period. The annual trade deficits over the forecast period are assumed to follow a straight-line path, an approach which simplifies the calculation for the change in foreign debt in the solution year.

Finally, the labour market and regional migration module computes the changes in population from natural growth and foreign and inter-regional migration, and relates this to labour supply. As with the foreign debt accumulation module, the solution for the change in population in the solution year is simplified by assuming that the population flow variables (international and inter-regional migration, and natural population growth) grow smoothly between the base and solution years.

1.3.2.3 The MONASH model

The MONASH model is a large-scale multi-sectoral CGE forecasting model of the Australian economy. In broad terms, the CGE core of the MONASH model is similar to that of the earlier ORANI model, however the structure of MONASH then departs from ORANI in three ways. First, it contains a new investment and rate of return theory. Second, it contains accumulation relationships linking stock and flow variables between years. Third, it contains a large number of relationships that allow major changes in the closure of the model. These changes in model closure are made to facilitate the use of the model in simulations over historical and forecast periods. An overview of the MONASH model is provided in Adams et al. (1994), and a detailed discussion of the model's theory is given in Dixon and Rimmer (1999a). Many of the attributes of MONASH which distinguish it from ORANI have been incorporated in FEDERAL-F, and so a more detailed discussion of the various elements of MONASH are reserved for Chapter 2.

The regional dimension of MONASH is a variant of the ORANI-ORES method that also takes account of both population movements and major local projects. The MONASH method also involves a two-stage decomposition of the national results. The national results are first decomposed to the state level using the ORES method, with the addition of shifts in state shares in national industries to take account of state-specific factors. The second stage decomposes the state level results to the statistical division level, again using the ORES dichotomy between those industries producing commodities which are traded state-wide, and those producing commodities that are predominantly consumed within the region of production. However, unlike the treatment of local commodities in the first (national-state) decomposition, the second decomposition allows for the possibility of some demand for sub-state local commodities outside their region of production (Adams and Dixon 1995).

1.4 DYNAMIC CGE MODELLING

1.4.1 Inter-temporal vs recursive dynamic models

Malakellis (1994) notes that dynamic multi-period CGE models can be classified as either "recursive" or "inter-temporal" on the basis of their treatment of expectations. The key assumption of recursive models is that the behaviour of agents is dependent on either the current (static-expectations) or past (adaptive expectations) state of the economy. These models can be solved period-by-period as a sequence of temporary equilibria because the agents do not base their decisions in the current period on information concerning the future values of variables in the model. Examples of recursive CGE models include Hudson and Jorgenson (1974); Hudson and Jorgenson (1978); Fullerton, King, Shoven, and Whalley (1981); Bovenberg and Keller (1981); Dervis, de Melo, and Robinson (1982); Fullerton, Shoven and Whalley (1983); Borges and Goulder (1984); Longva, Lorentsen, and Olsen (1985); Ballard, Fullerton, Shoven and Whalley (1985); Ballard and Goulder (1985); Khorshid (1990); McGregor et al. (1996); and McGregor et al. (1999).

The defining feature of intertemporal models is the presence of forward-looking expectations (Malakellis 1994). Hence, these models typically[6] cannot be solved period by period because at least some agents in the model base their decisions in any given period on expected future states of the economy. Examples of intertemporal CGE models include Auerbach, Kotlikoff, and Skinner (1983); Chao (1982); Manne and Preckel (1983); Ballard and Goulder (1985); Malakellis (1994); and Adams et al. (1994).

In developing FEDERAL-F from the comparative-static FEDERAL model, a choice was made early on to develop a recursive model. Both the computer and labour resources required to develop and then operate a disaggregated multi-regional CGE model are already large, without the added burden of imposing an intertemporal solution on the model. Clearly, a prior consideration to this decision was that the high level of disaggregated detail in the FEDERAL model was also a desirable feature of the future FEDERAL-F model. As is apparent from the extensive list of applications of regional models contained in Madden and Giesecke (1999), Australian regional CGE models have enjoyed an on-going and widespread relevance to the analysis of a wide range of applied economic problems. The high level of disaggregation in these models - of commodity and industry detail, government taxation and expenditure instruments, and the regional distribution of economic activity - is an important factor in ensuring the continued application and relevance of these models to the investigation of a wide range of regional economic issues. FEDERAL-F is designed in the same tradition - large-scale with sufficient flexibility to be applied to other regions and problems, in addition to those applications undertaken in this

[6] One exception is MONASH, which achieves a converged sequence of solutions under an assumption of forward looking expectations via an iterative procedure in which successive year-on-year solutions of the model are generated using successively refined "guesses" of future solutions.

thesis. With these ends in mind, the starting point for developing FEDERAL into a dynamic model was the development of a recursive model. This has provided a tractable and efficient means of solving the model. It has also provided a starting point for the future development of an intertemporal model if future potential applications of the model so require. Yet sight should not be lost of the fact that a recursive dynamic approach is not an unrealistic approach if agents in the economy are thought to be myopic with respect to the future state of the economy. Even if the expectations of agents are not thought to be myopic, the recursive approach may still generate a satisfactory approximation to an intertemporal equilibrium so long as relative prices do not change too rapidly over time (Manne 1984). Hence, for example, the limitations of this treatment of expectations would need to be acknowledged most in the modelling of any scenario involving dramatic and sustained price changes.

1.4.2 Australian experience

Dynamic CGE models are capable of revealing many insights into applied economic issues that are not possible with a comparative static model; a conclusion borne out by applications of the MONASH model by the Centre of Policy Studies at Monash University. The most obvious benefit of a dynamic CGE model is that the model user is immediately freed from the restrictions of only two time periods the long-run and the short-run – which typically define the temporal dimension of comparative static models. This facilitates the analysis of economic issues that unfold over several years. Two common examples of such issues include the phasing-in of changes to economic policy, and the construction and subsequent operation of major pieces of infrastructure and other capital investments. Faced with a need to analyse such issues, the user of a comparative-static model is forced to second-best options such as concentrating solely on short-run and/or long-run impacts, examining impacts for an assumed "typical-year" for the issue under analysis[7], or making extraneous adjustments to the model to inform the analysis with some of the more important inter-temporal considerations for the case under investigation, such as the speed with which the labour market clears or the division of new capital ownership between local and foreign agents[8]. The user of a dynamic model such as MONASH or FEDERAL-F is not faced with such restrictions.

[7] See for example Dixon, Horridge and Johnson (1992).
[8] See for example Madden (1998b) and Madden (1999).

Recent investigations using dynamic CGE models have made explicit dimensions to economic problems that were not amenable to elucidation using comparative-static models. An important example of such is the question of adjustment costs to changes in economic policy. Comparative-static models such as ORANI and FEDERAL are not well suited to the investigation of the adjustment costs of policy change. Being comparative-static models, these models produce results for the endogenous variables in terms of deviations away from what they would otherwise have been. Unfortunately, for the modeller interested in the magnitude of adjustment costs the values the variables would otherwise have been is not specified in the modelling exercise. And yet this counter-factual can be a major consideration when measuring the adjustment costs to policy change. Two recent examples in the Australian context of ongoing tariff reform are the Centre of Policy Studies' analysis of the effect of tariff reductions on the Australian textiles, clothing and footwear (TCF) sector (Dixon, Parmenter and Rimmer 1997) and the Australian motor vehicles industry (Dixon, Malakellis and Rimmer 1997). The former study found that the tariff cuts under investigation would have a long run employment impact on the TCF sector of approximately –8.2 per cent. Broadly, this is the limit of the information on TCF employment that would be produced by a comparative static model. However, the MONASH model was able to specify the growth path of employment in this sector in the absence of the proposed policy change. Employment in the sector was found to be 27 per cent below its present levels by 2014. This implies that the potential adjustment costs for workers in this industry could be high, since the potential employment reductions associated with the tariff reform are projected to occur in an environment of generally poor prospects for security of tenure in this sector[9]. The latter study (Dixon, Malakellis and Rimmer 1997) provided an example of the opposite scenario. The long-run impact on automotive output of the proposed policy was found to be negative. However this negative impact was found to occur within a projected context of underlying growth for the industry. The tariff cuts, while reducing output relative to what it would otherwise have been, were projected to merely slow the industry's rate of output growth.

[9] Although the authors went on to conclude that, while the proposed tariff cuts may have been disruptive for a small number of TCF workers, within the wider context of the Australian labour market, the proposed policy would have helped many other workers avoid periods of unemployment and retraining.

The capacity to specify the underlying base case with dynamic CGE models has allowed other interesting insights into the potential welfare consequences of government policy. A dynamic model allows the researcher to make projections of the changes in the structure of the economy over time. These structural changes can have important consequences for the welfare effects of policy change. For example, Dixon and Rimmer (1999b), in researching the welfare consequences of a goods and services tax for Australia, found that projected changes in the structure of the economy had an important bearing on the welfare impact of the policy. Researchers using traditional comparative static models missed these underlying structural changes, and hence also their implications for the welfare consequences of the policy[10]. Specifically, Dixon and Rimmer forecast that, in the absence of the proposed policy, the prices of Australian agricultural and mineral products on world markets would decline over the coming decade, relative to the prices of tourism services. The proposed tax package was projected to change the composition of Australia's exports towards agriculture and mining (the relative export prices of which were projected to be declining) and away from tourism services (the relative export price of which was projected to be rising). By reducing the relative share of tourism service exports in total exports, the policy was projected to reduce Australia's future terms of trade and hence welfare.

Dynamic CGE models are well suited to researching the nature and causes of the observed changes in the structure of economies over time. Australian CGE models such as MONASH, FEDERAL, FEDERAL-F, and MMRF are large and detailed – characteristics that are a product of their design being general, rather than specific purpose. These models feature a very large number of variables that describe the structure of the economy: production technologies, household preferences, taxation rates, input shares and sales patterns, export demand elasticities, household propensities to save, relationships between rates of return and capital supply, and so on. To analyse the sources of change in the structure of the economy over time, these variables can be set endogenous to the model, and appropriate variables describing observed economic outcomes set exogenous to the model. When these exogenous variables are shocked by the values that they are observed to have achieved over the historical period under investigation, the model solves for values for the endogenous structural variables that ensure that these exogenous shocks are compatible

[10] See for example Murphy (1999) cited in Dixon and Rimmer (1999b).

with the model theory and data. In this way, one can solve for the values for structural variables (production technologies, household tastes, positions of export demand schedules, and so forth) which cannot otherwise be observed. This approach was pioneered in Australia by the Centre of Policy Studies in their applications of the MONASH model[11]. Using the FEDERAL-F model, this method has been applied in the regional context by Giesecke (1999a) to identify the structural and policy changes that account for the divergent growth performance of a small and ailing regional economy in Australia. The latter work is updated and significantly expanded upon in Chapter 4.

1.5 THE CONTRIBUTION OF FEDERAL-F

Outside of Australia, the field of regional CGE models is dominated by small-scale comparative static models. Within Australia, and before the development of FEDERAL-F, the field of dynamic multi-regional CGE models was dominated by MMRF and MONASH. However, both the MMRF and MONASH models face important limitations in their ability to be used to examine regional issues with a multi-period dimension. The MMRF model has the technical capability of producing state-level forecasts over the medium term, as it contains ORANI-F style annual average accounting of physical capital and foreign debt accumulation. However the model does not produce year-on-year results. Also, unlike MONASH, the model does not contain relationships that allow for major changes in the closure of the model. This raises questions about whether the model could be used to examine historical periods, and whether the model could be used to produce convincing medium term forecasts under a structural closure. Data constraints also mean that the model must trade industry and commodity detail for regional detail: with the behaviour of economic agents being modelled in eight regions, implementation of the model to date has involved a high level of industry and commodity aggregation. The MONASH model features extensive industry and commodity detail, and can be used to produce tops-down forecasts for many regions. However the use of the MONASH model to examine multi-period issues at the regional level is subject to two broad sets of limitations. The first relate to the method used to decompose the model's national results to the regions. These limitations include: the independence of regional industry outputs and regional demand patterns for inter-regionally traded commodities; differences in the shares of fixed factors in total costs for a given industry between regions not being incorporated within the

[11] See Dixon, Menon and Rimmer (2000) for a recent application of this technique.

decomposition theory; and the absence of a constraint on the mobility of capital between regions in the short run[12].

A second limitation is that while the model can be used to decompose the results for shocks originating at the national level, the model is not well suited to examining the impact of shocks originating at the state level. It cannot examine issues such as the causes of structural changes at the regional level, the consequences of state and local government policy changes, or foreign shocks that differ in their direct sub-national consequences. It is precisely these types of shocks to which the FEDERAL-F model is subjected in the simulations reported in Chapters 4, 5, and 6 of this thesis.

Turning to FEDERAL, there are two broad characteristics of this model which prevent it being used in multi-period analyses. First, the model lacks the required accumulation relationships necessary to link flow and stock variables across multi-period simulations. Hence, in the absence of exogenous shocks to the model, even those minimum changes in stock variables (such as capital) that are implicit in the base-period flow data (such as investment) have no effect on the model's endogenous variables as time passes. As a minimum, a multi-period model should incorporate within its theoretical structure the idea that both the act of investment, and the process of depreciation, ensures that the economy's equilibrium changes as time passes.

The second characteristic relates to the overall structure of the model as a bottom-up microeconomic model of the Australian economy. In undertaking multi-period simulations with the model over historical and prospective time periods, it will often be desirable to set exogenous some variables which are rightly endogenous under comparative-static simulations of the model. With MMRF, the FEDERAL model does not contain the necessary relationships to support such departures from the traditional set of comparative static closures.

The development of FEDERAL-F aims to fill the gap between the bottom-up comparative-static regional analysis that can be undertaken with models such as FEDERAL and MMRF, and the dynamic tops-down regional analysis that can be undertaken with MONASH. This

[12] See Madden (1990) for a full discussion of the limitations of the tops-down approach employed in the model.

requires FEDERAL-F to feature bottom-up dynamic modelling of regional economic activity. Furthermore, the new model is designed to remain in the Australian tradition of CGE modelling, defined by models that are large-scale in their sectoral detail and flexible in the range of applications to which they can be turned. The starting points for the development of FEDERAL-F are the FEDERAL and MONASH models. With FEDERAL as one of the starting points, another desired feature of FEDERAL-F is that it retain the detailed fiscal modelling in its parent model. The general approach will be to add to FEDERAL those broad features of MONASH that allow the latter model to be used in the dynamic analysis of a wide range of issues under a variety of closures. In each instance, the particular feature that is added will have to be adapted to the multi-regional character of FEDERAL-F. In some instances, the multi-regional dimension of the new model, the presence of its detailed fiscal modelling, or simply a desire to attempt to improve on the MONASH approach, will lead to a number of departures from the MONASH theory. Innovative features of the new model include: provision for change in the composition of exogenously determined sectoral activities during historical simulations; the introduction of inter-regional sourcing twists to allow for the exogenous determination of regional outputs; the treatment of phantom taxes as windfall gains to capital owners; the tracking of regional industry capital ownership, linking this with the savings behaviour of the various agents in the model; the tracking of capital ownership on the part of inter-regional migrants; and detailed modelling of the determinants of inter-regional migration.

2 THEORETICAL STRUCTURE OF THE FEDERAL-F MODEL

2.1 INTRODUCTION

2.1.1 Overview of the theoretical structure of the FEDERAL-F model

Section 2.1 starts by presenting a broad overview of the structure of the FEDERAL-F model. This is a precursor to the detailed and exhaustive discussion of the equations of the model in the remaining sections of Chapter 2. Section 2.1.2 goes on to provide an overview of the model solution method, some notes on the presentation of the percentage change forms of linearised equations, and some notes on the conventions followed in naming variables, equations and coefficients throughout this thesis. The latter section will be of value to those readers who are not already familiar with the Australian tradition of CGE modelling.

2.1.1.1 Production structure in FEDERAL-F

Current production is undertaken by firms that are aggregated within individual representative industries, and which in turn are specific to each region. Each regional industry is assumed to produce a single commodity, which is an imperfect substitute for the identically named commodity produced in other regions or imported from overseas. Firms in each regional industry are assumed to face a three-tiered production function. At the top level, effective inputs of intermediate inputs, effective inputs of primary factors, and certain other costs, are combined in a Leontief production[13] function to determine a given level of activity.

Effective inputs of intermediate input commodity i are a CRESH[14] combination of commodity i sourced from $r + 1$ regions (r domestic regions, and overseas imports). Effective units of primary factors are a CRESH combination of effective units of labour, regional-industry specific capital, and agricultural land. Labour inputs are further classified into eight occupational classes, with effective units of labour being a CRESH combination of these eight classes.

[13] That is, a fixed proportions production function. See Dixon et al. 1992 for a description of this function.
[14] "Constant ratio of elasticities of substitution, homothetic", See Dixon et al. 1992 for a description of this function.

In the absence of changes in relative prices and technology, the demand by a regional industry for inputs will be proportional to the regional industry's activity level. Within any given CRESH nest, changes in relative prices invoke substitution towards the relatively cheaper inputs, with the strength of this substitution being governed by the elasticity of substitution implicit in both the CRESH parameter for that effective input and the relative shares of the inputs to that effective unit.

Changes in production technology have a direct impact on input demands, independent of relative prices. One option for technological change that is employed frequently (but not exclusively) in FEDERAL-F is to ensure that such change is cost neutral. This requires technological change to operate on more than one input within a given CRESH nest, with these changes operating to switch or "twist" input demands within the nest in such a way that the cost of constructing the effective input remains unchanged.

To facilitate the implementation of such cost-neutral technological change, the demand for commodities for use as intermediate inputs, inputs into capital formation, and household consumption are also a function of commodity-specific import "twist" terms, and commodity specific inter-regional sourcing "twist" terms. These variables allow for the endogenisation of the preference for both imports and domestic goods during historical and forecasting applications of the model. Under the standard short-run closure of the model, these variables are typically exogenous. However they can be determined endogenously to facilitate the exogenous determination of import volumes (in the case of the import twists) and regional commodity outputs (in the case of the inter-regional sourcing twists) that would otherwise be incompatible with the other exogenous shocks, model theory, and parameter values under a given simulation.

The demand for capital and labour inputs are also a function of terms allowing for changes in the labour/capital ratio for a given ratio of the real wage and rental rate. These variables are typically exogenous, however they can be set endogenous to facilitate the exogenous determination of both the real wage and national level of employment in historical and forecasting simulations of the model.

2.1.1.2 Final demands in FEDERAL-F

2.1.1.2.1 Households

Regional households are assumed to maximise a Stone-Geary utility function by choosing among effective units of commodity *i* (which are in turn a cost-minimising CRESH combination of *i* from the *r*+1 geographic sources), subject to an aggregate expenditure constraint.

The aggregate expenditure constraint of each regional household is determined by after-tax factor income, government transfers payments, direct taxes, receipts of phantom-tax revenue, receipts of net foreign income, and changes in their average propensity to save.

After-tax income to region *r* residents from capital and land is related to the history of inter-regional migration over the simulation period. Households retain the pattern of capital ownership of the households in the region in which they were resident in the *base* period, even though their *current* region of residence may change over the simulation period. Labour market income is, however, determined by the region in which the household is *currently* resident.

Two choices are available for tracking the ownership by regional households of capital in domestic regional industries and net foreign assets. The first links changes in household domestic capital ownership to household savings. Under this approach, foreign capital ownership in each regional industry adjusts as a residual to reconcile the value of new capital installed in each regional industry with that supplied by domestic agents. Under the second approach, capital ownership shares in each regional industry are assumed fixed, and regional household net foreign asset holdings adjust as a residual to reconcile regional household savings with the value of any new capital that they are implicitly calculated to own.

2.1.1.2.2 Investment and capital accumulation

Simulations of the model can be undertaken under either a comparative-static or recursive[15] dynamic closure. The theory that is operational under the latter closure

[15] Recursive, in the sense that the model is solved for year t, then year t+1, and so on.

connects time periods through accumulation relationships tracking changes in regional industry capital stocks, regional government and Commonwealth Government debt, inter-regional migration, population growth, household foreign net assets and net interest receipts, and capital ownership shares.

Investment in each regional industry is determined by functions specifying the relationship between the expected rates of return on each regional industry's capital stock in the period $t+1$, and the rate of growth in the regional industry's capital stock during the simulation year. These functions are based on the industry-level capital supply functions in the MONASH model. Each regional industry faces a positively sloped capital supply function, reflecting an assumption that investors are more cautious about the prospects for a regional industry the greater the rate of growth in that industry's capital stock. The functions also have an inverse-logistic shape, with the negative asymptote set marginally above the negative of the depreciation rate, and the positive asymptote set equal to an exogenously specified maximum rate of regional industry capital growth.

Capital creators are assumed to create units of capital by combining effective units of intermediate inputs in a Leontief function. Effective units of commodity i are a CRESH combination of commodity i from each of the $r + 1$ geographical sources. Capital creators are assumed to minimise the cost of producing units of capital by substituting between the geographical sources of produced commodities.

The gestation lag between the undertaking of investment in one period, and the consequent installation of productive capital in a later period, is assumed to be such that the investment undertaken during a year is installed as productive capital at the commencement of the subsequent year. Assuming that investment expenditure occurs uniformly across a year, this translates to an average gestation of six months.

2.1.1.2.3 Regional government and Commonwealth Government current outlays

Current outlays by each regional government, and by the Commonwealth Government, on commodity i from source s are assumed to be equal to the sum of commodity-specific, source-specific, commodity and source-specific, and uniform, policy shift variables. These variables are typically exogenous under a standard comparative static closure of the model.

2.1.1.2.4 Foreign export demands

Three broad types of export commodity are identified in the model: traditional export commodities (which consist largely of primary exports) non-traditional export commodities (which consist largely of manufacturing exports), and exogenous export commodities (which consists of the commodities Dwellings and Residential Construction). In the absence of exogenous shocks to their export demand schedules, the volume of endogenous export commodities are assumed to be inversely related to their foreign currency price via constant elasticity export demand functions. The percentage changes in the volumes of exogenous export commodities are determined exogenously at zero. Two treatments of non-traditional export commodities are available. One allows for the volume of exports of each individual non-traditional export commodity to be determined by its own foreign currency export price via its own constant elasticity export demand function. The second approach allows for aggregate regional non-traditional export volumes to move as a block in response to changes in the aggregate regional foreign currency price index for non-traditional exports.

2.1.1.3 Margin commodities

Commodity flows between regions are facilitated by usage of margin commodities. These margins can be supplied by either or both of the source and destination regions. In the absence of technical change, margins are assumed to be required in fixed proportion to the flow of the commodity whose exchange they are facilitating.

2.1.1.4 Price equations

Firms are assumed to operate in a perfectly competitive environment. Hence per unit basic prices are equal to per unit production costs. These production costs include net production taxes, payroll taxes, primary factor payments, other cost tickets, and intermediate inputs valued at purchaser's prices. The basic prices of foreign imports are their landed duty paid domestic-currency value. Per-unit purchasers' prices (and port of exit export prices) differ from per unit basic prices by the value of any margins, sales taxes, and phantom taxes associated with the transaction. Commodity taxes can be levied by the

Commonwealth Government and by any of the regional level governments provided the commodity originates from, or is sold within, their region. Commodity tax rates vary across commodities depending on the levying government, the source of supply, and the class of purchaser. So called "phantom taxes" may be payable by all classes of purchaser. In comparative static simulations with the model, the rates of phantom taxes are typically exogenous and shocked to zero. However in historical and forecasting closures of the model these taxes may be determined endogenously, with corresponding price indices and / or individual purchasers' prices for commodities determined exogenously. The revenue from these taxes is assumed to accrue to households in each region (in the form of changes in super-normal profits or losses), in proportion to their ownership shares in the capital of the industries producing the commodities upon which the phantom taxes are accruing.

2.1.1.5 Market-clearing equations

Demand and supply are equated for all commodities, and for regional industry capital stocks and land. In comparative-static simulations, labour supply is assumed to be perfectly elastic in the short-run and exogenous in the long run. In policy or deviation simulations, with a year-on-year closure of the model, a MONASH-style labour market adjustment mechanism operates to return aggregate employment to its base level over a period of about five years following the policy shock, via adjustments in the economy-wide real wage.

2.1.1.6 Regional government and Commonwealth Government receipts

Commonwealth Government receipts from PAYE taxes, income taxes on rents from capital and land, import duties, production taxes, commodity taxes, export taxes, and other receipts are explicitly modelled as being determined by both the relevant tax bases upon which each tax is levied, and the rates of each tax. Inter-governmental fiscal relations are modelled through Commonwealth transfers to each regional government. Commonwealth nominal outlays on unemployment benefits and other transfer payments are determined through both indexing relationships to the consumer price index and policy shift variables.

Regional government receipts from payroll taxes, residential land taxes, commercial land taxes, fees and fines, commodity taxes, and production taxes, are related to movements in the relevant tax bases and the rates of each tax. Outlays on transfers to persons are determined through both indexing relationships to the consumer price index and a policy shift variable.

Outlays on interest payments by both levels of government are related to the stock of the respective government's outstanding debt. Outstanding debt for a given level of government at the commencement of each simulation period is equal to their outstanding debt at the beginning of the previous simulation period, plus their net financing requirement for the previous simulation period.

Like regional households, both the Commonwealth Government and the regional governments each receive an allocation of phantom tax revenue in proportion to their ownership of capital in the industries producing the commodities upon which the phantom tax revenue has accrued.

2.1.1.7 Inter-regional migration

A two-region adaptation of Jones and Whalley's (1989) migration theory is used to determine regional populations during the policy simulations undertaken in Chapter 6. It is assumed that individuals in each region differ in the intensity of their preferences regarding the region in which they might reside. This preference is reflected in a penalty that the individuals are assumed to incur if they leave their initial home region. The locational penalty varies across individuals. Individuals base their decision on the region in which to reside by weighing the locational penalty associated with migrating, against a measure of the additional real income they might receive if they were to migrate. This measure of income excludes those components of income that are invariant to the region in which the individual resides (such as capital returns). The measure does include real per-capita expected wages, real per-capita fiscal variables (namely: regional government consumption spending, Commonwealth transfer payments, regional government transfers to persons, regional government income and other taxes, and other Commonwealth taxes) and real per-capita expected unemployment benefits. Expected wages and expected unemployment benefits are calculated using the unemployment rate in each region as an indicator of the probability of employment. Inter-regional migration then responds to changes in the relative measure of expected real per-capita income between the two regions. If this measure changes, then some number of those individuals who reside in the region experiencing the relative decline in per-capita income, and who have the weakest preference (ie. incur the lowest penalty from migrating) for their home region, will now desire to live in the other region. This establishes the desired level of inter-regional migrants. Some proportion of the gap between the actual and desired level of inter-regional migrants is then assumed to be closed in each period through inter-regional migration.

2.1.1.8 Other equations

Many other equations compute aggregates derived from the equations of the core model, as outlined above. These equations calculate such variables as the balance of trade, the level of employment and unemployment, a complete set of regional and national income accounts, and the like. Other miscellaneous equations index various prices, wages, unemployment benefits and per-unit tax rates. Many equations exist to facilitate the use of extraneous values for certain variables during historical and forecasting simulations of the model.

2.1.2 Solution method, and the derivation and presentation of percentage change forms

2.1.2.1 Overview of the Johansen / Euler solution method

The FEDERAL-F model consists of a system of non-linear equations when expressed in terms of the original levels versions of the equations. This system of equations is solved using the Johansen / Euler solution method. This involves first converting the system of non-linear equations to a system of linear equations by taking total differentials of each equation. Deviations in the values of the model's variables away from their initial values are then evaluated in a number of steps, with the partial derivatives in the system of linear equations re-defined at each step. This technique is implemented using the GEMPACK suite of computer programs (Pearson (1988) and Harrison and Pearson (1996)). The following description of the Johansen/Euler method draws on similar discussions in Dixon et al. (1992) and Dixon and Rimmer (1999a), and the reader is referred to these publications for further elaboration on the method.

The FEDERAL-F model can be represented as a system of equations describing economic activity in period t as follows:

$$H(V_t) = 0 \qquad \text{(E2.1.1)}$$

Where H is a vector function of length m, and V_t is a vector of length n of equilibrium values for year t which satisfy (E2.1.1). It is assumed that H is differentiable, and that $n > m$, requiring that the value of n - m variables be determined exogenously.

Equation (E2.1.1) forms the starting point for solving FEDERAL-F as either a comparative-static model or a dynamic model. In solving FEDERAL-F as a dynamic model, I follow the MONASH approach of solving (E2.1.1) on a year by year basis: that is, each solution period is equal to one year. Within each year, values are provided exogenously for n - m variables, and (E2.1.1) is then used to solve for the remaining m components of V_t. Each solution period is linked by the fact that the initial values for the stock components of V_t are equal to their post-simulation values for t-1.

The first step in implementing the Johansen / Euler solution method is to convert (E2.1.1) into a system of linear equations by totally differentiating each function, and then expressing the variables in terms of either percentage or absolute rates of change[16]. Generally, percentage rates of change are the preferred mode of expressing the linearised variables because the coefficients in the equations in which they appear are then more easily interpretable. Expression in terms of absolute rates of change is typically reserved for variables that can pass through zero, and for certain government accounts variables. For convenience, here I assume that all the variables in the linearised expression of (E2.1.1) are converted to percentage rate of change form, so that the model now expressed as a system of linear equations becomes:

$$A(\overline{V_t})v_t = 0 \qquad \text{(E2.1.2)}$$

[16] See Sections 2.1.2.2 and 2.1.2.3 for an example and further discussion on this.

Where $A(\overline{V_t})$ is an m x n matrix of elasticities evaluated at $\overline{V_t}$, and v_t is the n x 1 vector of percentage changes in the variables away from $\overline{V_t}$. To calculate how the model's endogenous variables respond to changes in the model's exogenous variables, it is necessary that an equilibrium vector $\overline{V_t}$ is available. This is initially the base year data, or V_{t-1}, although in a multi-step (Euler) solution $\overline{V_t}$ is re-evaluated at the commencement of each step. For the moment, (E2.1.2) can be written:

$$A^a(V_{t-1})v_t^a + A^b(V_{t-1})v_t^b = 0 \qquad \text{(E2.1.3)}$$

v_t^a	Is the m x 1 sub-vector of endogenous components of v_t;
v_t^b	Is the n - m subvector of exogenous components of v_t;
$A^a(V_{t-1})$	Is the m x m matrix of elasticities corresponding to the endogenous variables, evaluated using the solution to the model for t-1; and
$A^b(V_{t-1})$	Is the m x (n-m) matrix of elasticities corresponding to the exogenous variables, evaluated using the solution to the model for t-1.

Equation (E2.1.3) can be re-arranged to express the percentage changes in the model's endogenous variables, v_t^a, as a function of the percentage changes in the model's exogenous variables, v_t^b:

$$v_t^a = -A^a(V_{t-1})^{-1}A^b(V_{t-1})v_t^b \qquad \text{(E2.1.4)}$$

Or more compactly,

$$v_t^a = B(V_{t-1})v_t^b \qquad \text{(E2.1.5)}$$

Where $B(V_{t-1})$ is defined as $-A^a(V_{t-1})^{-1}A^b(V_{t-1})$

Equation (E2.1.5) is a satisfactory representation of the solution method when a single-step (Johansen) solution method is employed. In this case, $\overline{V_t} = V_{t-1}$. In a multi-step (Euler) solution, this is only true for the solution to the first step. In an Euler computation, the percentage changes in the exogenous variables are divided into and administered in *k* steps, such that the change in each exogenous variable is divided into *k* equal steps. In the case of a two-step Euler computation, the impact on the endogenous variables after the first step would be calculated as:

$$v^{a}_{t[1,2]} = B(V_{t-1})v^{b}_{t[1,2]} \qquad \text{(E2.1.6)}$$

where the subscript [1,2] denotes the first step of a two-step computation. The solution for year *t* is now re-evaluated at this point, that is, where the levels of the exogenous variables have moved half way towards their new values:

$$V_{t[1,2]} = V_{t-1}\left(1 + v_{t[1,2]}/100\right) \qquad \text{(E2.1.7)}$$

The effects on the endogenous variables of the second step are now evaluated as:

$$v^{a}_{t[2,2]} = B(V_{t[1,2]})v^{b}_{t[2,2]} \qquad \text{(E2.1.8)}$$

and the two-step solution for year *t* can then be evaluated as:

$$V_{t[2,2]} = V_{t-1}\left(1 + v_{t[1,2]}/100\right)\left(1 + v_{t[2,2]}/100\right) \qquad \text{(E2.1.9)}$$

The two step solution is likely to be a more accurate estimate of the true solution to (E2.1.1) than a Johansen solution, and increasing the number of steps is likely to improve further the accuracy of the solution (Dixon and Rimmer 1999a). In the simulations undertaken in Chapters 4 - 6 of this thesis, I use Euler computations ranging from 8 to 32 steps. Through experimenting with the number of steps, while moving between historical/forecast and structural closures of the model for any given simulation, I found that the accuracy[17] of the solution at the regional level could be sensitive to the size of the shifts in export demand schedules. For the majority of simulations, 8-step Euler solutions were sufficient, however for one year in which there were relatively large movements in export demand schedules a 32-step solution was used to guarantee that the structural closure reproduced the results of the historical closure.

2.1.2.2 The linearised expression of FEDERAL-F equations

As already discussed in Section 2.1.2.1, many of the equations in FEDERAL-F are non-linear in their original levels form. Following Johansen (1960), and the Australian tradition established by Dixon et al. (1982), the model is solved by first representing the levels equations in percentage change form. Expressions in percentage rate of change form can usually be derived from the original levels equation using one of three rules (Dixon and Rimmer 1999a):

$X = YZ$ becomes $x = y + z$ (Multiplication rule)

$X = Y^{\alpha}$ becomes $x = \alpha y$ (Power rule)

$X = Y + Z$ becomes $Xx = Yy + Zz$ (Addition rule)

Where X, Y, and Z are levels of the variables, and x, y, and z are the respective percentage changes in those levels. For example, a levels equation of the form:

$$Y = \beta W \left[\frac{X}{Z}\right]^{\alpha} + V \tag{E2.1.10}$$

(where V, W, X, Y, Z are variables, and α and β are fixed parameters) is converted to a percentage rate of change form by first taking the total differential of the equation:

$$dY = \beta \left[\frac{X}{Z}\right]^{\alpha} dW + \alpha\beta W \left[\frac{X}{Z}\right]^{\alpha-1} \left(\frac{dX}{Z} - \frac{dZ}{Z}\frac{X}{Z}\right) + dV \tag{E2.1.11}$$

[17] In terms of the capacity of the shocks under the structural closure to reproduce the results of the historical/forecast closure.

Percentage changes in the 5 variables in (E2.1.10): V, W, X, Y and Z; are then defined as:

$$v = \frac{dV}{V}100, \quad w = \frac{dW}{W}100, \text{ and so on.}$$

So that the original levels equation becomes:

$$y = A_0 w + \alpha A_0 (x - z) + A_1 v \qquad \text{(E2.1.12)}$$

Where

$$A_0 = \left[1 + \frac{V}{\beta W[X/Z]^{\alpha}}\right]^{-1}$$

$$A_1 = \left[\beta W[X/Z]^{\alpha} V^{-1} + 1\right]^{-1}$$

The original non-linear equation has now been transformed to a linear percentage rate of change form. The lower case letters in Equation E2.1.12 - the percentage rates of change in the original underlying levels variables - are the variables in the linear equation. The upper-case letters represent the coefficients in the new equation. In the first step of a multi-step solution these coefficients are evaluated at the values they possessed in the original (pre-simulation) solution to Equation E2.1.10, and they are then recomputed in subsequent steps as the solution moves away from the original solution.

2.1.2.3 A note on the presentation of equations, variable names, and coefficient names

In presenting the complete FEDERAL-F equation system in Appendix A, it is the percentage rate of change equations that are presented, not the underlying levels equations. In many instances, the form of the underlying levels equation is readily apparent in the percentage rate of change form. Nevertheless, each equation in Appendix A is described in the remainder of Chapter 2. The detail devoted to the description of each equation differs across equations, depending on the extent to which the equation differs from (or is in fact present in) the original FEDERAL model. Either the levels representation or a detailed discussion of new and modified equations is typically provided for those equations that are either not present in FEDERAL, or represent a significant modification of an equation that is present in that model. The remaining equations (that is, those that are not changed from the original FEDERAL model) are discussed in a more summary manner, while still allowing the reader, if they desire, to recover the form of the underlying levels equation from the original descriptions in Madden (1990), or Dixon ct al. (1982). To further assist the reader in interpreting the percentage rate of change equations, Table 2.1.1 presents examples of percentage change equations, and the underlying levels equations from which they are derived (Horridge, Parmenter, and Pearson 1998). Two forms of the linearised equations are presented in Table 2.1.1: "intermediate form" and "percentage change form". The key difference between these forms is that the "intermediate form" stops one step short of evaluating the share-based coefficients on the right hand side of the "percentage change" form equations. In constructing the computer implementation of the model, the "intermediate form" is often preferable to the percentage change form because it obviates the need to evaluate a large number of share coefficients. Both intermediate and percentage change forms of the linearised equations are present in FEDERAL-F, and so will be found in the equations presented in Appendix A.

A number of FEDERAL-F equations, in the levels, are the sum and/or difference of quantity or value variables, such as given by examples 9-11 in Table 2.1.1. To avoid calculating a large number of share coefficients for these equations, their percentage change representations are typically presented in intermediate form. However, to facilitate the description of these equations in the remainder of this chapter they may nonetheless still be described as a share-weighted sum of percentage changes, reflecting the equivalence of the intermediate and percentage change forms.

A final word on the presentation of the FEDERAL-F equations relates to my choice of variable and coefficient names. In presenting the equations in Appendix A, I have made a choice not to continue using the, equation, variable, and coefficient names of the original FEDERAL model. First, FEDERAL equations were distinguished from one-another by equation numbers. In FEDERAL-F, I have followed the MONASH equation naming convention. Each equation has been named after the variable which it can most easily be thought of as "determining" (in this case, under a standard comparative-static short run closure). Second, the naming of FEDERAL variables and coefficients followed conventional

Table 2.1.1: Examples of percentage change forms

Example	(1) Original or Levels Form	(2) Intermediate Form	(3) Percentage-Change Form
1	$Y = 4$	$Yy = 4*0$	$y = 0$
2	$Y = X$	$Yy = Xx$	$y = x$
3	$Y = 3X$	$Yy = 3Xx$	$y = x$
4	$Y = XZ$	$Yy = XZx + XZz$	$y = x + z$
5	$Y = X/Z$	$Yy = (X/Z)x - (X/Z)z$	$y = x - z$ *or* $100(Z)\Delta Y = Xx - Xz$
6	$X_1 = M/4P_1$	$X_1x_1 = (M/4P_1)m - (M/4P_1)p_1$	$x_1 = m - p_1$
7	$Y = X^3$	$Yy = X^3 3x$	$y = 3x$
8	$Y = X^\alpha$	$Yy = X^\alpha \alpha x$	$y = \alpha x$ (α assumed constant)
9	$Y = X + Z$	$Yy = Xx + Zz$	$y = S_x x + S_z z$ where $S_x = X/Y$, etc
10	$Y = X - Z$	$Yy = Xx - Zz$	$y = S_x x - S_z z$ *or* $100(\Delta Y) = Xx - Zz$
11	$PY = PX + PZ$	$PY(y+p) = PX(x+p) + PZ(z+p)$ *or* $PYy = PXx + PZz$	$y = S_x x + S_z z$ where $S_x = PX/PY$, etc
12	$Z = \Sigma x_i$	$Zz = \Sigma X_i x_i$ *or* $0 = \Sigma X_i(x_i - z)$	$z = \Sigma S_i x_i$ Where $S_i = X_i Z$
13	$XP = \Sigma X_i P_i$	$XP(x+p) = \Sigma X_i P_i(x_i+p_i)$	$x+p = \Sigma S_i(x_i+p_i)$ Where $S_i = X_i P_i/XP$

Source: Reproduced from Horridge, Parmenter and Pearson (1998)

lines - that is, relying on single Roman and Greek characters with the addition of a large number of subscripts and superscripts to expand the range of available names. This approach has not been followed in presenting the FEDERAL-F equations. Rather, the names allotted to both variables and coefficients are typically comprised of a sequence of letters and numbers, and these often bear some phonetic and/or abbreviated relationship to the "long name" for the variable or coefficient. I have followed this approach for a number of reasons. First, the FEDERAL-F model contains approximately 600 variable names and 360 coefficient names. This is too large a number to allow for the continued use of the original FEDERAL notation. Second, the variable and coefficient names used in this thesis correspond to the variable and coefficient names used in the TABLO representation of the model (that is, the computer implementation of the model. See Pearson (1988) and

Harrison and Pearson (1996)). This facilitates the task of ensuring that the FEDERAL-F equations as documented here correspond with the actual computer implementation of the model. Notwithstanding the advantages of using this notation to present the equations in Appendix A, it can nevertheless prove cumbersome when deriving or discussing these equations in other sections of the paper. Hence, to facilitate derivation and discussion of individual equations, I will often resort to more traditional notation in the remainder or this chapter. In all such cases the correspondence between this more traditional notation, and the notation in Appendices A-C will be self-evident. Finally, those variables and coefficients that trace their origins to the MONASH model, typically bear similar names to their counterparts in this national model. This serves to both facilitate a more rapid understanding of the function of these variables among readers who are familiar with MONASH, and to acknowledge the origin of the theory of which these variables form a part.

2.2 CURRENT PRODUCTION AND COMMODITY OUTPUTS

2.2.1 Introduction

The equations in Appendix A Section 1 describe both industry outputs, and the demands by industry for intermediate inputs, primary factors, and other costs as inputs to current production. The section also includes equations which link variables describing employment and output for broad sectoral groupings with the industries and commodities represented in the present implementation of the FEDERAL-F model. These equations facilitate the exogenous determination of sectoral outputs and employments during historical simulations. The structure of a number of the equations relating to industry input demands and outputs in the original FEDERAL model are easily identifiable among the equations in Section 1 of Appendix A. As described in more detail in Madden (1990), firms are assumed to face a fixed-proportions production function, in which effective inputs of intermediate inputs, primary factors, and other cost items are combined to produce a given level of activity. An effective input of a given intermediate input commodity is a CRESH[18] combination of that input from the foreign source and each of the domestic sources. Effective inputs of primary factors are a CRESH combination of land, labour, and capital. The effective labour input into a regional industry's primary

[18] "Constant ratios of elasticity of substitution, homothetic." See Hanoch (1971).

factor input is itself a CRESH combination of labour of eight occupational types. Commonwealth and regional government net production taxes are levied in fixed proportions to industry outputs.

2.2.2 Intermediate input demands for current production

Industry demands for source specific intermediate inputs in FEDERAL-F are described by Equations *E_x1A* and *E_x1B*. The structure of each of these equations is based on FEDERAL Equation 1. The reader is referred to Madden (1990) for a discussion of the derivation of the basic form of this equation. The key difference between Equations *E_x1A* and *E_x1B* and FEDERAL Equation 1 is the addition of both the domestic / foreign twist terms, and the inter-regional twist terms. These terms are used to impart cost-neutral shifts in the intermediate-input production technologies, with these shifts changing the domestic / foreign, or local / inter-regional input shares. A detailed discussion of the derivation and application of these variables is provided in Section 2.18.

2.2.3 Demands for primary factors

Industry demands for primary factors in FEDERAL-F are described by Equations *E_x_prim1, E_x_prim2, and E_x_prim3*. The structure of each of these equations is based on FEDERAL Equation 5. Again, the reader is referred to Madden (1990) for a discussion of the derivation of the basic form of this equation. The key difference between equations *E_x_prim1* – *E_x_prim3* and Equation 5 is the presence of the labour / capital twist terms on the equations describing regional industry demands for labour (*E_x_prim1*) and capital (*E_x_prim2*). These terms are used to impart cost-neutral shifts in labour / capital ratios (either economy-wide, or at the regional industry level).[19] The percentage change in the regional industry specific labour / capital twists is determined by Equation *E_ff_twistlk* as the sum of general, region-specific, and regional industry -specific, shift terms. Under the standard comparative static closure, the twist terms are inoperative, with $twistlk_{j,r}$ determined exogenously, and Equation *E_ff_twistlk* rendered inoperative via the endogenous determination of the values of $ff\_twistlk_{j,r}$. The equation is brought into

[19] The reader will see that the general form of these twist terms is identical to that of the inter-regional twist terms appearing in the equations for domestic demands for Australian produced goods. The derivation of the labour/capital twist terms follows the same logic as that used to derive the inter-regional sourcing twist terms (derived in Section 2.18). Hence a separate derivation of the labour/capital twists is not provided.

operation in the historical simulation by swapping the endogenous / exogenous status of the variables $twistlk_{j,r}$ and $ff\_twistlk_{j,r}$. Equation *E_ff_twistlk* then provides the user with some flexibility in the determination of regional industry specific labour / capital twists, depending on which of the right hand side variables are determined endogenously.

2.2.4 Production taxes and other costs

Equations *E_xcost*, *E_xsptax*, and *E_xcptax* are unchanged from Equations 2, 3 and 4 in Madden (1990). Commonwealth and regional government production taxes are assumed to be levied on a per-unit of output basis (hence no technical change variables appear on these equations). Since these are per-unit taxes, the percentage rates of change in the number of "production tax tickets" payable by a regional industry ($xcptax_{j,r}$ and $xsptax_{j,r}$) are equal to the percentage rate of change in the regional industry's output ($zact_{j,r}$). "Other costs", or "working capital", ($xcost_{j,r}$) is assumed to enter the Leontief production function directly. Therefore, in the absence of all-input using technical change, the percentage rate of change in the usage of working capital by a regional industry is equal to the percentage rate of change in that regional industry's activity level (Equation *E_xcost*).

2.2.5 Demands for labour distinguished by occupation

Equation *E_xlab* models the substitution possibilities that are available to each regional industry between labour of different occupational types. These substitution possibilities are governed by a CRESH function for the production of effective units of labour. This equation is essentially unchanged from Equation 6 in Madden (1990), and the reader is referred there for a full discussion of its operation. The only difference between the two equations is a trivial one – the occupation-specific technical change terms that appear in Equation 6 have been suppressed in Equation *E_xlab*. These terms are not used in any simulation undertaken in this thesis, and so have been omitted from Equation *E_xlab* for simplicity.

2.2.6 Regional industry outputs

Equations *E_x_rind* and *E_x_tot* replace Equations 8, 9, and 65 in Madden (1990). This simplifies the determination of regional industry outputs in FEDERAL-F. The original multi-product theory given by Equations 8 and 9 in FEDERAL is replaced in FEDERAL-F with the unique-product theory given by Equation *E_x_rind*. The coefficient $SHOIRJ_{i,j,r}$ in Equation *E_x_rind* is an identity matrix. Hence the percentage change in the output of commodity *i* by regional industry *j,r* is equal to the percentage change in the activity level of regional industry *j,r* for *i=j*, and zero otherwise. Equation *E_x_tot* (Equation 65 in Madden 1990) calculates the total output of commodity *u* from region *r*. The coefficient $B\_ZERO_{u,j,r}$ represents the share of the output of commodity *u* from region *r* accounted for by production by industry *j*. Again, because industries are assumed to represent unique product firms in FEDERAL-F, this means that the coefficient $B\_ZERO_{u,j,r}$ is an identity matrix.

Equation *E_x_total* calculates the percentage change in the economy-wide output of commodity *u* as the weighted sum of the output of commodity *u* from region *r*. The share weights are given by the regional shares in the economy-wide output of commodity *u*.

2.2.7 Exogenous determination of regional industry outputs

Information is available on output by industry by year from the Australian Bureau of Statistics (ABS). During historical simulations of the model, these data are used to determine output by industry for both Tasmania and Australia as a whole. Unfortunately, the sectors for which the ABS provides these data are broader in their definition than the commodities represented in FEDERAL-F. Hence it is necessary to establish a link between these broad output sectors and the FEDERAL-F commodities. Equations *E_x_sr*, *E_x_s*, *E_fx_total*, *E_fx_tot*, *E_del_f_a1 E_fai*, and *E_fi_twist_isbot* facilitate the exogenous determination of sectoral commodity outputs, both at the regional and national levels, during historical simulations of the model. These equations provide the model user with two options for setting sectoral commodity outputs exogenous. The first constrains the percentage change in the output of each FEDERAL-F commodity within a given commodity sector to equal the exogenously specified percentage change for the commodity sector as a whole. The second technique merely constrains the weighted sum of the outputs of each FEDERAL-F commodity within a given commodity sector to equal the exogenously specified percentage change for the commodity sector as a whole. Each of these approaches is described in turn below.

The first option follows a similar technique employed in the MONASH model for setting economy-wide outputs exogenous (Dixon and Rimmer 1999a). Equation *E_x_sr* calculates the percentage change in the output of commodity sector *s* in region *r* as the share weighted sum of the percentage changes in the outputs of the commodities in region *r* that are subsumed within sector *s*. The term "commodity sector" here is used to refer to some collection of the commodities in the set COM. ABS data are available on output by commodity sector[20], but not necessarily for each of the individual commodities in the set COM. Each of the commodities in the set COM is allocated to a unique element of the set of commodity sectors, XCOM. Hence, each of the *s* elements of XCOM can in turn be described as a set, each containing elements of the set COM. These *s* sets are described by QINDEXNO_s.[21] Note that the shift variable $fxsr_r$ allows for the weighted sum of regional sectoral commodity outputs ($x\_sr_{s,r}$) to deviate from the weighted sum of regional commodity outputs ($x\_tot_{i,r}$). By setting exogenous the regional sectoral commodity outputs during an historical simulation, one effectively sets exogenous real gross regional product at factor cost. Small differences between the ABS and model data on the implicit shares of sectoral value added in total gross regional product at factor cost can lead to differences between the value for real gross product at factor cost as calculated by the model, and that as provided by the ABS. If the ABS value for gross regional product at factor cost, for one region, is chosen to override the value as would otherwise be calculated by the model (as is done in Chapter 4 of this thesis), then the appropriate element of $fxsr_r$ is set endogenous, and r_grpfc3_r is set exogenous and shocked by the ABS value. The variable $fxsr_r$ then ensures that the results calculated for $x\_tot_{i,r}$ reconcile with both the exogenously determined sectoral outputs and the exogenously determined gross regional product at factor cost. The values attained by $fxsr_r$ must be examined to ensure that they are not overly large. Such a result would suggest important differences between the model and ABS shares of industry value added in gross regional product at factor cost. Large

[20] By definition – since the output sectors are defined on the basis of the availability of ABS data on output by commodity. See Section 4.4.4.
[21] See the set descriptions and elements in Appendix A.18.

differences between official statistics and the database would need to be isolated, investigated, and possibly remedied.

Equation *E_x_s* calculates the percentage change in the economy wide output of commodity sector *s* (x_s_s). This is the weighted sum of the percentage change in the regional commodity sector outputs ($x\_sr_{s,r}$). The relevant share weights are given by the share of region *r*'s output of commodity sector *s* in the total economy-wide output of commodity sector *s*.

Equation *E_fx_tot* provides the first of the two possible links between the exogenous determination of regional sectoral outputs, and the regional outputs of the elements of the set COM. Under the standard comparative static closure of the model, the variable $fx\_tot_{i,r}$ is endogenous. This variable does not appear elsewhere in the model, and so its endogenous status renders Equation *E_fx_tot* inoperative. Under the historical closure, one may wish to set certain elements of the set XCOM for region 1 exogenous. To do this, the appropriate elements of the variable $x\_sr_{s,r}$ are set exogenous, and the corresponding elements of shift variable $fx\_sr_{s,r}$ are set endogenous. Equation *E_fx_tot* is then brought into operation by setting exogenous those elements of variable $fx\_tot_{i,r}$ that correspond with the commodities that are subsumed within those sectors whose outputs are being determined exogenously. In order to reconcile the commodity outputs that are now given by Equation *E_fx_tot* with those given by the sum of the demands for the commodity by current producers, capital creators, households, foreigners, and governments, it is necessary to set endogenous some variables relating to the preference for the commodities the output of which is now determined by Equation *E_fx_tot*. Two choices are available: either the source-specific technical change shift terms ($ais_{i,s}$) or the inter-regional sourcing twist variables ($twist\_isbot_i$) can be determined endogenously. Depending on the nature of the commodity, either of these might be chosen. The considerations covering the choice of which of these variables to set endogenous for any given commodity are discussed in Section 4.4.4. Note however that by bringing Equation *E_fx_tot* into operation, the percentage change in the output of each of the elements of COM subsumed within commodity sector *s* will be identical.

An alternative to this approach (and the one used in the simulations undertaken in this thesis) is to allow commodity outputs within a given commodity sector to vary, while simultaneously ensuring that the weighted sum of the percentage changes in these commodity outputs sums to the exogenously specified percentage change in the output of their commodity sector as a whole. An advantage of this approach is that it allows the commodity composition of a given commodity sector to change over time, thereby reflecting some of the model's information on the relative growth prospects of individual commodities within each commodity sector. Equation *E_fi_twist_isbot* (See Section 2.18.2) is used to implement this procedure. Instead of setting $fx\_sr_{s,\text{"A1"}}$ endogenous, the relevant elements of $twist\_is\_s_s$ are set endogenous. Equation *E_fi_twist_isbot* is then brought into operation by swapping the endogenous / exogenous status of the appropriate elements of $twist\_isbot_i$ and $fi\_twist\_isbot_i$. The equation then operates to deliver identical inter-regional sourcing preference twists to each commodity within a given commodity sector. The value of this twist will be such that the weighted sum of the percentage changes in individual commodity outputs within a given commodity sector equals the exogenously specified value for the percentage change in the output of that commodity sector. One of two dampening terms can also be brought into operation. XIS_DAMP1 provides an extra twist in favour of the commodity sourced from region 2 for those commodities that are experiencing strong growth relative to the GSP at factor cost of region 1. Alternatively, XIS_DAMP1 can be set equal to zero, and a value provided to XIS_DAMP2. This provides an extra twist in favour of the commodity sourced from region 2 for those region 1 commodities that are growing strongly relative to the growth in the output of the region 1 commodity sector in which they are classified. In the historical simulations undertaken in Chapter 4, a value of zero has been given to XIS_DAMP1, and a value of 1 has been given to XIS_DAMP2.

Equation *E_fx_total* serves a similar role to that of Equation *E_fx_tot*. However, whereas the latter relates to outputs of regional commodities, the former provides the link between the exogenous determination of sectoral outputs at the national level, and the outputs at the national level of the elements of the set COM. Under the standard comparative static closure of the model, Equation *E_fx_total* is rendered inoperative via the endogenous determination of the variable fx_total_i. This variable only appears in this equation. Under the historical closure, most of the elements of the variable x_s_s are determined exogenously. The corresponding elements of the shift variable fx_s_s are set endogenous. Equation *E_fx_total* is then brought into operation by setting the appropriate[22] elements of fx_total_i exogenous. The shift variable fx_s_s then imparts equal percentage rates of change to the outputs of all those national commodities (x_total_i), for which *i* is classified within sector *s*. The values attained by shift variable fx_s_s are determined by the need for output by commodity (See Equation *E_x_total*) to sum to output by sector (see Equations *E_x_sr* and *E_x_s*).

With fx_total_i in Equation *E_fx_total* exogenous, it is necessary to set endogenous some other variable in the model to ensure that the demands for these commodities, as calculated endogenously by the model, are compatible with the exogenously specified sectoral outputs. This is achieved by setting endogenous the appropriate elements of the commodity-specific technical change shift variable ai_i. This variable operates as a uniform (across sources and users) shift variable in Equations *E_a1isjr*, *E_a2isjr*, *E_a1mar*, *E_a2mar*, *E_a3mar*, *E_a4mar*, *E_a5mar*, *E_a6mar*, and *E_x3_ff_na*. Hence values for the exogenously determined commodity outputs are reconciled with the endogenously determined commodity demands via shifts in commodity *i* using technical change among current producers, capital creators, and in the provision of margin services to facilitate transactions by all users. The variable ai_i also appears in Equation *E_x3_ff_na*. Under the historical closure, this variable allows the percentage change in the household demands for commodity *i* cross-classified with national accounts sector *na* to deviate from the results for national accounts sector *na* (independently of any such deviation given by Equation *E_x3_imputed*). This allows changes in household demands to contribute towards the achievement of exogenous sectoral commodity outputs through changes in the commodity composition of the national accounts consumption categories. These in turn are accommodated by changes in household tastes, which are endogenous under the historical closure (See Section 2.5.2).

Equation *E_fx_total* operates to equalise percentage changes in commodity outputs within each commodity sector. Equation *E_fai* provides an alternative approach, which allows for

[22] That is, those elements relating to those commodities in the set COM that are now effectively being determined exogenously by the exogenous status of certain elements of x_s_s.

the exogenous determination of national sectoral outputs, while also allowing variation in the commodity composition of national sectoral outputs. Under the standard comparative static closure, and under an historical closure in which Equation *E_fx_total* is operational, Equation *E_fai* is inoperative due to the endogenous determination of fai_i. As an alternative to Equation *E_fx_total*, Equation *E_fai* can be brought into operation by setting $shift\_ai_s$ endogenous when national sectoral outputs (x_s_s) are set exogenous. The equation is then brought into operation by swapping the endogenous / exogenous status of the appropriate elements of ai_i and fai_i. With X_DAMP_i set equal to zero, Equation *E_fai* operates to impart identical values to commodity using technical change for all commodities within each exogenous commodity sector. A positive value for X_DAMP_i provides an extra deterioration (improvement) in commodity using technical change for those commodities that are growing slowly (quickly) relative to the output of the commodity sector in which they are classified. It is this equation (rather than Equation *E_fx_total*) that is used in the simulations reported in Chapter 4 of this thesis. The coefficient X_DAMP_i has been given a value of 1 in these simulations.

2.2.8 Neutralisation of the cost impacts of technical change

Changes in commodity *i* using technical change on the part of current producers and capital creators will have implications for the costs of current production and capital creation. Following a similar treatment in MONASH, the potential impact of these technical changes on the costs of these two types of user is neutralised by introducing a second set of technical change shocks. Specifically, regional industry all-input-using technical change is effectively shocked (within the model) so as to ensure that the costs of current production and capital creation are not affected by the commodity using technical change outlined in Section 2.2.7 above. These shocks are calculated within the model by Equations *E_del_f_a1* (relating to current production) and *E_del_f_a2* (relating to capital creation). Under the standard short-run comparative static closure of the model, the variables $del\_f\_a1_{j,r}$ and $del\_f\_a2_{j,r}$ are endogenous, effectively removing these two equations from the model. However, during the historical simulations, the two equations are brought into effect by setting endogenous the all-input-using technical change variables $a\_in1_{j,r}$ and $a\_in2_{j,r}$, and setting exogenous the shift variables $del\_f\_a1_{j,r}$ and $del\_f\_a2_{j,r}$. The percentage change in the all-input-using technical efficiency of *j,r* is then given by the share-weighted difference of the percentage rates of change in the commodity *i* input-using technical changes experienced by j,r. The relevant weights are given by the share of the purchaser's value of the commodities experiencing technical change in the total of those elements of production costs that can be affected by all-input technical change. While all inputs into capital creation are affected by the all-input technical change variable $a\_in2_{j,r}$, this is not the case for current production. As discussed above in reference to Equations *E_xsptax* and *E_xcptax*, the per unit Commonwealth and regional government production taxes are unaffected by all-input using technical change. Hence these two components of total current production costs are explicitly excluded from the denominator in the (implicit) share calculations in Equation *E_del_f_a1*.

2.2.9 Exogenous determination of sectoral employments

Equations *E_emp_s*, *E_fempjr*, *E_empjr*, and *E_ffafac* facilitate the exogenous determination of regional sectoral employments during historical simulations of the model. The first three of these equations implement a similar technique (hereafter "Option 1") for exogenising national sectoral employments to that used in the MONASH model. When operational, these three equations operate to equalise percentage changes in regional industry employments within employment sectors. Equation *E_ffafac* provides an alternative treatment (hereafter "Option 2"), which still allows for the exogenous determination of sectoral employments but while also allowing the industrial composition of employment within each sector to vary. Under the standard comparative static closure of the model, Equation *E_empjr* simply links the variable defining regional industry demands for labour ($x\_prim_{labour,j,r}$) from the core of the CGE model, to the definition of regional industry employments used within this set of equations dealing with the exogenous determination of sectoral employments ($empjr_{j,r}$). Equation *E_emp_s* then calculates the percentage changes in regional sectoral employments ($emp\_s_{s,r}$) as the share-weighted sum of the percentage rates of change in employment in those regional industries subsumed within each regional employment sector. Equation *E_fempjr* is rendered inoperative via the endogenous status of the shift variable $fempjr_{j,r}$. Similarly, Equation *E_ffafac* is rendered inoperative via the endogenous determination of the shift variable $ffafac_{j,r}$.

Under an historical closure, regional sectoral employments ($emp\_s_{s,r}$) are set exogenous, and either the shift variables $femp\_s_{s,r}$ in Equation *E_fempjr* (Option 1) or the shift variables $shift\_afac_{s,r}$ in Equation *E_ffafac* (Option 2), are set endogenous. If the user desires to implement Option 1, then the link between regional sectoral employments and regional industry employments is established by setting exogenous the appropriate elements[23] of the shift variable $fempjr_{j,r}$ and setting endogenous the corresponding elements of the regional industry primary factor technical change shift variables $f\_a\_facjr_{j,r}$. The shift variable $femp\_s_{s,r}$ in Equation *E_fempjr* then imparts equal percentage rates of change to the levels of employment of all regional industries ($empjr_{j,r}$) within a given regional employment sector to ensure, via Equation *E_emp_s*, that the share weighted sum of those regional industry employments is equal to the exogenously specified employment within the regional employment sector to which they are allocated. Equation *E_empjr* simply operates to translate the percentage rates of change thus calculated within this set of equations, to the definition of regional industry employment used within the remainder of the CGE model (that is, $x\_prim_{labour,j,r}$).

If the model user desires to implement Option 2, then Equation *E_ffafac* is brought into operation in the place of Equation *E_fempjr*. This is achieved by setting the appropriate elements of $ffafac_{j,r}$ exogenous, and setting endogenous the corresponding elements of $f\_a\_facjr_{j,r}$. This equation then operates to impart identical shifts in primary factor productivity to all industries within a given employment sector, such that the share weighted sum of industry employments within that sector equals the exogenously specified value for such given by *Equation E_emp_s*. I prefer this approach to Option 1, since it allows the industrial composition of employment within each sector to vary in response to the differing prospects of each regional industry, while still ensuring that the exogenous regional sectoral employment targets are met. In the simulations reported in Chapter 4 of this thesis, it is Option 2 that is operational.

[23] The Dwellings industry does not employ labour. Hence it is excluded from this swap. Otherwise, employment in all other industries is determined via the exogenous determination of regional sectoral employments.

The shift variables $f\_lr\_emp_r$ in Equation *E_emp_s* allow for region-specific shocks to regional industry employments in addition to those provided by the exogenous determination of regional sectoral employments via $empjr_{j,r}$. During a simulation, the percentage changes in regional employments (lr_emp_r) that will be calculated by the model given the exogenous determination of regional sectoral employment ($emp\_s_{s,r}$) may deviate from official figures for the percentage changes in total regional employments for the period as given by the ABS[24]. To ensure that the percentage rate of change in total regional employment is equal to that provided by the ABS, one final swap is instituted in this set of equations. First, employment for region one (lr_emp_1) is set exogenous, and the shift variable $f\_lr\_emp_1$ in Equation *E_emp_s* is set endogenous. Next, national employment (*l_emp*), is set exogenous, and the shift variable for the remaining region ($f\_lr\_emp_2$) is set endogenous. The shift variables $f\_lr\_emp_r$ then effectively impart uniform shifts to all sectoral labour demands within region *r*. These uniform shifts ensure that the weighted sum of the percentage changes in regional industry employments is equal to the exogenously specified percentage rates of change in aggregate employment for region one and the nation as a whole. The values attained by $f\_lr\_emp_r$ should be inspected after each simulation to ensure they are not overly large.

2.2.10 Exogenous determination of primary factor and intermediate input using technical change.

Equations *E_a1isjr* and *E_a_fac* make intermediate input using and primary factor using technical change endogenous to the model. Equation *E_a1isjr* simply makes the percentage rate of change in source-specific intermediate input using technical change by regional industry *j,r* a function of a number of shift variables. Similarly, Equation *E_a_fac* writes the percentage change in factor-specific technical change experienced by regional industry *j,r* as the sum of the percentage rates of change of a number of shift variables.

[24] In the model, aggregate regional employment is calculated from regional industry employments using regional industry wage bill weights. The (implicit) corresponding shares used by the ABS are person weights.

2.3 ZERO PURE PROFIT CONDITIONS AND THE PRICE SYSTEM

2.3.1 Introduction

The FEDERAL-F model recognises a number of production and trading activities, each of which is assumed to be undertaken under conditions of perfect competition. Hence the agents undertaking each of these activities are assumed to earn zero pure profits. Any profits that are earned are treated as a cost of production. These profits accrue as rentals on capital and land, and as the phantom taxes (if any) that might be associated with a given transaction. A second assumption (in addition to that of perfect competition) underpinning the price system is that basic prices[25] do not vary across users. Both assumptions are standard in Australian CGE models.

The activities over which the zero pure profits assumption presides are: current production (Equation *E_zact*), the provision of intermediate inputs to current producers in each region (Equations *E_p1A* and *E_ p1B*), the provision of inputs to capital creators in each region (Equations *E_p2A* and *E_ p2B*), the provision of goods to households in each region (Equations *E_ E_p3A* and *E_ p3B*), the provision of goods for current consumption to each regional government (Equations *E_p_sgov1* and *E_p_sgov2*), the provision of goods for current consumption to the Commonwealth Government (Equations *E_p_cgovA* and *E_p_cgovB*) exporting (Equation *E_prexp*), the construction of units of capital (Equation *E_pi*), and importing (Equation *E_p_basic_3*). Each of these sets of equations is discussed in turn below. A final set of price equations relate the prices of certain composite commodities and the user price of primary factors to their various cost components. These too are discussed below.

Variables describing both normal and phantom tax terms appear in many of the price equations in this section. Normal taxes are expressed in the original FEDERAL manner - that is, as percentage rates of change in the per unit tax payable. This is not a satisfactory way of treating phantom taxes however. During historical simulations, these taxes are very often determined endogenously in order to determine individual purchaser's prices (or price indices composed thereof) exogenously. With very few exceptions, the phantom

[25] Basic prices for Australian produced goods are the prices received by the producers of those goods. Basic prices for imports are equal to the prices received by importers - that is, the landed duty paid price.

taxes are a very small share of the purchaser's price, so that the exogenous determination of purchaser's prices can imply very large percentage changes in the per-unit values of these taxes. These percentage changes are too large for the solution method to handle within a manageable number of steps. This is particularly apparent when the closure is reversed in the decomposition closure (See Chapter 4) and the phantom taxes are shocked by the values that they attained in the historical closure. Shocking the per-unit phantom taxes in this way, the percentage changes in these taxes are too large for the solution method to satisfactorily reproduce the original (historical) solution. This is not an issue when the phantom taxes are operationalised in the price equations as powers of the relevant tax rates (ie. as 1 plus the rate of the tax). This is because the percentage rates of change in these variables are quite small, even when they involve very large implicit percentage changes in the value of the per unit phantom tax. Regional and Commonwealth Government sales taxes could also have been implemented as powers of the relevant tax. However there was little advantage in doing this, since the percentage changes in these taxes are relatively small, and are not reduced to zero in any of the simulations that have been undertaken in this thesis. Hence these taxes retain their original FEDERAL model expression as per-unit taxes.

2.3.2 Zero pure profits in production

Equation *E_zact* is based on FEDERAL Equation 33 (Madden 1990), and equates the total revenue earned by regional industry *j,r* to the total costs of generating that revenue. Starting with the left hand side of this equation, the coefficient $H\_REV_{i,j,r}$ is the share of regional industry *j,r*'s revenue accounted for by sales of commodity *i*. Since all industries in the present implementation of FEDERAL-F are unique product industries, the entries in $H\_REV_{i,j,r}$ are 0 for $i \neq j$, and 1 otherwise. The right hand side of the equation accounts for the various elements of the production costs of regional industry *j,r*, and the technical change terms that operate upon them. The coefficients are cost shares for the various inputs. Hence, in the absence of technical change, the right hand side of this equation defines the percentage change in the per unit cost of production for regional industry *j,r* as the share-weighted sum of the percentage changes in the costs of *j,r*'s inputs to current production. A unit change in all input using technical change ($a\_in1_{j,r}$) raises or lowers the costs of production for regional industry j,r by the share of non-production tax[26] costs in total costs. Similarly, a unit change in primary factor technical change ($a\_fac_{v,j,r}$) raises or lowers the costs of production for a particular regional industry by the share of the primary factor experiencing the technical change in the total costs of that regional industry (given by the coefficient $H\_FAC_{v,j,r}$).

It is worth noting that as a zero pure profit condition applying to current production by regional industries, Equation *E_zact* covers j x r equations. Together with Equations *E_pbasicNMAR* and *E_pbasicMAR*, these three sets of equations determine, respectively, regional industry activity levels, and the basic prices of Australian sourced non margin and margin commodities.

2.3.3 Zero pure profits in the provision of intermediate inputs to current producers.

Equations *E_p1A* and *E_p1B* determine the purchaser's price of source-specific inputs to current production. Both equations are based on FEDERAL Equation 42. Equation *E_p1A* determines the purchaser's price of domestically sourced goods, while Equation *E_p1B* relates to foreign sourced goods. It is convenient to identify two sets of equations in this way (one relating to domestic goods and one relating to foreign goods) because of the possibility in FEDERAL-F of phantom taxes accruing on purchases of domestic goods[27]. Hence Equation *E_p1B* (defining the purchaser's price of imported goods) does not include a phantom tax term. Together, these equations relate the purchaser's price for intermediate inputs, by source, to the basic prices for those inputs, and the margins, sales taxes, and phantom taxes (if any) associated with the provision of those inputs to current producers. Because the equations defining purchaser's prices for inputs to current production and purchases by each of the five types of final demand have very similar forms, it is worth pausing here to consider a brief example. Suppressing commodity, source, region, and user subscripts, the purchaser's price ($P^{(*)}$) of a domestic commodity sold to a particular user can be written:

$$P^{(*)} = P^{(0)}H + \sum_{u} M_u + \sum_{g} T_g \qquad \text{(E.2.3.1)}$$

[26] Production taxes are not affected by all input using technical change. See Section 2.2.4.
[27] See Section 2.17.

where $P^{(0)}$ is the basic price, M_u is margin type u, T_g is the per unit tax levied by government g, and H is the power of the phantom tax, defined as $H = 1 + \frac{F}{P^{(0)}}$, where F is the per unit value of the phantom tax. The (intermediate) linearised form of (E.2.3.1) is

$$P^{(*)} p^{(*)} = P^{(0)} H\left(p^{(0)} + h\right) + \sum_u M_u m_u + \sum_g T_g t_g \qquad \text{(E.2.3.2)}$$

The general form of Equation (E.2.3.2) will be readily apparent in Equations *E_p1A*, *E_p2A*, *E_p3A*, *E_p_rexp*, *E_p_sgovA*, *E_p_cgovA*, which define purchaser's prices for domestically sourced goods.

Phantom taxes do not accrue on foreign sourced goods, so that in the original levels expression, the purchaser's price equations for such goods have the form:

$$P^{(*)} = P^{(0)} + \sum_u M_u + \sum_g T_g \qquad \text{(E.2.3.3)}$$

The linearised expression of which is:

$$P^{(*)} p^{(*)} = P^{(0)} p^{(0)} + \sum_u M_u m_u + \sum_g T_g t_g \qquad \text{(E.2.3.4)}$$

Again, the general form of Equation (E.2.3.4) will be readily apparent in Equations *E_p1B*, *E_p2B*, *E_p3B*, *E_p_sgovB*, and *E_p_cgovB*, which define purchaser's prices for foreign sourced goods.

2.3.4 Zero pure profits in the provision of inputs to capital creators.

Equations *E_p2A* and *E_p2B* determine the purchaser's price of inputs to capital creation, regardless of the source of those inputs. Like Equations *E_p1A* and *E_p1B*, both equations are based on FEDERAL Equation 42[28]. Equation *E_p2A* determines the purchaser's price to

[28] Equation 42 in Madden (1990) covers two purposes: current production and capital formation.

capital creators of domestically sourced goods, while Equation *E_p2B* relates to foreign sourced goods. Again, two sets of equations are identified in this way (one relating to domestic goods and one relating to foreign goods) because of the possibility in FEDERAL-F of phantom taxes accruing on purchases of domestic goods[29]. Again, like Equation *E_p1B*, Equation *E_p2B* does not include a phantom tax term. Together, these equations relate the purchaser's price for inputs to capital creation, by source, to the basic prices for those inputs, and the margins, sales taxes, and phantom taxes (if any) associated with the provision of those inputs to capital creators.

Note that, as in the original Equation 42, there is no explicit subscript on the regional government tax terms appearing in the zero pure profit equations relating to either intermediate input purchasers, or purchasers of inputs for capital creation. The assumption underlying this is that regional governments can levy sales taxes only on sales occurring within their own region. Hence a subscript denoting the regional government levying the tax is not required on the tax terms ($g\_sint_{i,s,j,r,k}$) since knowledge of the location of the agent making the purchase (r) is sufficient for this purpose. In the original Equation 42, no regional subscript appears on the Commonwealth Government sales tax terms because per unit Commonwealth sales taxes were assumed to be identical across regions (Madden 1990). For the GST simulations undertaken in Chapter 5 however, a regional dimension to the Commonwealth taxes was required, and this now appears on the Commonwealth tax terms throughout the price equations.

2.3.5 Zero pure profits in the supply of goods to regional households.

Equations *E_p3A* and *E_p3B* determine the purchaser's price faced by regional households for source-specific commodities from domestic and foreign sources respectively. The general form of these equations is little changed from Equation 43 in the FEDERAL model, from which they are derived. The important difference between the two equations is the possibility in FEDERAL-F for phantom taxes[30] to accrue on purchases of domestically sourced goods by regional households. Since these taxes only accrue on domestically sourced goods, they do not appear in Equation *E_p3B*, which relates to foreign sourced goods only. The possible presence of phantom taxes on domestically sourced purchases

[29] See Section 2.17.
[30] See Section 2.17.

also explains why two separate equations are identified - one for domestic sources and one for the foreign source - rather than continued use being made of the single Equation 43, which covered both sources in the original FEDERAL model.

2.3.6 Zero pure profits in exporting

Equation *E_p_rexp* equates the Australian dollar f.o.b export price of commodity *i* from region *r* to the basic price of that commodity and the genuine taxes, margins, and phantom taxes associated with delivering the commodity to the port of exit. Equation *E_p_rexp* is little changed from FEDERAL Equation 40, from which it has been derived. The important difference between the two equations is the possibility in FEDERAL-F for phantom taxes to accrue on sales to foreigners.

2.3.7 Zero pure profits in the provision of goods to regional governments for current consumption

Equations *E_p_sgovA* and *E_p_sgovB* provide for zero pure profits to be earned in the provision to regional governments of, respectively, domestic and foreign sourced goods, for current consumption. The form of these two equations is closely related to FEDERAL Equation 44 on which they are based. The important difference between Equations *E_p_sgovA* and *E_p_sgovB* and Equation 44 lies in the possibility of phantom taxes accruing on the provision of domestically produced goods to regional governments.

2.3.8 Zero pure profits in the provision of goods to the Commonwealth Government for current consumption

Equations *E_p_cgovA* and *E_p_cgovB* provide for zero pure profits in the provision of source-specific commodities to the Commonwealth Government for the purpose of current consumption. These two equations essentially provide for the separate modelling of the Commonwealth's purchaser price for domestic sourced (*E_p_cgovA*) and foreign sourced (*E_p_cgovB*) commodities. In the original FEDERAL model, these two price equations are subsumed by Equation 46. The need to distinguish domestic and foreign sources separately in the FEDERAL-F model arises from the possibility that phantom taxes may accrue on goods sourced domestically by the Commonwealth Government.

2.3.9 Zero pure profits in the construction of capital.

The Equations 35, 36, and 37 in FEDERAL are subsumed by FEDERAL-F Equation *E_pi*. The original FEDERAL model recognised the possibility of different input cost structures for different classes of investors (private, regional government and Commonwealth). This required three sets of zero pure profit equations - one each for private, regional governments, and Commonwealth investors. This detail has been suppressed in the FEDERAL-F model. The cost of constructing a unit of capital in a given industry no longer differs across classes of investor. These costs continue, however, to differ across regions and industries. Hence Equation *E_pi* provides for zero pure profits in the construction of a unit of capital in regional industry *j,r*, regardless of the type of agent financing the capital creation. The price of constructing a unit of capital in regional industry *j,r* ($pi_{j,r}$) is the weighted sum of the purchaser's prices of the inputs to capital creation for that regional industry.

2.3.10 Zero pure profits in importing

Equation *E_p_basic3* determines the percentage change in the basic price of commodity *i* from overseas. This equation is unchanged from the original FEDERAL Equation 38. The percentage change in the basic price of imported commodity *i* is the share-weighted sum of the percentage changes in the foreign c.i.f price converted to Australian dollars, and the per unit duty payable. The coefficient $TARF_i$ is the share of the ex-duty value of commodity *i* in the landed duty paid value of commodity *i*. The expression for the nominal exchange rate in FEDERAL-F is the same as that in FEDERAL: *x_rate* is the percentage change in the number of Australian dollars per foreign currency unit. Hence a nominal devaluation of 10% would require *x_rate* = 10. In the absence of changes in the foreign currency prices of imports, and in the presence of a 10 per cent increase in the per-unit tariff payable (g_tar_i =10), this would result in an increase in the basic price of foreign sourced commodities ($p\_basic_{i,RoW}$) of 10 per cent.

2.3.11 Price of labour faced by regional industry *j,r*

Equation *E_pprimL* defines the percentage change in the price of effective units of labour faced by regional industry *j,r* as the share weighted sum of the percentage changes in the prices of the labour of various skill types that are used by the regional industry. This equation is little changed from the original FEDERAL Equation 7, from which it is derived. The only (trivial) difference between the two equations is the omission from Equation *E_pprimL* of the variables relating to specific skill augmenting technical change, by regional industry, which are present in Equation 7. These variables are not used in any of the simulations that are undertaken in this thesis, and so have been omitted from the model.

2.3.12 Prices of composite commodities consumed by regional households

Equation *E_p3* determines the percentage change in the price of effective units of commodity *i* consumed by household *r* as the share weighted sum of the percentage changes in the price of commodity *i* consumed by regional household *r* from all three sources, *s*. This equation is unchanged from Equation 17 in the original FEDERAL model.

2.3.13 Prices of agricultural land to using industries

Equation *E_p_land* defines the percentage change in the price of land to individual agricultural industries in region *r* as the share weighted sum of the percentage change in the net rental received by the owners of that land ($p\_land_{j,r}$) and the percentage change in the Commonwealth income tax payable out of the user-price of that land ($p\_landtx_{j,r}$). With the gross rental price of land determined by the market clearing equation for land (Equation *E_pprimN*) and the income tax payable on land rentals being determined by Equation *E_p_landtx*, Equation *E_p_land* can be thought of as determining the net rental received by owners of land ($p\_land_{j,r}$) as the residual of the gross rental and the income tax payable on that rental.

2.3.14 The price of working capital

The percentage change in the price of working capital (*pcost*) is indexed to the percentage change in the national household consumption deflator via Equation *E_pcost*.

2.4 MARKET CLEARING CONDITIONS

2.4.1 Introduction

The equations in Section 3 of Appendix A equate demand and supply in the five types of markets that are recognised in FEDERAL-F: the market for domestically produced commodities; the regional markets for labour of each occupational type; the regional industry markets for capital and land; and the national market for working capital.

2.4.2 Market clearing for domestically produced commodities

Equations *E_p_basicNMAR* and *E_p_basicMAR* equate the demand and supply for domestically produced non-margin and margin commodities respectively. These two equations are essentially unchanged from FEDERAL Equation 64. Equation *E_p_basicMAR* equates the percentage change in the domestic supply of margin commodity i from region s ($x\_tot_{i,s}$), to the sales-share weighted sum of the percentage changes in the demands for good i from region s. Since margin commodity i can be used for both margin and non-margin purposes, both margin and non-margin demands appear on the RHS of *E_p_basicNMAR*. Hence, the percentage change in domestic supply of margin commodity i,s is equal to the sales share weighted sum of the percentage changes in: regional industry intermediate input demands for i,s ($x1_{i,s,j,r}$); regional industry demands for i,s for capital formation ($x2_{i,s,j,r}$); regional household demands for i,s ($xr\_hous_{i,s,r}$); exports of i,s ($xr\_exp_{i,s}$); demands for i,s by regional government r for current consumption, ($x\_sg_{i,s,r}$); demands for i,s by the Commonwealth Government for current consumption purposes, ($x\_cg_{i,s}$); demands for i,s for use as a margin on purchases of u from t for current production purposes by regional industry j,r ($x\_mar1_{i,s,u,t,j,r}$); demands for i,s for use as a margin on purchases of u from t for capital formation by regional industry j,r ($x\_mar2_{i,s,u,t,j,r}$); demands for i,s for use as a margin on purchases of u from t for current consumption by household r, ($x\_mar3_{i,s,u,t,r}$); demands for i,s for use as a margin on purchases of u from t for current consumption by regional government r ($x\_mar5_{i,s,u,t,r}$); demands for i,s for use as a margin on exports of u from t, ($x\_mar4_{i,s,u,t}$); and, demands for i,s for use as a margin on Commonwealth Government current consumption purchases of u from t ($x\_mar6_{i,s,u,t}$). Equation *E_p_basicNMAR* has essentially the same structure as

Equation *E_p_basicMAR*. Clearly, however, since (by definition) non-margin commodities are not used to provide margin services, the margin demands that appear on the RHS of *E_p_basicMAR* are not present in Equation *E_p_basicNMAR*.

2.4.3 Market clearing for physical capital and agricultural land

Equation *E_pprimK* is the market clearing condition for regional industry capital stocks. This equation is unchanged from the original FEDERAL model Equation 67. As in the original FEDERAL model, the markets for physical capital, and hence the market clearing conditions for physical capital, are specific to each industry within each region. That is, once installed, physical capital is assumed to be immobile both between industries and between regions. The modelling of the market clearing condition for agricultural land (Equation *E_pprimN*) is identical to that for physical capital. That is, agricultural land is specific to the agricultural industries in the set AGG, and is immobile between regions. This treatment is also unchanged from the original FEDERAL model Equation 68. However this is a more limiting assumption in the current implementation of FEDERAL-F than it was in the original FEDERAL model. This is because the theory of the present model currently allows only for unique-product industries. The FEDERAL model allowed for multi-product industries, with a view particularly towards the existence of such among the agricultural industries. Hence, while agricultural land might be specific to a particular agricultural industry under the FEDERAL model, it could nevertheless be mobile across the commodities produced by that industry (Madden 1990). In the FEDERAL-F model, an expansion in the number of agricultural commodities (beyond the current single "1. *Rural*" aggregate in the Tasmania/Mainland implementation) would require a corresponding expansion in the number of agricultural industries, each of which would be endowed with a specific and immobile stock of agricultural land via Equation *E_pprimN*. This would be unlikely to be a satisfactory treatment of the agricultural industry. Depending on the nature of the experiments undertaken, it may be appropriate to introduce the FEDERAL multi-product theory into FEDERAL-F at a later date.

Equations *E_n_aglandA* and *E_n_aglandNA* determine the supply of agricultural land to regional industries. The supply of agricultural land to regional industries within the set AGG is determined by Equation *E_n_aglandA* as the share weighted sum of the percentage changes in the supply of land to each regional industry by each class of land owner,

$on\_agland_{t,j,r}$. The share weights in this equation are given by the share of the gross rental on agricultural land in agricultural industry *j,r* accruing to owner class *t*. Equation *E_n_aglandNA* fixes the percentage change in the supply of agricultural land to non agricultural industries at zero.

2.4.4 Regional market clearing conditions for labour of each occupational type

Equation *E_lrm_emp* calculates the percentage change in the demand for labour of skill type *m*, within region *r*, as the wage bill share weighted sum of the percentage changes in regional industry demands for labour of skill type *m*. This equation is unchanged from Equation 66 in the FEDERAL model. As Madden (1990) notes, this equation can operate to either determine real wages for labour of a particular occupational class via the imposition a supply side constraint on the supply of that type of labour (through the exogenous determination of $lrm\_emp_{m,r}$), or, determine the aggregate demand within region *r* for labour of occupation *m* via the exogenous determination of the real wage for that type of labour within that region.

2.4.5 Market clearing condition for working capital

Equation *E_f_oxcost_1* equates the aggregate supply of working capital by the various owner types to the aggregate demand for working capital across all regional industries. The supply of working capital by owner type *t* ($oxcost_t$) is determined by the shift variable f_oxcost_t in Equation *E_oxcost*. The percentage change in the price of working capital is indexed to the percentage change in the household consumption deflator via Equation *E_pcost* (see Section 2.3.14). In the standard short-run comparative static closure of the model, f_oxcost_t is exogenous for t = 2-5. That is, the supply of working capital by all owner types other than foreigners is determined exogenously. Hence, the aggregate supply of working capital is equated to the aggregate demand for working capital in Equation *E_f_oxcost_1* via adjustments to the supply of working capital by foreign owners of working capital (f_oxcost_1).

2.5. HOUSEHOLD INCOME, CONSUMPTION, SAVINGS, AND CAPITAL OWNERSHIP

2.5.1 Household demands for commodities

The utility maximisation problem facing consumers in FEDERAL-F is unchanged from that in FEDERAL. Each regional consumer is assumed to face a two-step maximisation problem. First, the representative household in each region is assumed to allocate their budget across the consumption of effective units of each commodity type so as to maximise a Klein and Rubin (1948-49) or Stone - Geary (Stone (1954) and Geary (1950-51)) utility function. Second, the representative household in each region is assumed to minimise the cost of assembling effective units of each commodity type by substituting between alternative sources of that commodity type, subject to a CRESH production technology.

The first of these maximisation problems gives rise to Equations *E_x_hous*[31]. The taste change terms appearing in this equation are simplified (there are no explicit terms in this equation describing changes in marginal budget shares and subsistence levels of expenditure) following Dixon and Rimmer (1999a). They show that both (i) describing the percentage rates of change in the marginal budget shares by Equation *E_deltapc*, and (ii) assuming that the percentage rate of change in the subsistence level of consumption by household r of commodity i can be described by $a3_{i,r} - ave\_a3_r$ (which gives rise to Equation *E_d_gamma*), allows the taste change terms that would otherwise appear in Equation *E_x_hous* to simplify to $a3_{i,r} - ave\_a3_r$. Equations *E_d_gamma* and *E_deltapc* calculate, respectively, the change in the regional household r's subsistence level of consumption of i and the percentage change in the marginal budget share for i[32]. These variables are used to update the parameters of the linear expenditure system in multi-step and year-on-year simulations. The cost minimisation problem of assembling effective units of each commodity type gives rise to Equations *E_xr_housA* and *E_xr_housB*. These two equations have the same basic form as FEDERAL Equation 16 (Madden 1990). The important difference between Equations *E_xr_housA* and *E_xr_housB* and Equation 16 is

[31] See Dixon, Bowles and Kendrick (1980), and Dixon and Rimmer (1999a) for the derivation of this equation.
[32] See Dixon and Rimmer (1999a) for the derivation of these equations.

the addition to the former equations of the import / domestic and inter-regional twist terms. These twist terms are described in Section 2.18.

2.5.2 Exogenous determination of consumption by national accounts commodity classification

During historical simulations of the model, we may wish to impose exogenously on the model ABS data on changes in household consumption by commodity. The commodity classification system used by the ABS differs from that used in FEDERAL-F, requiring that equations be added to the model which provide a mapping between the two commodity classifications. The developers of the MONASH model have faced the same problem, and the procedures that they have developed to make use of ABS consumption data in historical simulations[33] are adopted in FEDERAL-F. These procedures are embodied in Equations *E_x3ncom*, *E_x3_na_i*, *E_x3_imputed*, *E_x3_ff_na*, and *E_a3shift*, which are described below.

Equation *E_x3_ff_na* calculates the percentage change in household *r*'s consumption of FEDERAL-F commodity *i* classified within national accounts commodity *na*. The right hand side of Equation *E_x3_ff_na* distinguishes a number of determinants of the consumption of cross-classified commodity *i/na* by household *r*. The variable $x3\_imputed_{i,r}$ measures that part of the percentage change in regional household *r*'s consumption of commodity *i* that is attributable to factors other than taste changes. This variable is calculated by Equation *E_x3_imputed*, which has the same general form as Equation *E_xhous* (less the taste change terms). The variable $a3ncom_{na,r}$ is a shift variable operating on the national accounts commodity classification. Under a standard short-run comparative static closure of the model, this variable is exogenous. The variable $a3shift_{i,r}$ is a shift variable, which is endogenous in the comparative static closure. Under this closure, this variable can be thought of as being determined by Equation *E_a3shift*, to ensure that the values for $x3\_na\_i_{i,r}$ produced by Equation *E_x3_na_i* equal the values of the corresponding elements of $x\_hous_{i,r}$. The variable ai_i measures economy-wide technical change in the usage of commodity *i*.

[33] See Dixon and Rimmer (1999a)

Equations *E_x3ncom* and *E_x3_na_i* translate the cross classified household consumption variables $x3\_ff\_na_{i,na,r}$ into consumption of national accounts commodities by region ($x3ncom_{na,r}$) and consumption of FEDERAL-F commodities by region ($x3\_na\_i_{i,r}$) respectively. Equation *E_x3ncom* calculates the percentage change in regional household *r*'s consumption of national accounts commodity *na*, as the share-weighted sum of the percentage changes in consumption of FEDERAL-F commodity *i* classified within national accounts commodity *na*. The relevant share weights are those of the purchaser's value of FEDERAL-F commodity *i* classified within national accounts commodity *na*. Equations *E_x3_na_i* calculates the percentage change in regional household *r*'s consumption of FEDERAL-F commodity *i*, as the share-weighted sum of the percentage changes in consumption of national accounts commodity *na* classified within FEDERAL-F commodity *i*. The relevant share weights are those of the purchaser's value of national accounts commodity *na* classified within FEDERAL-F commodity *i*. The share coefficients in each of these equations are ultimately derived from the corresponding MONASH model coefficients that map expenditure by MONASH model consumption categories and expenditure by national accounts consumption categories. Such a mapping matrix was calculated for FEDERAL-F by aggregating (in the dimension *i*) the MONASH coefficient $MM_{i,na}$ from the 104 MONASH commodities to the 37 FEDERAL-F commodities (See Section 3.1.6.4). The variable f_x3r_r is a shift variable that is useful in historical simulations in which both consumption by household consumption sector, and aggregate consumption by region, are determined exogenously. With these variables endogenous, the weighted-sum of the percentage changes in consumption by consumption sector is able to depart from the percentage change in economy-wide real consumption.

Equation *E_a3shift* provides the link between the consumption of good *i* by region *r* as calculated by the core FEDERAL-F consumption theory, and that as calculated by Equations *E_x3ncom*, *E_x3_na_i*, *E_x3_imputed*, and *E_x3_ff_na*. Under the standard short-run comparative static closure of the model, Equation *E_x_hous* determines the percentage change in region *r* household consumption of commodity *i* as a function of household expenditure, household numbers, prices, and taste changes (including sourcing twists). With $x3\_na\_i_{i,r}$ determined by Equation *E_x3_na_i*, Equation *E_a3shift* determines $a3shift_{i,r}$ under the standard comparative static closure.

Under the standard comparative-static short-run closure of the model, the Equations *E_x3_ff_na*, *E_x3_imputed*, *E_a3shift*, *E_x3_na_i*, and *E_x3nom*, serve only to calculate results for consumption of national accounts commodities by region ($x3ncom_{na,r}$), consumption of cross-classified commodities by region ($x3\_ff\_na_{i,na,r}$), household *r*'s commodity demand as influenced by factors other than technical change ($x3\_imputed_{i,r}$), and the shift term $a3shift_{i,r}$. These variables do not appear elsewhere in the model, and so exert no influence on the model solution under this closure. However, under historical simulations of the model, we may wish to ensure that the results for household consumption by commodity reconcile with the values for consumption by national accounts consumption categories as are available from the ABS. To achieve this, the variables $x3ncom_{na,r}$ in Equation *E_x3ncom* are determined exogenously, and the variables $a3ncom_{na,r}$ are determined endogenously. The variables $a3shift_{i,r}$ are switched to exogenous, and the household taste variables, $a3_{i,r}$ are determined endogenously by switching the appropriate elements of *f_a3_kr* in Equation *E_a3* to endogenous. The latter switch is undertaken for all commodities other than Residential Building Construction (which makes no sales to households), and Ownership of Dwellings (which sells only to households, but has a fixed short-run output due to the fixity of capital). With household consumption constrained at the commodity level, it is necessary to break the particular macroeconomic link that is determining regional household consumption. This is achieved by setting exogenous the variable ave_a3_r, and setting endogenous the relevant indexing variable (for example, f_apc_r in Equation *E_cnr*) determining regional consumption.

2.5.3 Household disposable income

Equation *E_n_dinc* calculates the percentage change in the nominal disposable income of the residents of region *r* (n_dinc_r) as the share weighted difference between the percentage changes in their nominal gross income (n_ginc_r) and their payments of direct taxes ($dtax_r$). Equation *E_n_dinc* is essentially the same equation as FEDERAL Equation 125, although expressed in "intermediate", rather than percentage change form.

The percentage change in the nominal gross income of the residents of region *r* (n_ginc_r) is provided by Equation *E_n_ginc*. This equation replaces Equation 126 in the original

FEDERAL model. The nominal gross income of the residents of region r is given by the sum of their pre-tax wages, their rental receipts from both physical and working capital leased to industry, their receipts from phantom taxes (if any), their net receipts of other foreign income, and either their net returns on net foreign assets or net interest payments on their net foreign debts. Equation *E_n_ginc* expresses the percentage change form of this relationship. The three main differences between Equation *E_n_ginc* and FEDERAL Equation 126 is in the calculation of the rental receipts ($p\_r\_grossrent_r$) by residents in region r (See Section 2.5.4), the addition of receipts from phantom taxes ($p\_houshphant_r$) (See Section 2.17.5), the addition of net returns (payments) on foreign assets (liabilities) ($net\_f\_int\_dc_r$) (See Section 2.5.8.1), and the addition of other net household foreign income (ex_hhnfi_r). This latter item (ex_hhnfi_r) is determined exogenously. Hence two net foreign household income sources are identified in the model: an exogenous component (*ex_hhnfi*) and a second component (*net_f_int_dc*) that is a function of the stock of net foreign household assets as recorded in the database. The variable $net\_f\_int\_dc_r$ is typically determined endogenously under all closures of the model. The variable *ex_hhnfi* is exogenous under the standard closure of the model. However, during historical simulations, *ex_hhnfi* can be determined endogenously in order to allow for the exogenous determination of household gross savings. This is the chief reason for distinguishing an endogenous and an exogenous component of household net foreign income.

Equation *E_dtax* calculates the percentage change in the net of direct taxes paid and transfer payments received by households in region r ($dtax_r$). This equation serves the same function as Equation 127 in FEDERAL. The percentage change in the net of direct taxes paid and transfer payments received by the residents of region r is given by the share weighted sum of the percentage changes in payments of capital taxes ($p\_r\_kaptax_r$), payments of PAYE taxes ($b41r_r$), payments of state government fees and fines ($b34r_r$), payments of other Commonwealth Government receipts (*b47*), payments of other regional government receipts ($b38r_r$), less gross receipts of unemployment benefits ($punb$ + x_unemp_r), less other Commonwealth Government transfers ($t62_r$), less regional government transfers to persons ($t51_r$). The important difference between Equation *E_dtax* and FEDERAL Equation (127) is in the treatment of payments of taxes on capital and land rentals. The determination of such tax payments is discussed in detail in Section 2.5.5.

2.5.4 Household gross capital rentals

To account for returns to capital and land accruing to residents of either region from capital and land located in either region, we start by calculating the nominal gross income accruing from capital and land to the *base-period* population of each region:

$$D_k^{K,\ell} = \sum_j \sum_t \left(V_{jt,k}^1 + V_{jt,k}^2 + V_{jt,k}^3\right) + \sum_j \sum_t \left(W_{jt,k}^1 + W_{jt,k}^2\right) \qquad \text{(E2.5.1)}$$

Where $V_{jt,k}^1$, $V_{jt,k}^2$ and $V_{jt,k}^3$ are, respectively, the net capital rentals, income tax on capital, and residential land tax on regional industry *j,t* capital, associated with owners initially resident in region *k*. The coefficients $W_{jt,k}^1$ and $W_{jt,k}^2$ are the net land rentals and land tax associated with owners initially resident in region *k*. $D_k^{(K,\ell)}$ is the gross returns from capital and land accruing to household type *k*; that is, households resident in region *k* in the base period.

Underlying Equation E2.5.1 is an assumption that there are *k* household types, which differ in their ownership of capital, and are each distinguished by the region (*k*) in which they resided in the benchmark year[34]. As the model is simulated, these residents move between the regions, but they retain the pattern and level of the capital ownership of the residents of their original region *k*. All other factors determining their disposable income (their labour market prospects, direct taxes payable on non capital and land income, government transfers, etc), are determined by the region in which they reside, rather than the region in which they initially resided. Essentially, this ensures that inter-regional migrants "carry" their capital ownership claims with them. Households moving to a new region do not suddenly acquire the capital ownership profile of their host region, but retain their original capital. This can be contrasted, say, with the treatment of post-migration capital ownership in the FEDERAL and MMRF models. In the long-run closure of the FEDERAL model, inter-regional migration is typically determined via an assumption of fixed long-run numbers of unemployed persons residing in each region. People that move between regions in

[34] In the simulations reported in Chapters 4 -6, that year is 1992/93 - the year to which the starting database pertains.

FEDERAL not only acquire the same pattern of capital ownership as the residents of the region into which they move, but they do not carry their capital claims with them. The result of the latter is a decrease in per-capita rental receipts in regions experiencing inter-regional immigration, and an increase in per-capita rental receipts in regions experiencing inter-regional emigration. This also occurs in the long-run closure of MMRF, since this model simply links regional household receipts from non-wage primary factor income to the regional aggregate gross operating surplus (Peter et al. 1996).

In FEDERAL-F, the capital returns accruing to the residents of either region in post-simulation periods will equal:

$$\mathrm{D}_{r}^{(K,\ell)*} = \sum_{k \in REG} \mathrm{S}_{k,r} \mathrm{D}_{k}^{(k,\ell)} \qquad \text{(E2.5.2)}$$

Where:

$\mathrm{D}_{r}^{(K,\ell)*}$: Gross land and capital rentals accruing to households currently resident in region r;

$\mathrm{S}_{k,r}$: The proportion of household type k currently resident in region r;

$\mathrm{D}_{k}^{(k,\ell)}$: Gross land and capital rentals accruing to household type k.

Converting equations (E2.5.1) and (E2.5.2) to percentage rate of change form provides:

$$\begin{aligned}\mathrm{D}_{k}^{(K,\ell)} d_{k}^{(K,\ell)} = & \sum_{j}\sum_{r} \mathrm{D}_{k\ r}^{(K)j}\left[p_{(g+1,2)j}^{(1)r} + k_{j}^{r}(0)\right] \\ & + \sum_{j}\sum_{r} \mathrm{D}_{k\ r}^{(\ell)j}\left[p_{(g+1,3)j}^{(1)r} + n_{j}^{r}\right]\end{aligned} \qquad \text{(E2.5.3)}$$

and

$$\mathrm{D}_{r}^{(K,\ell)*} d_{r}^{(K,\ell)*} = \sum_{k}\left[\mathrm{S}_{k,r}\mathrm{D}_{k}^{(K,\ell)}\right] d_{k}^{(K,\ell)} \qquad \text{(E2.5.4)}$$

Where:

$d_k^{(K,\ell)}$: percentage change in gross returns from capital and land accruing to household type k;

$D_{k\ r}^{(K)j}$: base value of gross capital returns to household type k from industry j,r;

$D_{k\ r}^{(\ell)j}$: base value of gross returns from land to household type k from industry j,r;and

$p_{(g+1,2)j}^{(1)r}$, $p_{(g+1,3)j}^{(1)jr}$, $k_j^r(0)$ and n_j^r are the percentage changes in the gross rental prices of capital and land respectively, and the quantities of capital and land respectively.

Making the obvious notational changes to Equations E2.5.3 and E2.5.4 provides Equations *E_p_k_grossrent* and *E_p_r_grossrent* respectively. Equation *E_p_k_grossrent* defines the percentage change in gross land and capital rentals accruing to household type k as the weighted-sum of the percentage changes in their receipts of gross land rentals and gross capital rentals. The weights are given by the shares in their total gross land and capital rentals of rentals from land and capital individually. Equation *E_p_r_grossrent* then defines the percentage change in the gross rental receipts of the residents of region r on the basis of the "types"[35] of households that are living within the region. Hence the percentage change in the gross rental receipts of households in r is calculated as the weighted sum of the percentage changes in the rental receipts of the k household types resident in the region. The weights are given by the share of gross rentals accruing to household type k in the total gross rentals accruing to households of all types resident in r.

2.5.5 Household net taxes on capital and land rentals

The net taxes and transfers payable by household type k on land and capital rentals in either region ($D_{2,k}^{(K,\ell)}$) is provided by:

$$D_{2,k}^{(K,\ell)} = \sum_r D_{1,k,r} + \sum_j \sum_r D_{2(j,r)k} + \sum_j \sum_r D_{3(j,r)k} + \sum_j \sum_r D_{4(j,r)k} \qquad \text{(E2.5.5)}$$

Where:

[35] Defined in terms of their origin region, k.

$D_{1,k,r}$: Residential land tax payable by household k on ownership of dwellings rentals from r;

$D_{2(jr)k}$: Commercial land taxes payable by household k on capital returns from regional industry j,r;

$D_{3(j,r)k}$: Commonwealth income taxes on capital rentals from regional industry j,r;

$D_{4(j,r)k}$: Income taxes on rentals from agricultural land;

Converting Equation E2.5.5 to a percentage rate of change form provides:

$$D_{2,k}^{(K,\ell)} d_{2,k}^{(K,\ell)} = \sum_r D_{1,k,r} d_{1,k,r} + \sum_j \sum_r D_{2(jr)k} d_{2(jr)k} + \sum_j \sum_r D_{3(j,r)k} d_{3(j,r)k} + \sum_j \sum_r D_{4(j,r)k} d_{4(jr)k} \quad \text{(E2.5.6)}$$

The derivation of each of the four percentage rate of change variables in this equation is presented in Sections 2.5.5.1 to 2.5.5.4 below. Substituting the expressions for these variables into Equation E2.5.6 provides Equation *E_pkaptax*.

2.5.5.1 Residential land taxes payable by household type k

In the levels, the residential land tax payable by household type k on residential land in region r is given by:

$$D_{1,k,r} = \left[P_{\text{Dwellings}}^{(7)r} K(0)_{\text{Dwellings}}^{r}\right] S_{(2)k}^{(\text{Dwellings})r} \quad \text{(E2.5.7)}$$

Where $S_{(2)k}^{(\text{Dwellings})r}$ is household k's share in the ownership of capital in the Dwellings industry in region r, and $P_{\text{Dwellings}}^{(7)r}$ is the residential land tax payable per unit of capital ($K(0)_{\text{Dwellings}}^{r}$) in the Dwellings industry.

In percentage change form Equation (E2.5.7) can be written:

$$d_{1,k,r} = p_9^{(7)r} + k(0)_9^r \quad \text{(E2.5.8)}$$

This is Equation *E_rltax* in Section 6 of Appendix A, which defines the variable $rltax_r$ appearing in Equation *E_pkaptax*.

2.5.5.2 Commercial land taxes payable by household type k

Commercial land taxes payable by household type *k* on land in region *r* is given by:

$$D_{2(jr)k} = \left[P_j^{(8)r} K(0)_j^r\right] S_{(2)(k)}^{jr} \qquad \text{(E2.5.9)}$$

Where $S_{(2)k}^{jr}$ is household type *k*'s share of the ownership of capital in regional industry *jr*, and $P_j^{(8)r}$ is the commercial land tax payable per unit of current capital $\left(K(0)_j^r\right)$ in regional industry *j,r*.

In percentage change form, Equation (E2.5.9) becomes:

$$d_{2(jr)k} = p_j^{(8)r} + k(0)_j^r \qquad \text{(E2.5.10)}$$

Where $p_j^{(8)r}$ and $k(0)_j^r$ are represented by $pcom\_tax_{j,r}$ and $cap\_at\_t_{j,r}$ respectively in Equation *E_pkaptax*.

2.5.5.3 Income taxes payable by household type k *on rentals earned from capital in regional industry j,r*

In the levels, the income taxes payable by household type *k* on rentals earned from capital in regional industry *j,r* are given by:

$$D_{3(jr)k} = \left[P_{(g+1,2)j}^{(4)r} K_j^r(0)\right] S_{(2)k}^{jr} \qquad \text{(E2.5.11)}$$

Where $P_{(g+1,2)j}^{(4)r}$, is the Commonwealth income tax payable per unit of current capital $\left(K(0)_j^r\right)$ in regional industry *j,r*.

In percentage change form, Equation (E2.5.11) becomes:

$$d_{3(jr)k} = p^{(4)r}_{(g+1,2)j} + k^{r}_{j}(0) \tag{E2.5.12}$$

Where $p^{(4)r}_{(g+1,2)j}$ is represented by $p\_kaptax_{j,r}$ in Equation *E_pkaptax*.

2.5.5.4 Income tax paid by household type k on rentals earned from agricultural land installed in regional industry j,r

In the levels, the income tax payable by household type *k* on rentals earned from agricultural land installed in regional industry *j,r* is given by:

$$\mathrm{D}_{4(jr)k} = \left[\mathrm{P}^{(4)r}_{(g+1,3)j}\mathrm{N}^{r}_{j}\right]\mathrm{S}^{jr}_{(3)k} \tag{E2.5.13}$$

Where $\mathrm{S}^{jr}_{(3)k}$ is the share of household type *k*'s ownership of agricultural land in regional industry *j,r*, and $\mathrm{P}^{(4)r}_{(g+1,3)j}$ is the Commonwealth income tax payable per unit of land $\left(\mathrm{N}^{r}_{j}\right)$ in regional industry *j,r*.

In percentage change form, Equation (E2.5.13) becomes:

$$d_{4(jr)k} = p^{(4)r}_{(g+1,3)j} + n^{r}_{j} \tag{E2.5.14}$$

Where $p^{(4)r}_{(g+1,3)j}$ is represented by $p\_landtx_{j,r}$ in Equation *E_pkaptax*.

Substituting Equations E2.5.8, E2.5.10, E2.5.12, E2.5.14 into Equation E2.5.6, and making the obvious notational changes, provides Equation *E_p_k_kaptax* in Section 4 of Appendix A.

2.5.6 Net capital and land taxes payable by region *r* residents

Total net capital and land taxes payable by households resident in region *r* are given by:

$$D_{2,r}^{(K,\ell)*} = \sum_k S_{k,r} D_{2,k}^{(K,\ell)} \quad \text{(E2.5.15)}$$

Converting Equation (E2.5.15) to percentage rate of change form provides:

$$D_{2,r}^{(K,\ell)*} d_{2,r}^{(K,\ell)*} = \sum_k \left[D_{2,k}^{(K,\ell)} \times S_{k,r} \right] d_{2,k}^{(K,\ell)} \quad \text{(E2.5.16)}$$

That is, the percentage change in the total net capital and land taxes payable by residents of region *r* is the share weighted sum of the percentage changes in the total net capital and land taxes payable by the *k* household types resident in *r*.

Making the obvious notational changes to Equation E2.5.16 provides Equation *E_p_r_kaptax* in Section 4 of Appendix A.

2.5.7 Household consumption budgets

Equation 19 of the FEDERAL model defines the percentage change in the nominal consumption budget of regional household *r* as the percentage change in regional household disposable income plus the percentage change in the regional household's average propensity to consume. Equation 19 is reproduced essentially unchanged in FEDERAL-F as Equation *E_cnr*. The key difference between this and Equation 19 is the addition to *E_cnr* of the economy-wide average propensity to consume shift variable *f_eq19*. The addition of this variable expands the range of available macroeconomic closures under which the model can be simulated (See Section 2.12.7).

Equation 20 of the FEDERAL model defines the percentage change in the real consumption budget of regional household *r* as the difference between the percentage changes in the household's nominal consumption budget and the percentage change in the regional consumer price index. This equation is adopted unchanged as Equation *E_crR* in FEDERAL-F. Equation *E_cR* corresponds to FEDERAL Equation 21, and calculates the percentage change in the real economy-wide household consumption budget as the weighted-sum of the percentage changes in the real regional consumption budgets.

2.5.8 Household capital ownership and net foreign assets

Households are assumed to hold their accumulated net savings as two types of assets: physical capital located within Australia, and net foreign assets. FEDERAL-F provides for two alternative treatments of the accumulation of household capital and foreign assets. Under the first treatment, capital ownership shares within each regional industry are held fixed. Each regional household's ownership of foreign net assets then adjusts to reconcile the value of any new domestic physical capital they are thus computed to own, with the value of their savings. Under the second treatment, the quantity of capital owned by each type of domestic agent is adjusted in line with their savings (or investment in the case of government). The change in the foreign ownership of capital in each regional industry is then calculated as a residual between the change in the supply of capital to that industry by domestic agents, and the change in the total quantity of capital installed in the regional industry. Each of these approaches is discussed in detail below.

2.5.8.1 Option 1: Constant regional industry capital ownership shares

This approach assumes that ownership shares in physical capital (which are implicit in the data on the distribution of returns to capital, among the different types of owners, contained in the base period database) remain constant over time. This assumption effectively determines the changes in domestic household's ownership of domestic physical capital in year-on-year simulations. The net foreign assets held by each regional household then adjusts as a residual to reconcile the value of their savings in the period with the value of the new net physical capital they have been calculated to own.

As discussed in Section 2.6, the distribution of each period's aggregate investment across regional industries is determined by expected rates of return. Since, under the present option, ownership shares remain constant, this also determines the value of each regional household's investment in physical capital in each period. Stating this more formally, if I_r^K is regional household r's investment in physical capital in the period, S_r^k is the share of household type k that is resident in region r, $I_{j,t}$ is gross fixed capital formation in regional industry j,t, and $O^{k}_{j,t}$ is the share of the capital in regional industry j,t owned by household type k, then $I^{K}_{r} = \sum_{k} S^{k}_{r}\left(\sum_{j}\sum_{t} I_{j,t} \times O^{k}_{j,t}\right)$.

The domestic currency value of household r's savings in any given period is simply equal to the value of disposable income less consumption[36]. Subtracting I^{K}_{r} from the domestic currency value of household r's savings provides the domestic currency value of the change in household r's net foreign assets. Clearly, this can be either a negative or a positive value, depending on whether household r's investment in physical capital during the period exceeds the value of its savings. Over time, the households in each region can accumulate either foreign assets or foreign liabilities, depending on the value of both their savings and their investment in physical capital, year by year. The rate of return on net foreign assets is determined exogenously, and is initially set at a rate of five per cent per annum.

In FEDERAL-F, the accounting for household's net foreign asset holdings is largely undertaken in foreign currency terms. Hence the domestic currency value of the change in household r's net foreign assets must be converted to a foreign currency value, by dividing it by the value of the nominal exchange rate. The foreign currency value of the change in household r's net foreign assets appears as an explicit coefficient in the model: FOR_INV_r (See Equation *E_del_netf* in Section 4 of Appendix A), evaluated from the base year values for disposable income, consumption, gross fixed capital formation, and the nominal exchange rate.

Equation *E_del_netf* calculates the change in household r's net foreign assets (measured in foreign currency units) across the database year, thereby establishing the correct value for the household's stock of foreign assets at the commencement of the simulation year. If

[36] For consistency, it would be preferable to treat household ownership of net foreign assets in the same way as that of physical capital: that is, distinguishing the type (k) of household owning the net assets from the region (r) in which they actually reside. This would require a calculation of the net income of household type k from all sources (not just capital and land). While possible, given the current applications of the model I feel this would introduce extra complexity with little likelihood of providing added insights into the issues investigated. Hence, I effectively tie net foreign asset ownership to a geographical location (r) rather than household type (k) aware of the apparent methodological inconsistency with the treatment of physical capital in Section 2.5.4.

$A(t)_r$ is the value of household *r*'s foreign assets (in foreign currency units) at time *t*, and $S(t-1)_r$ is the value of the addition to those stocks in the database year, then the derivation of *E_del_netf* starts with the identity: $A(t)_r = A(t-1)_r + S(t-1)_r$. The control solution for year *t* net assets is set equal to the year *t-1* net assets. A convenient expression for this identity is then:

$$A(t)_r = A(t-1)_r + S(t-1)_r + S(t-1)_r H \qquad \text{(E2.5.17)}$$

Where H has the value -1 in the control solution to the model. With H equal to -1, the above expression establishes $A(t-1)_r$ as the control solution for $A(t)_r$. Converting (E2.5.17) to a rate of change format provides:

$$\Delta A(t)_r = S(t-1)_r \Delta H \qquad \text{(E2.5.18)}$$

Which, upon making the obvious notational changes, provides Equation *E_del_netf* in Section 4 of Appendix A. In a simulation, the variable ΔH is shocked equal to 1, thereby establishing the required net asset accumulation relationships by bringing the value of H in (E2.5.17) to 0.

The percentage change in the foreign currency value of the net interest earned by household *r* on its net foreign assets is given by Equation *E_net_f_int* (Section 4, Appendix A). In the levels, the net interest received by each regional household (T^r) on its net foreign assets ($A(t)_r$) can be calculated as $T^r = A(t)_r \times E$, where E is the rate of return on the net foreign assets. Converting this relationship to a percentage rate of change form and noting that the base solution for $A(t)_r$ is $A(t-1)_r$ provides:

$$t^r = \frac{100}{A(t-1)_r}\Delta A(t) + e \qquad \text{(E2.5.19)}$$

Which, upon making the obvious notational translations, provides Equation *E_net_f_int*.

Finally, Equation *E_net_f_int_dc* computes the percentage change in the domestic currency value of the net foreign interest receipts ($net\_f\_int\_dc_r$) of household *r*.

2.5.8.2 Option 2: Ownership of physical capital determined by savings

Under this approach, changes in household savings and in government investment are reflected in changes in their ownership of domestic physical capital. Hence household net foreign liabilities are exogenous. This is the approach that has been used in the simulations reported in Chapters 4 - 6.

Equations *E_k_owners1 - E_k_owners5B* calculate the percentage rates of change in the quantity of capital in each regional industry owned by each of the six types[37] of owner in the set OWNER2[38]. The first stage in deriving these equations is to note the following levels relationship between the net investment of owner type *t* ($I(0)^t$) during the database year, and the quantity of capital owned by owner *t* at the beginning ($K(0)^t$) and end ($K(t)^t$) of the database year::

$$K(t)^t = K(0)^t + I(0)^t \qquad t = 2\text{-}6. \qquad \text{(E2.5.20)}$$

The base solution for $K(t)^t$ is $K(0)^t$, implying that $I(0)^t$ is zero in the base solution. A convenient expression for the above levels equation is then:

$$K(t)^t = K(0)^t + I(0)^t\,\mathrm{H} \qquad t = 2\text{-}6. \qquad \text{(E2.5.21)}$$

Where H is equal to zero in the base solution (thereby establishing $K(0)^t$ as the base solution for $K(t)^t$) but is shocked equal to 1 in a simulation, thereby establishing the

[37] i. Foreigners; ii. Commonwealth Government; iii. Regional government 1; iv. Regional government 2; v. Region 1 households; vi. Region 2 households.

[38] Note that the only difference between the sets OWNER and OWNER2 is the separate identification in the latter of the regional dimension to regional government ownership. This is necessary to calculate the percentage change in the capital ownership of the "regional government" owner identified in the set OWNER. The latter set is used for all other purposes in the model because, since regional governments are assumed only to own capital in their own region, it is not necessary to identify the region of the regional government owner - this is given by the region in which the industry is located.

relationship given by Equation (E2.5.20). Converting Equation (E2.5.21) to a percentage rate of change form provides:

$$k(t)' = 100 \times \left[\mathrm{I}(0)^{t} / \mathrm{K}(t)^{t} \right] \Delta H \qquad t = 2\text{-}6. \qquad \text{(E2.5.22)}$$

The percentage change in the quantity of capital owned by each domestic agent in each regional industry, $k(t)'_{j,r}$ is then assumed to be equal to the percentage change in the aggregate quantity of capital owned by each domestic agent, $k(t)'$:

$$k(t)'_{j,r} = 100 \times \left[\mathrm{I}(0)^{t} / \mathrm{K}(t)^{t} \right] \Delta H \qquad t = 2\text{-}6. \qquad \text{(E2.5.23)}$$

Noting that regional governments only own capital in industries located within their own region, and then making the obvious notational translations to Equation (E2.5.23), provides Equations *E_k_owners1* - *E_k_owners4* in Appendix A. It is worth discussing briefly how the coefficients on the right hand side of Equation (E2.5.23) are evaluated. First, the quantity of net investment attributable to owner type *t* is evaluated by first calculating the funds available for gross fixed capital expenditure, to each domestic agent, during the database year. For households in each region, this is given as the difference between household disposable income and household consumption[39]. The value of gross fixed capital formation by each regional government is recorded in the database. Foreign gross fixed capital formation is then calculated as the difference between national gross fixed capital formation and that of the total of all domestic agents. The share of each owner type in economy-wide gross fixed capital formation is then calculated. These shares are then applied to the economy-wide quantity of *net* investment to calculate the quantity of net investment undertaken by each domestic agent. This provides the coefficient $I(0)'$ in

[39] This introduces a methodological inconsistency with the treatment of returns to capital in the inter-regional migration theory. In terms of its impact on results, this inconsistency is trivial (it would require very large changes in migrant numbers, major differences in capital ownership levels, and major differences in savings per household, for this incompatibility to have a noticeable impact on simulation results). To be compatible with that theory, household savings for the present application should not be defined on the basis of the region of residence of the household, but rather, on the basis of the class of household owning the capital (which, in the presence of inter-regional migration, is independent of the region of residence in all periods other than the initial year). This would not only require that the disposable income of these households be calculated, but also their aggregate consumption. While possible, for the current applications of the model I have not considered the introduction of this extra complexity to the household income / consumption accounts to be worthwhile.

Equation (E2.5.23). Note that this coefficient is evaluated directly from the base year data and is not updated during multi-step simulations.

The economy-wide quantity of capital owned by owner type t ($K(t)^{t}$) is equal to the sum across regional industries of the quantity of capital owned by t in each regional industry, $K(t)^{t}_{j,r}$. The latter is calculated by applying the ownership shares implicit in the database matrices MV1 - MV3 (See Chapter 3) to the database value for the quantity of capital in each regional industry. The coefficient $K(t)^{t}_{j,r}$ is updated during multi-step simulations of the model, reflecting the changes occurring in ownership shares, capital quantities, and capital prices.

In the levels, the quantity of capital in each regional industry that is owned by foreigners is equal to the total quantity of capital in the industry less that owned by domestic agents. That is:

$$K(t)^{Foreign}_{j,r} = K(t)_{j,r} - \sum_{i=2}^{6} K(t)^{i}_{j,r} \qquad \text{(E2.5.24)}$$

Converting Equation (E2.5.24) to a percentage rate of change form, and making the obvious notational translations, provides Equations *E_k_owners5A* and *E_k_owners5B* in Appendix A.

The final set of equations relating to the updating of capital ownership is given by Equation *E_fsk_owners*. This calculates the percentage change in the share of the capital owned by owner type t ($t \in$ OWNERS) in regional industry j,r. Under a comparative static closure of the model, or a closure in which the household net foreign assets are endogenous[40], this equation is rendered inoperative via the endogenous determination of $fsk\_owners_{t,j,r}$. Otherwise, the equation is brought into operation by swapping the endogenous / exogenous status of $sk\_owners_{t,j,r}$ and $fsk\_owners_{t,j,r}$. The variables $sk\_owners_{t,j,r}$ appear in no other equation in the model. Their purpose is solely in the

[40] See Section 2.5.8.1.

updating of the matrices $MV1_{q,j,r}$, $MV2_{q,j,r}$ and $MV3_{q,j,r}$[41] to reflect changes in capital ownership shares.

2.5.9 Nominal household gross savings

Household gross[42] savings by region are equal to household gross income less net taxes and consumption. Equation *E_n_sav* defines the percentage change in nominal household savings as the weighted difference in the percentage changes in household disposable income (n_dinc_r) and household nominal consumption ($n3reg_r$).

2.5.10 Equations to facilitate the exogenous determination of household purchaser's prices

During an historical simulation of the model, it is likely that the purchaser's price calculated by the model for any individual commodity consumed by a regional household will differ from the price as available from the ABS. It is preferable, for a number of reasons, to determine exogenously the prices faced by regional consumers for individual commodities. First, as discussed in Section 2.5.2, real household consumption by commodity is determined exogenously in the historical simulation, with household preferences determined endogenously. Hence, given the model's consumption theory, the model will over (under) estimate the magnitude of the true shift in preference towards those goods, the consumer prices of which, are growing more (less) rapidly in the model relative to their price change in reality. This is an issue if the values computed for these taste change variables are to later form part of the shocks to the model during forecasting simulations (as they do in Chapter 5). Second, deviations in the model calculated consumer prices by commodity from actual consumer prices by commodity will, as the model is simulated through time, alter the value shares of individual commodities in regional household consumption budgets away from the value shares implicit in ABS data. This can begin to become apparent for some commodities when the model is simulated over a period as long as say 1992/93 - 1998/99, as is done in Chapter 4.

Equations *E_p3shift* through to *E_phant3natB* in Section 4 of Appendix A, and Equation *E_tax3ph* in Section 15 of Appendix A, facilitate the exogenous determination of the

[41] See Chapter 3.

[42] In the sense that no allowance is made for depreciation of physical assets.

household purchaser's prices of individual commodities. Equations *E_p3ncom* and *E_p3_na_i* have the same general form as Equations *E_x3ncom* and *E_x3_na_i* described in Section 2.5.2. In the historical simulations, I calculate implicit price deflators by national accounts commodity (NCOM) from current price and chain volume measures of household consumption by commodity and region supplied by the Australian Bureau of Statistics. The percentage change in these deflators is given by $p3ncom_{na,r}$ in Equation *E_p3ncom*. This equation calculates the percentage change in the price faced by regional household *r* for national accounts commodity *na* as the share-weighted sum of the percentage changes in consumption of FEDERAL-F commodity *i* classified within national accounts commodity *na* (i.e $p3\_ff\_na_{i,na,r}$). The relevant share weights are those of the purchaser's value of FEDERAL-F commodity *i* classified within national accounts commodity *na*. The variables f_p3r_r and *f_p3gen* are shift variables that are exogenous under the standard comparative static closure of the model. Equation *E_p3_na_i* calculates the percentage change in the price faced by regional household *r* for FEDERAL-F commodity *i* as the share-weighted sum of the percentage changes in the consumption of national accounts commodity *na* classified within FEDERAL-F commodity *i*. The relevant share weights are those of the purchaser's value of national accounts commodity *na* classified within FEDERAL-F commodity *i*.

Under the standard comparative static closure, *E_p3_ff_na* calculates the percentage change in the purchaser's price of commodity *i* cross-classified with national accounts commodity *na*. This shift variable $p3shift_{i,r}$ is endogenous, and is effectively determined by Equation *E_p3shift* to maintain the equality between $p3_{i,r}$ and $p3\_na\_i_{i,r}$. Finally, Equation *E_phant3natB* calculates the percentage change in total economy-wide collections of phantom taxes accruing on household purchases.

Under the historical closure, the consumer purchaser's prices by national accounts commodity by region, $p3ncom_{na,r}$, are set exogenously, and the shift variables $fp3ncom_{na,r}$ in Equation *E_p3_ff_na* are determined endogenously. Next, the commodity and region specific shift variable ($fp3r_{i,r}$) in Equation *E_ffp3r* is switched to being determined endogenously, and the corresponding elements of the shift variable $p3shift_{i,r}$ in Equation *E_p3_ff_na* is switched to being determined exogenously. Equation *E_ffp3r* is then brought into operation by setting exogenous the shift variable $ffp3r_{i,s,r}$ and setting endogenous the corresponding elements of the household phantom tax shift variables

($fphtax3_{i,s,r}$) in Equation *E_tax3ph*. Under this closure Equations *E_p3shift* through to *E_p3_ff_na* operate as follows. Commodity prices by national accounts commodity ($p3ncom_{na,r}$) are determined exogenously in Equation *E_p3ncom*. The shift variables $fp3ncom_{na,r}$ in Equation *E_p3_ff_na* are endogenous, and attain those values necessary to ensure that the weighted sum of the cross classified consumer prices ($p3\_ff\_na_{i,na,r}$) within any given national accounts commodity sector corresponds with the price that has been exogenously determined for that sector (i.e via the exogenous determination of $p3ncom_{na,r}$). Equation *E_p3shift* operates to force household consumption prices regardless of source ($p3_{i,r}$) to equal the weighted sum (across national accounts categories) of cross classified national accounts prices ($p3\_na\_i_{i,r}$). This is achieved via the endogenous shift variable $fp3r_{i,r}$ in Equation *E_ffp3r*, which delivers a uniform (across domestic sources) shift in the price faced by household *r* for commodity *i* from domestic source *s* such that the equality given in Equation *E_p3shift* is met. The shifts delivered to $p3r_{i,s,r}$ in Equation *E_ffp3r* are accommodated by shifts in the household phantom tax shift variable $fphtax3_{i,s,r}$ in Equation *E_tax3ph*.

By setting the prices of commodities consumed by each regional household exogenously, one has also effectively determined both national and regional consumer price indices. However, the consumer price index, *p3nat*, is already determined exogenously as the numeraire. To avoid an inconsistency between the exogenous setting of *p3nat*, and the exogenous determination of $p3ncom_{na,r}$, the uniform shift variable *f_p3gen* in Equation *E_p3shift* is determined endogenously, and the aggregate value of phantom taxes collected on consumption, *phant3nat*, is determined exogenously at zero. This transforms the role of Equation *E_p3ncom* to that of determining consumer prices in each region relative to the exogenously specified national consumer price index. The final swap undertaken in moving to the historical closure is to set the regional consumer price index for the region of focus ($p3reg_1$) exogenous, and set endogenous the region 1 shift variable f_p3r_1 in Equation *E_p3ncom*.

2.6 RATES OF RETURN, INVESTMENT, AND CAPITAL SUPPLY

2.6.1 Overview

FEDERAL-F retains the original theory governing rates of return and investment contained in the comparative static FEDERAL model. However, it also incorporates the static-expectations rate of return theory and capital supply theory of the MONASH model. Hence, the FEDERAL-F model can be run under one of two modes: a comparative-static mode, in which the original FEDERAL rate of return and investment theory is operational; and a year-on-year mode, in which the MONASH static-expectations year-on-year capital and investment theory is operational. The treatment of capital and investment in the multi-period mode of FEDERAL-F follows that of the MONASH model, adapted to the multi-regional case. This adaptation is discussed in detail in the remainder of Section 2.6. This discussion follows closely that provided by Dixon and Rimmer (1997) and Dixon and Rimmer (1999a), and the reader is referred to these for a full description of the MONASH theory upon which this part of the FEDERAL-F theory is based.

Table 2.6.1 describes the endogenous and exogenous status of the key variables necessary to move between the comparative static and year-on-year capital and investment theories. The full meaning of each of these variables, and the equations to which they relate, are described in detail in the remainder of Section 2.6. The table is introduced now, however, because it will be of considerable assistance to the reader in understanding the functions, under various closures, of the equations described later in Section 2.6, and the swaps that are undertaken in moving between those closures. Column 1 describes certain elements of the short-run comparative static closure. Aggregate real private investment at the national level (*i_real*) is endogenous. However, it is indexed to real national consumption spending via *E_omega* and the exogenous status of the variable *finv_com* - the ratio of real private investment to real consumption spending. The shift variable $f\_eqn54_{j,r}$ on Equation *E_cap_at_tplus1* is exogenous, and hence this equation determines the relationship between current regional industry rates of return relative to the economy wide expected rate of return, and the growth rate in regional industry capital stocks. The economy-wide expected rate of return (*omega*) is endogenous, and can be thought of as adjusting to ensure

Table 2.6.1: Endogenous / exogenous status of the key variables of the investment theory under alternative closures

Variables			Comparative Static Closure			Year - on - year Closures		
Description	Name	Dim	Short-run (Standard) (1)	Long-run (Standard) (2)	Long-run (Variant) (3)	Year-on-year (Structural) (4)	Year-on-year (Historical/ Forecasting) (5)	Year-on-year (Decomposition) (6)
Real national private investment	*i_real*	1	N	N	N	N	X	N
Consumption – investment link	*finv_com*	1	X	X	X	X	N	N
Economy-wide capital supply shift variable	*d_f_eeqror*	1	X	X	X	N	N	X
Current capital stocks by regional industry	*cap_at_t*	j,r	X	N	N	N	N	N
Regional industry capital supply shifters	*d_f_eeqror_jr*	j,r	N	N	N	X	X	X
Shift on current capital equation	*del_f_ac_p_y*	j,r	N	N	N	X	X	X
Economy-wide expected rate of return	*omega*	1	N	N	X	X	X	X
Shift on Equation *E_cap_at_tplus1*	*f_eqn54*	j,r	X	X	X	N	N	N
Regional industry rates of return	*crates*	j,r	N	X	N	N	N	N
Investment - capital ratios	*r_inv_cap*	j,r	N	N	X	N	N	N
Uniform investment - capital ratio shift	*r_inv_cap_u*	1	X	X	N	X	X	X

N: Denotes endogenous. X: Denotes exogenous.

that regional industry capital growth rates in the solution year are compatible with the economy-wide investment budget in the solution year. Regional industry current capital stocks ($cap\_at\_t_{j,r}$) are exogenous and the rates of return on these stocks ($crates_{j,r}$) are endogenous. With current capital stocks exogenous, it is necessary to have the corresponding shift variables $del\_f\_ac\_p\_y_{j,r}$ on Equation *E_del_f_ac_p_y* endogenous, thus effectively removing Equation *E_del_f_ac_p_y* from the model. With regional industry investment endogenous, and regional industry capital stocks exogenous, it is necessary for the variable measuring the investment / capital ratio for each regional industry ($r\_inv\_cap_{j,r}$) to be endogenous. Equation *E_d_f_eeqror_jr*, describing the relationship between regional industry capital growth rates and expected rates of return in the year-on-year theory, is made inoperative by setting endogenous the shifters on the positions of the regional industry capital supply functions ($d\_f\_eeqror\_jr_{j,r}$).

As Table 2.6.1 indicates, two long-run closure options are available for this part of the model theory. One of the defining attributes of the long-run is that sufficient time is assumed to have elapsed to allow regional industry capital stocks to have adjusted to changes in capital demand. Hence, under both long run closure options, $cap\_at\_t_{j,r}$ is endogenous. In the first long-run closure (Column 2), long-run rates of return on regional industry capital stocks ($crates_{j,r}$) are set exogenous. The supply of capital to regional industries ($cap\_at\_t_{j,r}$) then adjusts to the demands for capital by firms in order to ensure that the rental price on capital is compatible with the exogenous status of $crates_{j,r}$ and the endogenous construction cost of capital in each regional industry ($pi_{j,r}$).

Two long-run closures for industry level investment are then available. The first continues to rely on Equations *E_cap_at_tplus1* and *E_yp56* to allocate economy-wide investment and determine industry-level capital growth rates in the solution year, and hence industry-level investment in the solution year. The second closure (Column 3) is similar to the MONASH structural closure. This closure does not use Equation *E_cap_at_tplus1* to determine the capital stock in the period following the solution year on the basis of changes in the economy-wide rate of return. Instead, it is assumed that in the long-run, investment:capital ratios in all regional industries are exogenous. Hence the variable

$r\_inv\_cap_{j,r}$ in Equation *E_r_inv_cap* is set exogenous, and the rates of return on capital in the solution year ($crates_{j,r}$) are set endogenous. The economy-wide investment constraint is met by setting endogenous the common shift variable on the regional industry investment/capital ratios (*r_inv_cap_u*) and setting exogenous the expected economy-wide rate of return on capital (*omega*).

Column 4 in Table 2.6.1 contains the swaps necessary to move to the closure that is used in year-on-year deviation or policy simulations. First, the relationship between current rates of return, the expected economy-wide rate of return, and the capital growth rate in regional industry *j,r* given by Equation *E_cap_at_tplus1* is no longer used. It is removed from the model by setting endogenous the shift variables $f\_eqn54_{j,r}$. The shift variables on the capital supply functions ($d\_f\_eeqror\_jr_{j,r}$) are set exogenous, thereby bringing Equation *E_d_f_eeqror* into operation. The equation linking changes in capital availability in the solution year to the database values for capital, investment, and depreciation (Equation *E_del_f_ac_p_y*) is brought into operation by setting $del\_f\_ac\_p\_y_{j,r}$ exogenous. Changes in the opening capital stocks are now (essentially) determined exogenously[43] (via unitary shocks to del_unityr_r) and changes in regional industry investment are determined by the relationship between expected rates of return and capital growth rates given by Equation *E_d_f_eeqror_jr*. Hence the regional industry investment / capital ratios ($r\_inv\_cap_{j,r}$) are now endogenous. With the regional industry investment / capital ratios endogenous, and the regional industry capital supply functions now operative, the endogenous status of the uniform shifter on the investment capital ratios (*r_inv_cap_u*) must be swapped with the uniform shifter on the capital supply functions (*d_f_eeqror*) to ensure that the economy-wide investment budget is met.

Column 5 contains the swaps necessary to move to the closure used in year-on-year historical or forecasting simulations. In these simulations, real economy-wide investment[44] is typically set exogenous, and shocked equal to either the value it was observed to have attained over the historical period under investigation, or by the value it is expected to have over the future period under investigation. This requires that the indexation with real

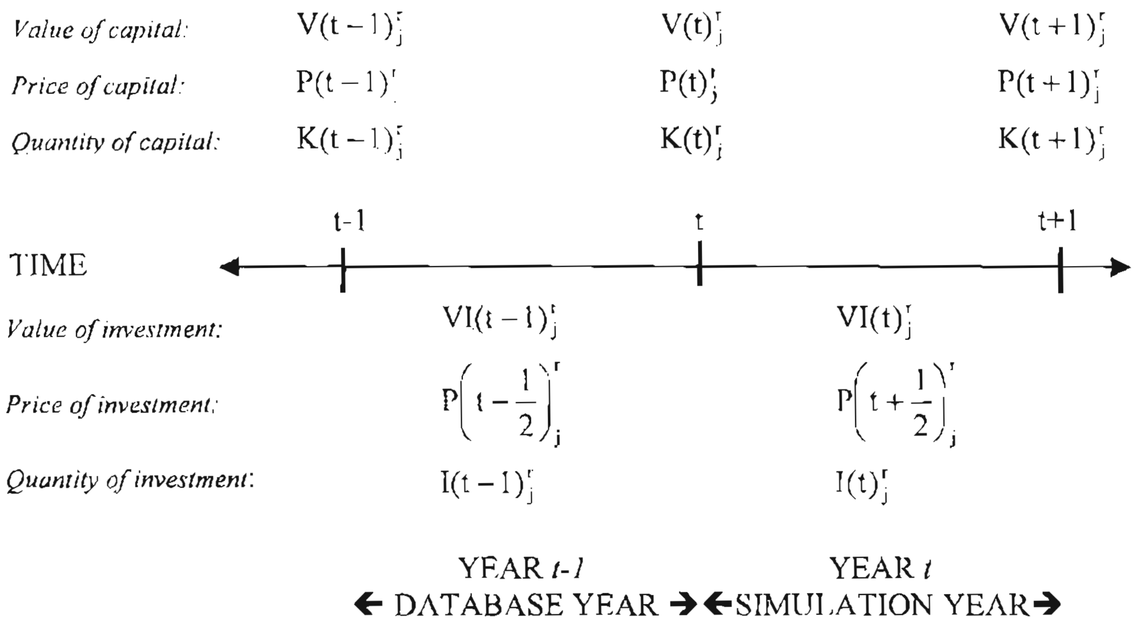
[43] On the basis of the opening database values for initial capital stocks, investment, and depreciation rates.
[44] Or some other measure of economy-wide investment.

consumption spending be broken. That is, the ratio of real private investment spending to real consumption spending (*finv com*) is now endogenous. Column 6 shows the swaps necessary to move to the closure used in year-on-year decomposition simulations. Under this closure, the economy-wide shifter on the capital supply schedules (*d_f_eeqror*) is exogenous, and economy wide real private investment expenditure is endogenous. Economy-wide real private investment spending is no longer constrained, but is the sum of the investment expenditure across all regional industries.

2.6.2 Preliminary definitions

Before proceeding with the explanation of the equations describing capital accumulation and rates of return in FEDERAL-F, it is useful to describe a number of definitions relating to both the model database and the calculation of control solutions in the forecast model.

Figure 2.6.1: Examples of naming conventions for stock and flow variables



As discussed in Section 2.1.2.1, the Johansen / Euler solution method calculates solutions for the model's variables as percentage deviations away from a base solution. These base solutions are either provided directly by, or calculated from, the model's database. The database records information on (among many other things) stock and flow variables on investment and capital formation that relate to a particular year of economic activity (the "database year"). Two conventions in recording these data are worth making explicit. The first is that the database information on stock variables relates to their status at the commencement of the database year. The data on flow variables relate to their status during the entirety of the year, or in the middle of that year (for average capital asset prices). The only data for which end of year information is retained is end of year capital asset prices, $P(t)_j^r$. The second convention is that data on physical quantities (of capital and gross fixed capital formation) are not recorded. Rather, data on both their values and per unit prices are recorded, with quantities calculated by dividing one into the other. Figure 2.6.1 attempts to summarise these conventions. The database year is the year *t-1*. The database contains, among many other variables, information on the value of capital and investment, and capital asset prices, by regional industry. The value of capital in regional industry *j,r* at the commencement of the database year is given by $V(t-1)_j^r$. The price per unit of this capital is $P(t-1)_j^r$, hence the quantity of capital can be calculated as $V(t-1)_j^r / P(t-1)_j^r = K(t-1)_j^r$. $VI(t-1)_j^r$ is the database value of investment in each regional industry during the database year. Given the mid-year price per unit of capital, the quantity of gross fixed capital formation in the database year can be calculated as $VI(t-1)_j^r \Big/ P(t-\frac{1}{2})_j^r = I(t-1)_j^r$.

The database values for $K(t-1)_j^r$ form the control values for the calculation of $K(t)_j^r$ in the historical and forecasting simulations. The values for $I(t-1)_j^r$ form the control values for the calculation of the percentage growth in investment across the simulation year. The values $K(t-1)_j^r(1-D_j^r)+I(t-1)_j^r$ (that is, $K(t)_j^r$) form the control solutions for the calculation of the percentage growth in capital across the forecast year.

2.6.3 Rate of return on regional industry *j,r*'s capital - comparative static definition

The net rate of return on capital in regional industry *j,r* in the FEDERAL model is defined as the post-tax rental price of a unit of that capital $P_j^{(0)r}$, divided by the cost of constructing a unit of that capital Π_j^r, less the depreciation rate on that capital D_j^r:

$$R^{(0)}_{j,r} = \frac{P^{(9)r}_{j}}{\Pi^{r}_{j}} - D^{r}_{j}$$ (Levels version of FEDERAL Equation 52)

Converting this to a percentage rate of change format, and noting that the depreciation rate D^r_j is assumed to be fixed, provides:

$$r^{(0)}_{j,r} = Q^{(1)r}_{j}\left(p^{(9)r}_{j} - \pi^{r}_{j}\right)$$ (FEDERAL Equation 52)

Where $Q^{(1)r}_{j}$ is the ratio of the gross rate of return (that is, before depreciation) to the net rate of return (that is, after depreciation). Making the obvious notational translations to FEDERAL Equation 52 provides Equation *E_crates*.

2.6.4 Capital growth rates related to expected rates of return - comparative static definition

The relationship between capital growth rates and expected rates of return is based on the ORANI (Dixon et al. 1982) assumption that investors behave as if an expansion in the capital stock of a particular regional industry will lower its rate of return in one period's time. Furthermore, they behave as if they expect that an increase in this period's rate of return will correspond to an increase in next period's rate of return. The precise form of the function in the levels is:

$$R^{(1)}_{j,r} = R^{(0)}_{j,r}\left(\frac{K^{r}_{j}(1)}{K^{r}_{j}(0)}\right)^{-\beta^{r}_{j}}$$

From this equation it is apparent that if next period's capital stock is thought by investors to be equal to the current capital stock, then the expected rate of return will equal the current rate of return. However, since β^{r}_{j} is a positive parameter, if next period's capital stock is expected to exceed the current capital stock, then next period's rate of return will be expected to fall below the current rate of return. The converse is obviously also true. An increase in the current period's rate of return will produce a vertical upward shift in the function, and hence generate an increase in the expected rate of return for any given capital growth rate.

The next important assumption is that investors allocate the total private investment budget across industries so as to equate the expected rates of return across regional industry capital stocks to some economy-wide rate of return. Hence the equation for the expected rate of return in regional industry *j,r* is:

$$\Omega = F_{j,r}^{(E54)} R_{j,r}^{(0)} \left(\frac{K_j^r(1)}{K_j^r(0)} \right)^{\beta_j^r} \qquad \text{(Levels version of FEDERAL Equation 54)}$$

The economy-wide expected rate of return, Ω is endogenous. The variable $F_{jr}^{(E54)}$ is a shift variable[45] that is exogenous in the comparative static closure. Given the relationship between expected rates of return and capital growth rates across regional industries, Ω adjusts to ensure that the rates of capital growth across regional industries are compatible with the economy-wide investment budget. Converting Equation 54 to a percentage rate of change format, and re-arranging, makes the relationship between capital growth rates and rates of return more clear:

$$\left(k_j^r(1) - k_j^r(0)\right) = \left(\frac{1}{\beta_j^r}\right)\left[f_{jr}^{E54} + r_{jr}(0) - \omega\right] \qquad \text{(FEDERAL Equation 54)}$$

The rate of growth of regional industry *j,r*'s capital stock is a positive function of the difference between the growth rate in that industry's rate of return on capital and the economy-wide rate of return. The sensitivity of capital growth rates to the difference between regional industry current rates of return and the economy wide expected rate of return is given by the coefficient $1/\beta_j^r$. Making the obvious notational translations to Equation 54 provides Equation *F_cap_at_tplus1* in Section 5 of Appendix A.

45 This variable is not present in the original FEDERAL theory, but is added in FEDERAL-F to allow this equation to be eliminated in year-to-year simulations.

2.6.5 Accounting for the rate of growth of regional industry capital stocks

The capital stock available at the beginning of next period is assumed to be equal to the depreciated level of the current capital stock, plus the current period's level of investment. In the levels, this can be expressed as:

$$K_j^r(1) = K_j^r(0)\left(1 - D_j^r\right) + I_j^r \qquad \text{(Levels version of FEDERAL Equation 55)}$$

The same accounting relationship is used in both the comparative static and year-on-year theory to relate next period's capital stock to the current period's capital stock and investment. Section 2.6.6 describes the linearised version of the above equation which is used in the model.

2.6.6 Capital at the beginning of year *t*

Recall from the discussion in Section 2.6.2 that the quantity of capital specified in the database relates to the quantity available at the commencement of the database year. Hence, in undertaking a simulation across the year t, it is necessary to calculate the quantity of capital available to each regional industry at the commencement of the year t. The control value for each regional industry's capital stock at the commencement of the simulation year is taken to be the quantity of capital available to each regional industry at the commencement of the database year. However, we know that the quantity of capital available to each regional industry at the commencement of the simulation year will differ from that available at the commencement of the database year because of the investment and depreciation that occurred during the database year. Hence the following percentage-change shocks should be imposed on the model, given the assumed base solutions for $K(t)_j^r$:

$$k(t)_j^r = \frac{100\left(I(t-1)_j^r - K(t-1)_j^r D_j^r\right)}{K(t-1)_j^r} \qquad \text{(E2.6.1)}$$

One could determine the $k(t)_j^r$'s exogenously, conduct the calculations given by Equation (E2.6.1) outside of the model, and then shock the $k(t)_j^r$'s by the values thus calculated.

However as Dixon and Rimmer (1999a) note, for convenience the shocks to $k(t)_j^r$ can be calculated within the model. The first step in deriving the equations that achieve this is to note that, in the levels, the quantity of capital available to each regional industry at the commencement of the database year is given by Equation (E2.6.2).

$$K(t)_j^r = K(t-1)_j^r\left[1 - D_j^r\right] + I(t-1)_j^r \qquad \text{(E2.6.2)}$$

The initial solution in the year t for $K(t)_j^r$ is $K(t-1)_j^r$. However given (E2.6.2), for $K(t-1)_j^r$ to be a legitimate element of the model's initial solution requires that:

$$D_j^r\left[K(t-1)_j^r\right] - I(t-1)_j^r = 0 \qquad \text{(E2.6.3)}$$

That is, for $K(t)_j^r = K(t-1)_j^r$ to be a legitimate element of the model's base solution, the level of investment in each regional industry must equal the level of depreciation of physical capital. With $K(t)_j^r = K(t-1)_j^r$ we can write:

$$K(t)_j^r - K(t-1)_j^r\left[1-D_j^r\right] - I(t-1)_j^r = K(t-1)_j^r - K(t-1)_j^r\left[1-D_j^r\right] - I(t-1)_j^r \qquad \text{(E2.6.4)}$$

Or:

$$K(t)_j^r - K(t-1)_j^r\left[1-D_j^r\right] - I(t-1)_j^r = -\left[K(t-1)_j^r D_j^r - I(t-1)_j^r\right]H$$

Which is the levels expression for Equation *E_del_f_ac_py*:

$$K(t)_j^r = K(t-1)_j^r\left[1-D_j^r\right] + I(t-1)_j^r - \left[K(t-1)_j^r D_j^r - I(t-1)_j^r\right]H \qquad \text{(E2.6.5)}$$

The variable H is equal to -1 in the control solution (thereby allowing the base year data to be a solution to the model in the simulation year). In a simulation, H must be shocked equal to zero, thereby establishing the accumulation relationship given by (E2.6.2).

Converting Equation (E2.6.5) to a percentage change form, and adding the shift term $\Delta f_j^{[k(t)]r}$, yields:

$$K(t)_j^r k(t)_j^r = -100\left[K(t-1)_j^r D_j^r - I(t-1)_j^r\right]\Delta H + 100\Delta f_j^{[k(t)]r} \qquad \text{(E2.6.6)}$$

Making the obvious notational translations to Equation (E2.6.6) provides Equation *E_del_f_ac_py* in Section 5 of Appendix A.

In year-on-year simulations the endogenous variable in this equation is $k(t)_j^r$. The exogenous variable is the variable ΔH (which must be shocked by 1). By shocking ΔH by 1 the value of the *level* for this variable is changed to zero. This provides the accumulation relationship (as expressed in the levels) provided by Equation (E2.6.2).

The shift term $\Delta f_j^{[k(t)]r}$ (*del_f_ac_py* in Equation *E_del_f_ac_py*) is exogenous during year-on-year simulations with the model. However in short-run comparative static simulations, current capital stocks ($cap\_at\_t_{j,r}$) are exogenous. In long-run comparative-static simulations the availability of capital in the solution year is determined by the requirement that changes in rates of return are zero. In both these cases the opening capital stock at the start of the solution year is not given by Equation (E2.6.6). Hence the equation is rendered inoperative by setting $\Delta f_j^{[k(t)]r}$ endogenous.

2.6.7 Capital accumulation across the forecast year

The gestation lag between the undertaking of investment in one period, and the consequent installation of productive capital in a later period, is assumed to be such that the investment undertaken during a year is installed as productive capital at the commencement of the subsequent year.[46] Given this assumption, the capital available to each regional industry at the end of the simulation year is equal to the depreciated quantity of capital available to the

[46] Assuming that investment expenditure occurs uniformly across a year, this corresponds to an average gestation of six months.

regional industry at the beginning of the period, plus the quantity of new investment in the regional industry during the period.

In the levels, this relationship can be expressed:

$$K(t+1)_j^r = K(t)_j^r\left(1-D_j^r\right)+I(t)_j^r \qquad \text{(E2.6.7)}$$

The initial solution for $K(t+1)_j^r$ is set equal to the level of capital available to the regional industry at the end of the database year (that is, the commencement of the forecast year). The control solution for $K(t)_j^r$ remains $K(t-1)_j^r$, and the control solution for $I(t)_j^r$ is $I(t-1)_j^r$. Hence the control solution for both Equations (E2.6.5) and (E2.6.7) is:

$$K(t+1)_j^r = K(t-1)_j^r\left(1-D_j^r\right)+I(t-1)_j^r \qquad \text{(a)}$$
$$K(t)_j^r = K(t-1)_j^r \qquad \text{(b)}$$
$$I(t)_j^r = I(t-1)_j^r \qquad \text{(c)}$$

It can be seen that these are legitimate elements of the initial solution for the model by substituting (b) and (c) into the right hand side of (E2.6.7), and (a) into the left-hand side of (E2.6.7)

The linearised version of Equation (E2.6.7) is (E2.6.8):

$$k(t+1)_j^r\left[K(t+1)_j^r\right] = k(t)_j^r\left[K(t)_j^r\left(1-D_j^r\right)\right]+i(t)_j^r\left[I(t)_j^r\right] \qquad \text{(E2.6.8)}$$

where the coefficients $K(t+1)_j^r, K(t)_j^r$ and $I(t)_j^r$ are evaluated from the model's database using the control solutions (a)-(c) above. Equation (E2.6.8) provides Equation *E_y_p56* in Section 5 of Appendix A, after making the obvious notational translations.

2.6.8 Beginning and end of year capital asset prices

Section 2.6.2 introduced the idea that the database contains information on start of year capital asset values and the value of investment through the year. The database also contains information on per unit capital asset prices as at: the start of the database year, the end of the database year, and the middle of the database year. This information on total values and per-unit prices allows the calculation of the coefficients for the quantity concepts for capital and investment which appear in the equations in Section 5 of Appendix A. Given the presence in the database of data related to start, middle and end of year capital asset prices, it is necessary to add two sets of equations to the model to calculate the variables used to update these data. These two equations have the same general form (adapted to the multi-regional case) as those serving the same function in MONASH, and so the discussion below follows closely that of Dixon and Rimmer (1999a).

Since the database contains values for the start of year and end of year capital asset prices, the database contains all the information necessary to calculate start of year capital asset prices, $pcapatt_r^j$. The following equation calculates the shocks to $pcapatt_r^j$ using the database values for the start and end-of-year capital asset prices:

$$\begin{aligned}&\mathrm{PCAP\_AT\_T}_r^j \times pcapatt_r^j = \\ &100 \times \left[\mathrm{PCAP\_AT\_T1\_B}_r^j - \mathrm{PCAP\_AT\_T\_B}_r^j\right] \times del\_unityr_r\end{aligned} \qquad \text{(E2.6.9)}$$

Which is Equation *E_pcapatt* in Section 5 of Appendix A. This equation is derived by first noting that, by definition, capital asset prices at the start of the simulation year, $\mathrm{P}(t)_j^r$ (represented by $\mathrm{PCAP\_AT\_T}_r^j$ in Equation *E_pcapatt*), are equal to the database values for end of year capital asset prices, $\overline{\mathrm{P}(t+1)_j^r}$ (which is $\mathrm{PCAP\_AT\_T1\_B}_r^j$ in Equation *E_pcapatt*), hence:

$$\mathrm{P}(t)_j^r - \overline{\mathrm{P}(t+1)_j^r} = 0 \qquad \text{(E2.6.10)}$$

The control solution for $P(t)_j^r$ is its value at the start of the database year, $\overline{P(t)_j^r}$ (which is given by $PCAP\_AT\_T\_B_r^j$ in Equation *E_pcapatt*). Hence, the initial solution for the model requires that:

$$\overline{P(t+1)_j^r} - \overline{P(t)_j^r} = 0 \qquad \text{(E2.6.11)}$$

The following levels equation, with the value of the new parameter H set at -1 in the initial solution, establishes $\overline{P(t)_j^r}$ as the base solution for $P(t)_j^r$:

$$P(t)_j^r - \overline{P(t+1)_j^r} = \left[\overline{P(t+1)_j^r} - \overline{P(t)_j^r}\right] H \qquad \text{(E2.6.12)}$$

In the solution year, H must be equal to zero (its rate of change representation in Equation *E_pcapatt*, del_unityr_r, is shocked by 1) to establish the levels relationship $\overline{P(t)_j^r} - \overline{P(t+1)_j^r}$. Converting Equation (E2.6.12) to a percentage rate of change format provides Equation *E_pcapatt* above.

The calculation of $pcapatt_r^j$ has introduced the idea of the end of year capital asset price, $\overline{P(t+1)_r^j}$. Note that the bar on this variable (and the suffix "_B" on the coefficient $PCAP\_AT\_T\_B_r^j$) denotes that it is a base value that is not updated for the purpose of evaluating the equations in which it appears - that is - its value remains identical to its value in the database year throughout the simulation year calculations. However, the coefficient in the database from which $\overline{P(t+1)_r^j}$ is evaluated must of course be updated, since it must reflect the activity that occurs in the simulation year so that a correct base value for $\overline{P(t+1)_r^j}$ (or, what might now be labelled "$\overline{P(t+2)_r^j}$") is available for the simulation year *t*+1. In calculating end of year asset prices, it is assumed (following its method of calculation in MONASH) that the end of year asset prices for year *t* are equal to the middle of year asset prices for year *t*, $P\left(t+\frac{1}{2}\right)_r^j$ (which is represented by $PCAP\_I_r^j$ in Equation *E_pcappatt1*), plus six month's worth of growth calculated at the rate of growth in capital asset prices established between the middle of year t-1 and the middle of year t. Hence:

$$P(t+1)_r^j = P\left(t+\tfrac{1}{2}\right)_r^j \times \left[\frac{P\left(t+\tfrac{1}{2}\right)_r^j}{P\left(t-\tfrac{1}{2}\right)_r^j}\right]^{\frac{1}{2}} \qquad \text{(E2.6.13)}$$

The control solution for $P(t+1)_r^j$ is $\overline{P(t+1)_r^j}$, and the control solution for $P\left(t+\tfrac{1}{2}\right)_r^j$ is $\overline{P\left(t-\tfrac{1}{2}\right)_r^j}$. Upon substituting these control values into equation (E2.6.13), it is apparent that for these values to be legitimate elements of the control solution then it is also necessary that $\overline{P(t+1)_r^j}$ equals $\overline{P\left(t-\tfrac{1}{2}\right)_r^j}$. Evaluating equation (E2.6.13) with these control values provides:

$$P(t+1)_r^j - P\left(t+\tfrac{1}{2}\right)_r^j \times \left[\frac{P\left(t+\tfrac{1}{2}\right)_r^j}{P\left(t-\tfrac{1}{2}\right)_r^j}\right]^{\frac{1}{2}} = \overline{P(t+1)_r^j} - \overline{P\left(t-\tfrac{1}{2}\right)_r^j} \qquad \text{(E2.6.14)}$$

What is now required is a form for (E2.6.14) that holds in the model's base solution for year t, but which also allows condition (E2.6.13) to be instated during a simulation. To create such a form, the RHS of the above expression is multiplied through, first by -1 and then by H. The coefficient H has the value -1 in the initial solution to the model. This provides:

$$P(t+1)_r^j - P\left(t+\tfrac{1}{2}\right)_r^j \times \left[\frac{P\left(t+\tfrac{1}{2}\right)_r^j}{P\left(t-\tfrac{1}{2}\right)_r^j}\right]^{\frac{1}{2}} = \left[\overline{P\left(t-\tfrac{1}{2}\right)_r^j} - \overline{P(t+1)_r^j}\right] \times \mathrm{H} \qquad \text{(E2.6.15)}$$

Linearising equation (E2.6.15) provides:

$$\left[\mathrm{P}(t+1)_r^j\right]\times p(t+1)_r^j = \left[1.5\times \mathrm{P}\left(t+\tfrac{1}{2}\right)_r^j \times \left[\frac{\mathrm{P}\left(t+\tfrac{1}{2}\right)_r^j}{\mathrm{P}\left(t-\tfrac{1}{2}\right)_r^j}\right]^{\frac{1}{2}}\right]\times \pi_r^j + 100\times\left[\overline{\mathrm{P}\left(t-\tfrac{1}{2}\right)_r^j} - \overline{\mathrm{P}(t+1)_r^j}\right]\times \Delta H \qquad \text{(E2.6.16)}$$

Which, after making the obvious notational translations, is Equation *E_pcapatt1* in Section 5 of Appendix A.

2.6.9 Investment-capital ratios by regional industry

In the levels, investment-capital ratios, by regional industry, are given by:

$$F^{(I:K)} F_r^{(I:K)}\left(R_j^{r(I:K)}\right) = \frac{I(t)_j^r}{K(t)_j^r} \qquad \text{(E2.6.17)}$$

Where:

$F^{(I:K)}$ is a shift variable common to each equation;

$F_r^{(I:K)}$ is a region-specific shift variable on investment/capital ratios.

$R_j^{r(I:K)}$ is the investment/capital ratio in regional industry *jr*;

$I(t)_j^r$ is investment in regional industry *jr*; and

$K(t)_j^r$ is the capital stock in regional industry *jr*.

Converting the above to a percentage change form provides:

$$f_r^{(I:K)} + f^{(I:K)} + r_j^{r(I:K)} = i(t)_j^r - k(t)_j^r \qquad \text{(E2.6.18)}$$

Which is Equation *E_r_inv_cap* in Section 5 of Appendix A.

Equation *E_r_inv_cap* serves two functions. Under the short-run comparative static and year-on-year closures, the equation serves to report the percentage changes in regional industry investment-capital ratios. This is also the case under the conventional long-run comparative static closure of the model. Otherwise, the equation can be used to impose an alternative long-run comparative static closure on the model, under which investment-capital ratios by regional industry are exogenous. Under this closure, Equation *E_rinv_cap* determines investment by regional industry ($y\_p56_{j,r}$). The economy-wide shift variable *f_inv_cap_u* in this equation will likely also be endogenous, and determined by the economy-wide investment budget. This alternative long-run closure is discussed in more detail in Section 2.6.1.

2.6.10 Capital growth through the forecast year

The growth rate in regional industry *j,r*'s capital stock across the forecast period, G_j^r, is given by Equation (E2.6.19):

$$G_j^r = \frac{K(t+1)_j^r}{K(t)_j^r} - 1 \qquad \text{(E2.6.19)}$$

The linearised form of Equation (E2.6.19) is:

$$100\Delta G_j^r \left[\frac{K(t+1)_j^r}{K(t)_j^r}\right]\left(k(t+1)_j^r - k(t)_j^r\right) \qquad \text{(E2.6.20)}$$

Which, after making the obvious notational conversions, is Equation *E_del_k_gr* in Section 5 of Appendix A.

2.6.11 Expected rate of return on capital in the current year

Following Dixon and Rimmer (1997), the expected actual rate of return on regional industry *j,r*'s capital in the current year, $R^{(ROR)r}_j$, is assumed to be the sum of both the equilibrium expected rate of return on regional industry *j,r*'s capital, $R^{(Eqm)r}_j$, and a measure of the deviation from the equilibrium expected rate of return on regional industry *j,r*'s capital, $R^{(Dis)r}_j$. The levels version of this relationship is given by:

$$R^{(ROR)r}_{j} = R^{(Eqm)r}_{j} + R^{(Dis)r}_{j} \qquad (E2.6.21)$$

The equilibrium expected rate of return, $R^{(Eqm)r}_{j}$, is that rate of return required to maintain the current rate of capital growth in regional industry *j,r*: it is the rate of return established by the schedule linking capital growth rates and rates of return, which is outlined in Section 2.6.12.

Converting Equation (E2.6.21) to a rate of change format provides:

$$\Delta R^{(ROR)r}_{j} = \Delta R^{(Eqm)r}_{j} + \Delta R^{(Dis)r}_{j} \qquad (E2.6.22)$$

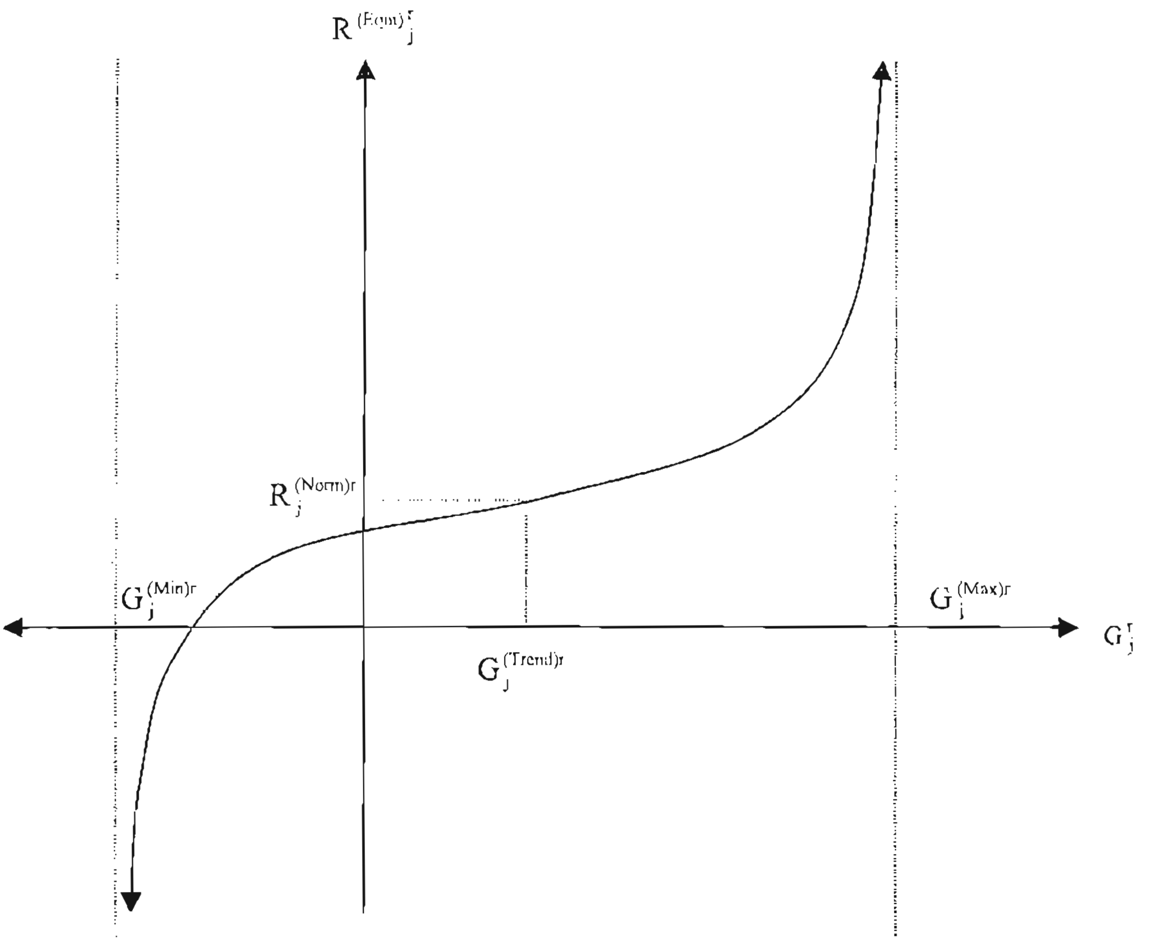
Which, after making the obvious notational conversions, is Equation *E_d_eeqror* in Section 5 of Appendix A.

Equation *E_d_eror* simply sets the change in the expected rate of return ($d\_eror_{j,r}$) equal to the change in the static expectations rate of return ($del\_ror\_se_{j,r}$).

2.6.12 The change in the equilibrium rate of return on capital in the current year

The "inverse-logistic" functions describing industry-level capital growth rates in the MONASH model (Dixon and Rimmer 1997) have also been implemented in FEDERAL-F, adapted to the multi-regional case. Figure 2.6.2 describes such a capital supply function for regional industry *j,r*. The capital supply curve relates the equilibrium rate of return expected to prevail on regional industry *j,r*'s capital in *t+1* to the rate of growth in the industry's capital stock across the simulation year. The positive slope of the function reflects an assumption that investors are more cautious about the prospects for a regional industry the greater the rate of growth in that industry's capital stock. Fluctuations in the rate of growth of capital are dampened by increases in the slope of the function at both high and low rates of capital growth. A concomitant of the dampening of changes in the capital growth rate is the dampening of percentage changes in the level of investment. Indeed, the percentage change in the level of investment is constrained to being greater than -100% by setting an asymptote to the curve at a capital growth rate given by the depreciation rate. This is necessary to ensure that the solution for investment is greater than -100%, since any other result would be incompatible with the assumption that, once installed, capital cannot be shifted from a regional industry (except by the gradual process of depreciation).

Figure 2.6.2: Regional industry capital supply related to expected rates of return



Source: Adapted from Dixon and Rimmer (1999a), Figure 33.1.

In the levels, the inverse-logistic function described in Figure 2.6.2 is given by:

$$R_j^{(Eqm)r} = \left(R_j^{(Norm)r} + F_{(1)j}^{(Eqm)r} + F_{(2)}^{(Eqm)r} + F_{(3)}^{(Eqm)} + F_{(4)j}^{(Eqm)}\right) + \left(\frac{1}{C_j^r}\right) \times \begin{bmatrix} \ln\left(G_j^r - G_j^{(Min)r}\right) - \ln\left(G_j^{(Max)r} - G_j^r\right) \\ - \ln\left(G_j^{(Trend)r} - G_j^{(Min)r}\right) + \ln\left(G_j^{(Max)r} - G_j^{(Trend)r}\right) \end{bmatrix} \quad \text{(E2.6.23)}$$

Where:

$R_j^{(Eqm)r}$ Is the expected equilibrium rate of return.

$R_j^{(Norm)r}$ Is an estimate of the average rate of return that applied over the historical period in which the industry's average annual rate of capital growth was $G_j^{(Trend)r}$. These values are read in as data.

$F_{(1)j}^{(Eqm)r}$ Is a variable which allows for vertical shifts in the capital supply curve of a specific regional industry. These variables are endogenous during comparative static simulations of the model. They may also be set endogenous during historical simulations of the model if the level of investment in each regional industry is known, and the capital supply schedules are not needed to determine the relationship between rates of return and capital growth.

$F_{(2)}^{(Eqm)r}$ Is a variable which allows for uniform vertical shifts in all the capital supply curves of industries in region *r*. These variables will be determined endogenously for those regions for which aggregate investment is determined exogenously.

$F_{(3)}^{(Eqm)}$ Is a variable which allows for uniform vertical shifts in all regional industry capital supply curves.

$F_{(4)j}^{(Eqm)}$ Is a variable which allows for vertical shifts in the capital supply functions of industry *j* irrespective of the regions in which it is located.

C_j^r Is a positive parameter equal to the sensitivity of regional industry *j,r*'s expected equilibrium rate of return to changes in its capital growth rate in the vicinity of $G_j^r = G_j^{(Trend)r}$.

G_j^r Is the rate of growth in regional industry *j,r*'s capital stock across the simulation year.

$G_j^{(Min)r}$ Is the minimum allowable rate of growth in regional industry *j,r*'s capital stock. It is set equal to the negative of depreciation rate for the regional industry.

$G_j^{(Max)r}$ Is the maximum allowable rate of growth in regional industry *j,r*'s capital stock. This is set at a fixed amount ($N_j^{(Diff)r}$) above the historically normal rate of growth, $G_j^{(Trend)r}$.

$G_j^{(Trend)r}$ This is the industry's historically normal capital growth rate, as observed from the historical data, and recorded in the model's database.

Converting Equation (E2.6.23) to a rate of change version provides:

$$\Delta R_j^{(Eqm)r} = \left(\frac{1}{C_j^r}\right) \times \left[\left(\frac{1}{G_j^r - G_j^{(Min)r}}\right) + \left(\frac{1}{G_j^{(Max)r} - G_j^r}\right)\right] \times \Delta G_j^r \quad \text{(E2.6.24)}$$
$$+ \Delta F_{(1)j}^{(Eqm)r} + \Delta F_{(2)}^{(Eqm)r} + \Delta F_{(3)}^{(Eqm)} + \Delta F_{(4)j}^{(Eqm)}$$

To facilitate the interpretation of results, Equation (E2.6.24) can alternatively be expressed as:

$$\Delta R_j^{(Eqm)r} = \left(\frac{1}{Z_j^r}\right) \Delta G_j^r + \Delta F_{(1)j}^{(Eqm)r} + \Delta F_{(2)}^{(Eqm)r} + \Delta F_{(3)}^{(Eqm)} + \Delta F_{(4)j}^{(Eqm)} \quad \text{(E2.6.25)}$$

or

$$\Delta G_j^r = Z_j^r \left[\Delta R_j^{(Eqm)r} - \Delta F_{(1)j}^{(Eqm)r} - \Delta F_{(2)}^{(Eqm)r} - \Delta F_{(3)}^{(Eqm)} - \Delta F_{(4)j}^{(Eqm)}\right] \quad \text{(E2.6.26)}$$

Where:

$$Z_j^r = \left[\left(\frac{1}{C_j^r}\right) \times \left[\left(\frac{1}{G_j^r - G_j^{(min)r}}\right) + \left(\frac{1}{G_j^{(max)r} - G_j^r}\right)\right]\right]^{-1}$$

Which, after making the obvious notational translations, is Equation *E_d_f_eeqror_jr*.

That this is a useful transformation of this equation is made more apparent by substituting Equation (E2.6.22) into (E2.6.26), as is done below:

$$\Delta G_j^r = Z_j^r \left[\Delta R_j^{(ROR)r} - \Delta R_j^{(Dis)r} - \Delta F_{(1)j}^{(Eqm)r} - \Delta F_{(2)}^{(Eqm)r} - \Delta F_{(3)}^{(Eqm)} - \Delta F_{(4)j}^{(Eqm)}\right] \quad \text{(E2.6.27)}$$

Equation (E2.6.27) makes clear that changes in the rate of return residuals ($\Delta R_j^{(Dis)r}$) and changes in the positions of the capital supply schedules ($\Delta F_{(1)j}^{(Eqn)r}$, $\Delta F_{(2)}^{(Eqn)r}$, $\Delta F_{(3)}^{(Eqn)}$) have an equivalent impact on changes in capital growth rates and hence levels of regional industry investment. This is useful when interpreting the results of simulations in which these variables are endogenous. In year-on-year simulations in which both $\Delta R_j^{(Dis)r}$ and various elements of $\Delta F_{(1)j}^{(Eqn)r}$, $\Delta F_{(2)}^{(Eqn)r}$, and $\Delta F_{(3)}^{(Eqn)}$ are endogenous[47], it is unlikely that the results for any one of these variables will be meaningful without reference to the values of the others. In particular, the positions of capital supply schedules are determined by the capital growth rate which is itself given by exogenously determined regional industry investment budgets. The closure of residuals, $\Delta R_j^{(Dis)r}$, determined by Equation *E_d_diseq*, will have its own implications for regional industry capital growth rates and hence investment. However this will simply be offset by whatever value $\Delta F_{(1)j}^{(Eqn)r}$ (and $\Delta F_{(2)}^{(Eqn)r}$, $\Delta F_{(3)}^{(Eqn)}$ in the case of exogenous national and regional investment budgets) then needs to acquire, given the exogenous status of regional investment. Hence, when analysing the results of a structural closure in which these shift variables are then exogenous, the impact of the closure of residuals and shifts in the positions of capital supply schedules for individual regional industries should be summed and thus treated as a single shock.

The sensitivity of industry *j,r*'s expected equilibrium rate of return to changes in its capital growth rate is determined by the parameter C_j^r. Dixon and Rimmer (1997) note that it is possible to evaluate these parameters if one can calculate the slope of the capital supply function in the vicinity of $G_j^r = G_j^{(Trend)r}$. They proceed by differentiating (E2.6.23) with respect to G_j^r:

$$\frac{\partial R_j^{(Eqm)r}}{\partial G_j^r} = \left(\frac{1}{C_j^r}\right) \times \left[\frac{1}{\left(G_j^r - G_j^{(Min)r}\right)} + \frac{1}{\left(G_j^{(Max)r} - G_j^r\right)}\right] \qquad \text{(E2.6.28)}$$

Solving (E2.6.28) for C_j^r:

[47] For example, an historical simulation in which Equation *E_d_diseq* is operational, and regional industry investments are determined exogenously, requiring the positions of the capital supply functions to be endogenous.

$$C_j^r = \left(\frac{\partial R_j^{(Eqm)r}}{\partial G_j^r} \right)^{-1} \times \left[\frac{G_j^{(Max)r} - G_j^{(Min)r}}{\left(G_j^r - G_j^{(Min)r}\right)\left(G_j^{(Max)r} - G_j^r\right)} \right] \quad \text{(E2.6.29)}$$

Evaluating (E2.6.29) in the region of $G_j^r = G_j^{(Trend)r}$ provides:

$$C_j^r = \left(\left. \frac{\partial R_j^{(Eqm)r}}{\partial G_j^r} \right|_{G_j^r = G_j^{(Trend)r}} \right)^{-1} \times \left[\frac{G_j^{(Max)r} - G_j^{(Min)r}}{\left(G_j^{(Trend)r} - G_j^{(Min)r}\right)\left(G_j^{(Max)r} - G_j^{(Trend)r}\right)} \right] \quad \text{(E2.6.30)}$$

Dixon and Rimmer note there are no data on the slopes of the capital supply functions at the industry level. However they obtain an idea of the overall sensitivity of capital growth attributable to variations in expected rates of return from investment functions in Australian macroeconometric models. This parameter, M, is read in as data, allowing the evaluation of the coefficient C_j^r as follows:

$$C_j^r = \left(\frac{1}{M} \right) \times \left[\frac{G_j^{(Max)r} - G_j^{(Min)r}}{\left(G_j^{(Trend)r} - G_j^{(Min)r}\right)\left(G_j^{(Max)r} - G_j^{(Trend)r}\right)} \right] \quad \text{(E2.6.31)}$$

The same approach is followed in FEDERAL-F, with the value of M being set equal to its value (which is 1) in the MONASH model.

2.6.13 Elimination of the residual between the initial rate-of-return and the capital supply schedule.

Recall that the expected actual rate of return on regional industry *j,r*'s capital in the current year ($R^{(ROR)r}_j$) is assumed to be the sum of both the equilibrium expected rate of return on regional industry *j,r*'s capital ($R^{(Eqm)r}_j$) and a measure of the deviation from the equilibrium expected rate of return on regional industry *j,r*'s capital ($R^{(Dis)r}_j$). The database values for expected rates of return (as given by the values for returns to capital, depreciation rates, and the real interest rate) need not accord with the equilibrium expected rate of return as given by the regional industry's capital supply function and the rate of growth in capital across the database year. That is, the database year value for $R^{(Dis)r}_j$ will be non-zero.

Following Dixon and Rimmer (1997), it is assumed that some proportion of the gap between the database year expected rate of return, and the equilibrium rate of return, is closed across the simulation year. Equation (E2.6.32) calculates each periods movement of expected rates of return towards the capital supply function:

$$R^{(Dis)r}_{j} = (1-\Phi^{r}_{j})\overline{R^{(Dis)r}_{j}} \qquad \text{(E2.6.32)}$$

Where:

Φ^{r}_{j} A parameter with a value between 0 and 1, and typically set at 0.5

$\overline{R^{(Dis)r}_{j}}$ The disequilibrium in rates of return in the database year.

The base solution for $R^{(Dis)r}_{j}$ is $\overline{R^{(Dis)r}_{j}}$. Hence, a form for Equation (E2.6.32) is required which is consistent with $R^{(Dis)r}_{j} = \overline{R^{(Dis)r}_{j}}$ in the base solution, but which also establishes the adjustment mechanism given by Equation (E2.6.32) when the model is shocked. This form is given by Equation (E2.6.33):

$$R^{(Dis)r}_{j} = \left(1-\Phi^{r}_{j}\right)\overline{R^{(Dis)r}_{j}} - \Phi\overline{R^{(Dis)r}_{j}}H^{(Dis)r} \qquad \text{(E2.6.33)}$$

In the base-year solution to the model, the value of $H^{(Dis)r}$ is -1, thereby establishing $\overline{R^{(Dis)r}_{j}}$ as the control solution for $R^{(Dis)r}_{j}$. When the model is simulated, $H^{(Dis)r}$ is shocked equal to 0, which establishes Equation (E2.6.32). Expressing Equation (E2.6.33) in rate of change format, and including the shift variable $\Delta F^{(Dis)r}_{j}$, provides:

$$\Delta R^{(Dis)r}_{j} = -\left[\Phi^{r}_{j}\overline{R^{(Dis)r}_{j}}\right]\Delta H^{(Dis)r} + \Delta F^{(Dis)r}_{j} \qquad \text{(E2.6.34)}$$

Making the obvious notational changes, Equation (E2.6.34) provides Equation *E_d_diseq* in Section 5 of Appendix A.

2.6.14 Checking that capital growth remains within its minimum and maximum bounds.

Dixon and Rimmer (1997) note that during a badly behaved simulation it is possible for G_j^r to stray outside of the limits imposed by $G_j^{(Min)r}$ and $G_j^{(Max)r}$. This presents a problem for the evaluation of Equation (E2.6.23), which requires the calculation of $\ln\left(G_j^r - G_j^{(Min)r}\right)$ and $\ln\left(G_j^{(Max)r} - G_j^r\right)$. Rather than allowing the computation to terminate, Dixon and Rimmer allow the computation to continue by resetting G_j^r to either $G_j^{(Min)r} + 0.005$, or $G_j^{(Max)r} - 0.005$, depending on whether the capital growth rate has strayed below $G_j^{(Min)r}$ or above $G_j^{(Max)r}$ respectively. To alert the user that the value for G_j^r has been reset, the following equations are then added to the model:

$$g_r^{(K\min)j} = D_r^{(Kmin)j} \times \Delta H^{(Chk)} \qquad \text{(E2.6.35)}$$

$$g_r^{(K\max)j} = D_r^{(Kmax)j} \times \Delta H^{(Chk)} \qquad \text{(E2.6.36)}$$

Making the obvious notational translations, these provide Equations *E_ch_kgr1* and *E_ch_kgr2* in Section 5 of Appendix A. These equations serve no function other than to alert the model user that the capital growth rates have strayed outside of the boundaries imposed by $G_j^{(Min)r}$ and $G_j^{(Max)r}$ - the variables $g_r^{(K\min)j}$ and $g_r^{(K\max)j}$ appear in no other equation in the model. The values for the coefficients $D_r^{(Kmin)j}$ and $D_r^{(Kmax)j}$ are set at zero, unless the capital growth rate either moves below $G_j^{(Min)r}$ (in which case $D_r^{(Kmin)j}$ is set equal to 1), or moves above $G_j^{(Max)r}$ (in which case $D_r^{(Kmax)j}$ is set equal to 1). The variable $\Delta H^{(Chk)}$ is shocked equal to 1. A problem in the computation of capital growth rates is then indicated for any regional industry where either $g_r^{(K\min)j}$ or $g_r^{(K\max)j}$ does not equal zero.

2.6.15 Post tax rental price of regional industry capital

The percentage change in the post-tax rental price of a unit of capital in regional industry *j,r* is given by FEDERAL Equation 53, and is reproduced in FEDERAL-F as Equation *E_p1cap* in Section 5 of Appendix A. Expressed in the levels format, Equation *E_p1cap* simply says that the post-tax rental value of a unit of capital in regional industry *j,r* is equal to the pre-tax rental price less the regional and Commonwealth taxes payable out of that rental. That is, using the original FEDERAL notation:

$$P_j^{(9)r} = P_{(g+1,2)j}^{(1)r} - P_{(g+1,2)j}^{(4)r} - P_j^{(7)r} - P_j^{(8)r} \quad \text{(E2.6.37)}$$

Where $P_j^{(9)r}$ is the post-tax rental price for regional industry capital, $P_{(g+1,2)j}^{(1)r}$ is the price paid by each regional industry for the rental of capital, $P_{(g+1,2)j}^{(4)r}$ is the Commonwealth income tax on returns to capital per unit of capital, $P_j^{(7)r}$ is the regional government residential land tax payable per unit of current capital in Dwellings, and $P_j^{(8)r}$ is the regional government commercial land tax payable per unit of current capital in the regional industry.

2.6.16 Changes in rates of return on regional industry capital stocks

To describe an expression for the present value of investing in a unit of capital in regional industry *j,r* I follow Dixon and Rimmer (1997) in assuming that the present value in year *t* of investing in a unit of capital in regional industry *j,r* ($PV_{(t)j}^{r}$) is equal to the post tax rental rate on that capital in the subsequent year ($P_{(t+1)j}^{(9)r}$), plus the scrap value of the unit of capital at the end of the subsequent year ($\Pi_{(t+1)j}^{r}\left(1-D_j^r\right)$, where $\Pi_{(t+1)j}^{r}$ is the price per unit of capital in *t*+1, and D_j^r is the depreciation rate), plus the tax advantage available from the depreciation of the capital ($F_{(g+1,2)j}^{(4)(t+1)}\Pi_{(t+1)j}^{r}D_j^r$, where $F_{(g+1,2)j}^{(4)(t+1)}$ is the effective Commonwealth income tax rate on returns to capital in *j,r*), all discounted by the tax-adjusted interest rate[48] ($R_{(t)}^{[Nom]}\left(1-F_{(g+1,2)j}^{(4)(t+1)}\right)$, where $R_{(t)}^{[Nom]}$ is the nominal interest rate in period *t*), less the cost of purchasing the capital in the current period ($\Pi_{(t)j}^{r}$). Hence:

[48] Note that depreciation and interest costs are assumed to only be deductable against Commonwealth income taxes.

$$PV^{r}_{(t)j} = \left[\frac{P^{(9)r}_{(t+1)j} + \Pi^{r}_{(t+1)j}\left(1 - D^{r}_{j}\right) + F^{(4)(t+1)}_{(g+1,2)j}\Pi^{r}_{(t+1)j}D^{r}_{j}}{\left(1 + R^{[Nom]}_{(t)}\left(1 - F^{(4)(t+1)}_{(g+1,2)j}\right)\right)} \right] - \Pi^{r}_{(t)j} \qquad \text{(E2.6.38)}$$

Equation (E2.6.38) is converted to an expression for the actual rate of return in year t on physical capital in regional industry j,r ($R^{(ROR)r}_{(t)\;j}$) by dividing both sides by $\Pi^{r}_{(t)j}$:

$$R^{(ROR)r}_{(t)\;j} = \left[\frac{P^{(9)r}_{(t+1)j} + \Pi^{r}_{(t+1)j}\left(1 - D^{r}_{j}\right) + F^{(4)(t+1)}_{(g+1,2)j}\Pi^{r}_{(t+1)j}D^{r}_{j}}{\Pi^{r}_{(t)j}\left(1 + R^{[Nom]}_{(t)}\left(1 - F^{(4)(t+1)}_{(g+1,2)j}\right)\right)} \right] - 1 \qquad \text{(E2.6.39)}$$

Static expectations are assumed to govern investors' expectations regarding rates of return. It is assumed that investors expect no change in the tax rate, and that post-tax rental rates, and asset prices, will increase by the current rate of consumer price inflation[49] ($\dot{p}$). Hence:

$$F^{(4)(t+1)}_{(g+1,2)j} = F^{(4)(t)}_{(g+1,2)j} \qquad \text{(E2.6.40)}$$

$$P^{(9)r}_{(t+1)j} = P^{(9)r}_{(t)j}\left(1 + \dot{p}\right) \qquad \text{(E2.6.41)}$$

$$\Pi^{r}_{(t+1)j} = \Pi^{r}_{(t)j}\left(1 + \dot{p}\right) \qquad \text{(E2.6.42)}$$

Given these assumptions, investors' static expectation of the actual rate of return on capital in regional industry j,r, is given by:

$$R^{(ROR)r}_{(t)\;j} = \left[\frac{P^{(9)r}_{(t)j}\left(1 + \dot{p}\right) + \Pi^{r}_{(t)j}\left(1 + \dot{p}\right)\left(1 - D^{r}_{j}\right) + F^{(4)(t)}_{(g+1,2)j}\Pi^{r}_{(t)j}\left(1 + \dot{p}\right)D^{r}_{j}}{\Pi^{r}_{(t)j}\left(1 + R^{[Nom]}_{(t)}\left(1 - F^{(4)(t)}_{(g+1,2)j}\right)\right)} \right] - 1 \qquad \text{(E2.6.43)}$$

or:

[49] Assuming that both post-tax rental rates and asset prices increase by the rate of consumer price inflation allows for the simplification of Equation (E2.6.43). A more accurate representation of static expectations would have investors' expectations of the change in post-tax rental rates and asset prices based on the historical rates of change of those variables themselves, rather than the historical rate of change of a general measure of price inflation such as the CPI.

$$R_{(t)\ \ j}^{(ROR)^r} = \frac{1}{\Pi_{(t)j}^r}\left[\frac{P_{(t)j}^{(9)r} + \Pi_{(t)j}^r\left(1 - D_j^r\right) + F_{(g+1,2)j}^{(4)(t)}\Pi_{(t)j}^r D_j^r}{\left(1 + R_{(t)}^{[Nom]}\left(1 - F_{(g+1,2)j}^{(4)(t)}\right)\right)/\left(1 + \dot{p}\right)}\right] - 1$$

or:

$$R_{(t)\ \ j}^{(ROR)^r} = \frac{1}{\Pi_{(t)j}^r}\left[\frac{P_{(t)j}^{(9)r} + \Pi_{(t)j}^r\left(1 - D_j^r\right) + F_{(g+1,2)j}^{(4)(t)}\Pi_{(t)j}^r D_j^r}{Y_{(t)j}^r}\right] - 1 \qquad \text{(E2.6.44)}$$

Where $Y_{(t),j}^r$ is the static expectation of the real post-tax discount factor, given by $\frac{\left(1 + R_{(t)}^{[Nom]}\left(1 - F_{(g+1,2)j}^{(4)(t)}\right)\right)}{\left(1 + \dot{p}\right)}$.

Converting (E2.6.44) to a rate of change format provides:

$$\begin{aligned}
&\left(100\Pi_{(t)j}^r Y_{(t)j}^r\right)\Delta R_{(t)\ \ j}^{(ROR)^r} = \\
&\left(P_{(t)j}^{(9)r} p_{(t)j}^{(9)r} + \left(\Pi_{(t)j}^r\left(1 - D_j^r\right)\right)\pi_{(t)j}^r + \left(F_{(g+1,2)j}^{(4)(t)}\Pi_{(t)j}^r D_j^r\right)\left(f_{(g+1,2)j}^{(4)r} + \pi_{(t)j}^r\right)\right) \\
&- \left(P_{(t)j}^{(9)r} + \Pi_{(t)j}^r\left(1 - D_j^r\right) + F_{(g+1,2)j}^{(4)(t)}\Pi_{(t)j}^r D_j^r\right)\left(\pi_{(t)j}^r + \Delta Y_{(t)j}^r\left(100 / Y_{(t)j}^r\right)\right)
\end{aligned} \qquad \text{(E2.6.45)}$$

Making the appropriate notational adjustments, Equation (E2.6.45) provides Equation *E_del_ror_se* in Section 5 of Appendix A.

2.6.17 Change in the discount factor

In Section 2.6.16 above the static expectation of the discount factor $Y_{(t)j}^r$ was defined as:

$$Y_{(t)j}^r = \frac{\left(1 + R_{(t)}^{[Nom]}\left(1 - F_{(g+1,2)j}^{(4)(t)}\right)\right)}{\left(1 + \dot{p}\right)} \qquad \text{(E2.6.46)}$$

Calculating the change in $Y_{(t)j}^r$ as a function of the change in the nominal interest rate ($\Delta R_{(t)}^{(Nom)}$), change in the rate of inflation ($\Delta\dot{p}$), and percentage change in the rate of capital taxation ($f_{(g+1,2)j}^{(4)r}$), provides:

$$100\Delta Y'_{(t)j} = \frac{1}{(1+\dot{p})}\left\{ \left[\left(1 - F^{(4)(t)}_{(g+1,2)j}\right)100\Delta R^{(Nom)}_{(t)} - F^{(4)(t)}_{(g+1,2)j} R^{[Nom]}_{(t)} f^{(4)r}_{(g+1,2)j}\right] - 100\frac{\left(1 + R^{[Nom]}_{(t)}\left(1 - F^{(4)(t)}_{(g+1,2)j}\right)\right)}{(1+\dot{p})}\Delta\dot{p}\right\} \quad \text{(E2.6.47)}$$

Making the appropriate notational conversions, this provides Equation *E_d_rint_pt_se* in Section 5 of Appendix A.

2.6.18 Change in the nominal rate of interest

Equation (E2.6.47) has introduced the rate of change in the nominal pre-tax rate of interest ($\Delta R^{(Nom)}_{(t)}$). Dixon and Rimmer (1997) define the real pre-tax rate of interest as:

$$\left(1 + R^{[Real]}_{(t)}\right) = \frac{\left(1 + R^{[Nom]}_{(t)}\right)}{(1+\dot{p})} \quad \text{(E2.6.48)}$$

Hence the nominal pre-tax rate of interest can be defined as:

$$R^{[Nom]}_{(t)} = \left(1 + R^{[Real]}_{(t)}\right)(1+\dot{p}) - 1 \quad \text{(E2.6.49)}$$

Converting (E2.6.49) to a rate of change format provides:

$$\Delta R^{[Nom]}_{(t)} = \left(1 + R^{[Real]}_{(t)}\right)\Delta\dot{p} + (1+\dot{p})\Delta R^{[Real]}_{(t)} \quad \text{(E2.6.50)}$$

Making the appropriate notational conversions, this provides Equation *E_d_int* in Section 5 of Appendix A.

2.6.19 The change in the rate of inflation

Equation (E2.6.50) requires that the change in the rate of inflation be calculated. The level of inflation can be defined by the following formula:

$$\dot{p} = \frac{\Xi^3_{(t)}}{\Xi^3_{(t-1)}} - 1 \qquad \text{(E2.6.51)}$$

Where $\Xi^3_{(t)}$ and $\Xi^3_{(t-1)}$ are the levels of the consumer price index at the start of the current and previous years respectively. Converting (E2.6.51) to a rate of change format provides:

$$100\Delta\dot{p} = \frac{\Xi^3_{(t)}}{\Xi^3_{(t-1)}}\left[\xi^3_{(t)} - \xi^3_{(t-1)}\right] \qquad \text{(E2.6.52)}$$

or:

$$100\Delta\dot{p} = \left(1+\dot{p}\right)\left[\xi^3_{(t)} - \xi^3_{(t-1)}\right] \qquad \text{(E2.6.53)}$$

Where $\xi^3_{(t)}$ is the percentage deviation in the level of the consumer price index in year t from its initial solution for year t, and $\xi^3_{(t-1)}$ is the percentage deviation in the lagged value of the consumer price index in year t from its value in the initial solution for year t. The variable $\Delta\dot{p}$ is the deviation in the rate of inflation in year t from its value in the initial solution for year t. Making the appropriate notational adjustments to Equation (E2.6.53) provides Equation *E_d_inf* in Section 5 of Appendix A.

2.6.20 The percentage change in the lagged rate of inflation

The percentage change in the lagged rate of inflation has been introduced into Equation (E2.6.53) above. Dixon and Rimmer note that this variable is essentially an exogenous variable, however its value can be computed within the model on the basis of certain database values for the lagged level of the consumer price index. If $\xi^3_{(t-1)}$ were to be calculated exogenously in year-on-year simulations, it would be calculated as follows:

$$\xi^3_{(t-1)} = 100\left[\frac{\Xi^{3[B]}_{(t)}}{\Xi^{3[B]}_{(t-1)}} - 1\right] \qquad \text{(E2.6.54)}$$

Where $\Xi^{3[B]}_{(t-1)}$ and $\Xi^{3[B]}_{(t)}$ are the base solutions for the CPI at the beginning and at the end respectively, of the year t-1.

In the levels, the change in the level of the CPI in the year t-1 ($\Xi^{3}_{(t-1)}$) from its base solution ($\Xi^{3[B]}_{(t-1)}$) can be expressed as:

$$\Xi^{3}_{(t-1)} - \Xi^{3[B]}_{(t-1)} = \left[\Xi^{3[B]}_{(t)} - \Xi^{3[B]}_{(t-1)}\right]H^{\Xi 3} + F^{\Xi 3}_{(t-1)} \qquad \text{(E2.6.55)}$$

where, in the solution for year t $\Xi^{3[B]}_{(t-1)}$ and $\Xi^{3[B]}_{(t)}$ are parameters which are fixed equal to the database values for $\Xi^{3}_{(t-1)}$ and $\Xi^{3}_{(t)}$ respectively. The variables $H^{\Xi 3}$ and $F^{\Xi 3}_{(t-1)}$ are assigned a zero value in the initial solution for year t, thereby establishing an initial solution for t which satisfies the requirement that the base solution for $\Xi^{3}_{(t-1)}$ is $\Xi^{3[B]}_{(t-1)}$. The percentage change version of (E2.6.55) is provided by:

$$\Xi^{3}_{(t-1)}\xi^{3}_{t-1} = 100\left[\Xi^{3[B]}_{(t)} - \Xi^{3[B]}_{(t-1)}\right]\Delta H^{\Xi 3} + 100\Delta F^{\Xi 3}_{(t-1)} \qquad \text{(E2.6.56)}$$

Which is Equation *E_cpi_l* in Section 5 of Appendix A. By shocking $\Delta H^{\Xi 3}$ equal to 1 and setting $\Delta F^{\xi 3}_{(t-1)}$ exogenously at zero, Equation (E2.6.56) generates a solution for $\xi^{3}_{(t-1)}$ compatible with Equation (E2.6.54).

2.6.21 The composition of investment by regional industry

The total gross fixed capital formation in a given regional industry will be the sum of gross fixed capital expenditure by both private investors and each of the two levels of government. Equation *E_y_kap* is the percentage change form of this relationship. It expresses the percentage change in gross fixed capital formation in regional industry j,r ($y\_p56_{j,r}$) as the weighted sum of the percentage rates of change in gross fixed capital formation by private investors ($y\_kap_{j,r}$), the Commonwealth Government ($y\_cgk_{j,r}$), and regional government r ($y\_sgk_{j,r}$). The share weights attached to each of these variables are simply the share of total investment represented by the investment of each respective investor type.

2.6.22 Equations to facilitate the exogenous determination of industry investment in the historical closure

Equations *E_y_sr*, *E_y_tr*, *E_fy_p56*, *E_fyt_p56*, *E_y_s*, *E_y_nat*, *E_fy_nat*, *E_fd_f_eeqror_jr*, *E_fd_f_eeqror_j*, and *E_tfd_f_eeqror_jr* provide a number of options for the exogenous determination of sectoral investments, both at the national and regional levels, under the historical closure. The model user essentially has two sets of choices: the first relating to the choice of sectoral definitions the investments of which will be determined exogenously; and the second relating to the manner in which industry level investments adjust to reconcile with the exogenously determined sectoral investments.

With respect to the first set of choices, essentially three definitions of sectoral investment are available to choose from. The first two recognise 21 sectors for which investment data are available at the national level. Investment for each of these sectors is defined at the regional level (by Equation *E_y_sr*) and at the national level (by Equation *E_y_s*). However in practice sectoral investment data for Tasmania is only readily available for 10 sectors. To accommodate these data, Equation *E_y_tr* defines regional investment for each of these broad sectors.

With respect to the second set of choices, the model user is faced with two options. The first option broadly follows that used in MONASH for exogenising national sectoral investments. This option (hereafter "Option 1") constrains the percentage change in the investment in each industry within a given investment sector to equal the exogenously specified percentage change in that sector's aggregate investment. The second option (hereafter "Option 2") also involves the exogenous specification of sectoral investments, but allows the distribution of that investment among the industries of which each sector is comprised to vary in response to differences in expected rates of return. Each of these approaches is described below.

At the national level, data on gross fixed capital formation are available for 21 sectoral groups for each year between 1992/93 and the 1998/99 (See Section 4.4.3). These sectors correspond to the elements of the set XIND. The variable $y\_sr_{s,r}$ ($s \in$ XIND) defines the percentage change in gross fixed capital expenditure by sector s in region r. This variable is calculated by Equation *E_y_sr*. For Tasmania, data on gross fixed capital formation were only readily available for a broad 10 sector classification (See Section 4.4.3). These sectors correspond to the set INDT. The variable $y\_tr_{t,r}$ ($t \in$ INDT) defines the percentage change in gross fixed capital expenditure in sector *t* in region *r*. This variable is calculated by Equation *E_y_tr*.

The notation used in both Equation *E_y_sr* and *E_y_tr* requires further explanation. Since the basic structure of both equations is the same, a description of the notation in Equation *E_y_sr* serves to elucidate the notation of both equations. The qualifier on the summation operator in this equation restricts the operation to those *j* elements of the set IND that are subsumed within sector *s* (that is, are elements of the set SNO_S). Hence the coefficient on the left hand side of Equation *E_y_sr* represents the base level of gross fixed capital formation in sector *s* in region *r*. With *yshift* equal to zero, Equation *E_y_sr* can be seen then to be calculating the percentage change in gross fixed capital formation in sector *s* in region *r* as the share weighted sum of the percentage changes in the gross fixed capital formation of those industries *j*, within region *r*, that are classified within sector *s*. The share of region *r* sector *s* investment represented by investment by regional industry *j,r* gives the relevant share weights for this equation.

The variable *yshift*, appearing in both Equation *E_y_sr* and *E_y_tr*, allows total investment as given by the share weighted sum of regional industry investments, $y\_p56_{j,r}$, to diverge from total investment as given by the share-weighted sum of regional sectoral investments, $y\_sr_{s,r}$ and $y\_tr_{t,r}$. As is discussed in more detail below, this variable plays a role in historical simulations in which both economy-wide real gross fixed capital expenditure (*x2nat*) and national sectoral investments (y_s_s) are determined exogenously. However, under the standard comparative static closure of the model, *yshift* is exogenous and zero. Under this same closure, the variables $y\_sr_{s,r}$ and $y\_tr_{t,r}$ are both endogenous. These variables do not exert an influence on the model solution under the comparative static closure (only $y\_sr_{s,r}$ appears elsewhere in the model, in Equation *E_y_s*).

The percentage change in economy-wide gross fixed capital formation within sector *s* is given by the variable y_s_s. Equation *E_y_s* calculates the percentage change in this variable as the share weighted sum of the percentage changes in gross fixed capital formation within regional sectors ($y\_sr_{s,r}$). The variable y_s_s is endogenous under the comparative static closure. The variable does not appear elsewhere in the model, and so exerts no influence on the model solution under this closure.

The percentage change in economy-wide gross fixed capital formation within industry j is given by the variable y_nat_j. Equation *E_y_nat* calculates the percentage change in this variable as the share weighted sum of the percentage changes in gross fixed capital formation within regional industries ($y\_p56_{j,r}$).

Equations *E_fy_p56*, *E_fyt_p56*, and *E_fy_nat* provide the first ("Option 1") of the two possible links between sectoral investments and industry investments. Equation *E_fy_p56* represents the percentage change in regional industry investments ($y\_p56_{j,r}$) as the sum of regional industry specific shift variables ($fy\_p56_{j,r}$) and exogenous regional sectoral specific shift variables ($fy\_sr_{s,r}$). The summation operator ensures that any movements in $fy\_sr_{s,r}$ are transmitted to those elements of j that are effectively mapped to s via the value of the single element in each of the j sets JNO$_j$. Each of these j sets contains a single integer value from 1 through to s. Equation *E_fyt_p56* has the same form as Equation *E_fy_p56*, except that it provides a mapping between regional industry investments ($y\_p56_{j,r}$) and regional sectoral investments in the set INDT (via movements in $fy\_tr_{t,r}$). Similarly, Equation *E_fy_nat* has the same general form as both *E_fy_p56* and *E_fyt_p56*. However the former equation represents the percentage change in national (rather than regional) industry investments (y_nat_j) as the sum of national industry-specific shift variables (fy_nat_j) and exogenous national sectoral shift variables (fy_s_s). Under the standard short-run comparative-static closure of the model, the shift variables $fy\_p56_{j,r}$, $fyt\_p56_{j,r}$, and fy_nat_j appearing in Equations *E_fy_p56*, *E_fyt_p56*, and *E_fy_nat* are endogenous. These variables do not appear elsewhere, and so their endogenous status effectively removes these three equations from the model.

Equations *E_fd_eeqror_jr*, *E_tfd_f_eeqror_jr*, and *E_fd_eeqror_j*, provide the second ("Option 2") of the two possible links between sectoral investments and industry investments. These equations define the regional industry ($d\_f\_eeqror\_jr_{j,r}$) and national industry ($d\_f\_eeqror\_j_j$) vertical shifts in regional industry capital supply functions as the sum of various industry and sectoral shift variables. Under the standard comparative static closure, $fd\_f\_eeqror\_jr_{j,r}$, $tfd\_f\_eeqror\_jr_{j,r}$, and $fd\_f\_eeqror\_j_j$ are endogenous, rendering these three equations inoperative. The operation of these equations under the historical closure is described below.

In the historical simulations, the variables y_s_s are set exogenous, and shocked equal to the values that they were observed to have attained over the historical period in question (see Section 4.4.3). The shift variables fy_s_s (appearing in Equations *E_fy_nat* and *E_fd_f_eeqror_j*) are set endogenous to ensure that the values for $y\_p56_{j,r}$ in Equation *E_y_sr* are compatible with the exogenously determined values for national sectoral investments. However, before this can be so, either Equation *E_fy_nat* (Option 1) or Equation *E_fd_f_eeqror_j* (Option 2) must be brought into operation. Option 1 is implemented by setting exogenous the shift variables fy_nat_j. With industry investments at the national level (y_nat_j) now determined by Equation $E\_fy\_nat_j$, the relationship between industry rates of return and industry investment given by Equation *E_d_f_eeqror_jr* must be broken by setting endogenous the shift variables on the positions of the industry capital supply functions ($d\_f\_eeqror\_j_j$). Note that under Option 1, with Equation *E_fy_nat* operational, the percentage rate of change in the investment of each national industry (y_nat_j) is equal to the percentage rate of change in the aggregate investment of the sector (y_s_s) of which it forms a part. The vertical positions of individual regional industry capital supply schedules ($d\_f\_eeqror\_j_j$) are determined endogenously to accommodate this.

An alternative to Option 1 is to impose identical vertical shifts to the capital supply functions of all industries within each investment sector, while allowing individual industry investments to respond to differences in expected rates of return. Option 2, which allows this, can be implemented by setting the shift variables $fd\_f\_eeqror\_j_j$ exogenous, instead of the shift variables fy_nat_j. This brings Equation *E_fd_f_eeqror_j* into operation. With this equation operational, the shift variable fy_s_s provides uniform shifts to the vertical positions of the capital supply functions ($d\_f\_eeqror\_j_j$) of all industries within a given investment sector in order to accommodate the exogenous setting of y_s_s. This approach allows the industrial composition of sectoral investments to vary while still allowing for the exogenous determination of sectoral investment. This is my preferred approach, and is the one implemented in the simulations reported in Chapter 4.

Under either Option 1 or Option 2, with economy-wide real investment effectively determined by the exogenous determination of regional sectoral investment, there can be no indexing relationship determining economy-wide investment in operation. Typically, this will require that the real investment / real GNE indexing parameter (*r_ir_rgne*) be set endogenous, and the economy-wide shift variable on the capital supply functions (*d_f_eeqror*) be set exogenous.

Under the foregoing closure, there may be a small divergence between aggregate national gross fixed capital formation as calculated by the model (*x2nat*) and that given by the Australian Bureau of Statistics. This divergence may arise because of small differences between the model's database and ABS data on industry shares in total investment. To ensure that aggregate national real gross fixed capital formation is equal to the ABS estimate for the same, the variable *x2nat* is set exogenous, and the variable *yshift* is set endogenous under the historical closure. The exogenous determination of aggregate national investment in this way does not introduce any closure-related problems (outside of Equation *E_y_sr*), since the positions of all industry capital supply schedules are endogenous. The variable *yshift* in Equation *E_y_sr* then allows the weighted sum of the model-determined regional industry investments (y_p56_{j,r^*}) to diverge from the weighted sum of the sectoral regional industry investments. That is, the variable *yshift* allows Equation *E_y_sr* to continue to function in a situation where aggregate investment as determined by the exogenously provided sectoral investments diverges from aggregate investment as determined by the share weighted sum of regional industry investments. Effectively, *yshift* provides a uniform shift to the otherwise exogenous sectoral investments in order to accommodate the exogenous status of *x2nat*.

The final set of swaps undertaken in the historical simulation relate to the exogenous determination of sectoral investments for the region of focus, which in the simulations reported in Chapter 4, is Tasmania. The model theory allows for the exogenous determination, for one region, of sectoral investments for sectors in either the set XIND or the set INDT. In practice, data on gross fixed capital formation in Tasmania from the Australian Bureau of Statistics is available for the elements of INDT (See Section 4.4.3). However, in general, sectoral gross fixed capital formation for one region ($y\_sr_{s,r}$ or $y\_tr_{t,r}$) is set exogenous by setting endogenous the corresponding elements of either $fy\_sr_{s,r}$ in Equation *E_fy_p56* (if $y\_sr_{s,r}$ is determined exogenously) or $fy\_tr_{t,r}$ in Equation *E_fyt_p56* (if $y\_tr_{t,r}$ is determined exogenously). Then one of either, Equation *E_fy_p56* or *E_fty_p56* (if Option 1 is being implemented) or Equation *E_fd_f_eeqror_jr* or *E_tfd_f_eeqror_jr* (if Option 2 is being implemented) is brought into operation. Option 1 is implemented by setting endogenous the appropriate elements of $d\_f\_eeqror\_jr_{j,r}$ and setting exogenous the corresponding elements of either $fy\_p56_{j,r}$ (if $y\_sr_{s,r}$ is determined exogenously) or $fyt\_p56_{j,r}$ (if $y\_tr_{t,r}$ is determined exogenously). Option 2 is implemented by setting endogenous the appropriate elements $d\_f\_eeqror\_jr_{j,r}$ and setting exogenous the corresponding elements of $fd\_f\_eeqror\_jr_{j,r}$ (if $y\_sr_{s,r}$ is determined exogenously) or $tfd\_f\_eeqror\_jr_{j,r}$ (if $y\_tr_{t,r}$ is determined exogenously).

2.6.23 Demands for source-specific commodities for capital formation

Demands for commodity and source-specific inputs to capital creation in FEDERAL-F are described by Equations *E_x2A* and *E_x2B*. The structure of each of these equations is based on that of FEDERAL Equation 11. The reader is referred to Madden (1990) for a discussion of the derivation of the basic form of this equation. The key difference between Equations *E_x2A* and *E_x2B* and FEDERAL Equation 11 is the addition of the domestic / foreign twist terms, and inter-regional twist terms. These terms impart cost-neutral changes in the technology associated with the assembly of effective units of each commodity for input to capital creation by each regional industry. A detailed discussion of the derivation and application of these variables is provided in Section 2.18.

2.6.24 Technical change in source-specific commodity usage for capital formation

Technical change in the usage of source specific commodities for capital creation, $a2isjr_{i,s,j,r}$, is defined by Equation *E_a2isjr* as the sum of a number of shift variables. First, the technical change can be expressed as change that is unique to the usage of particular source-specific commodities by a given regional industry via shifts in the appropriate elements of $f\_a\_mat2_{i,s,j,r}$. Also, economy-wide and region-specific movements in the efficiency with which commodity i is used in general operates on commodity using technical change in capital formation via movements in ai_i and $ais_{i,s}$ respectively.

2.6.25 Investment budgets and investment price indices

The FEDERAL model allows the model user to choose between a macroeconomic environment in which one of either private investment expenditure, or total investment expenditure, is constrained. In the latter case, government investment crowds out private investment. The equations that facilitate this choice of closure have been retained in FEDERAL-F. FEDERAL Equation 56 (FEDERAL-F Equation *E_i_wide*) equates the percentage change in economy-wide private investment spending with the weighted-sum of the percentage rates of change in nominal investment expenditure by regional industries within the set of endogenous investment industries. The weights are given by the share in economy-wide private investment spending of investment in endogenous investment industry *j,r*. FEDERAL Equation 57 (FEDERAL-F Equation *E_i_priv*) equates the percentage change in the nominal value of private investment spending in region *r* as the weighted sum of nominal investment spending in endogenous investment industries within region *r*. The share weights are given by the share in total region *r* private investment expenditure of investment in endogenous investment industry *j*. Equation *E_i_aust* (FEDERAL Equation 58) constrains the share weighted sum of the percentage changes in nominal investment by the private sector, regional governments, and the Commonwealth government, to equal the percentage change in economy-wide nominal investment expenditure. The weights in this equation are the shares of the relevant type of investment within each regional industry in total economy-wide investment.

Equations *E_ipi_r* (FEDERAL Equation 75) and *E_ipi* (FEDERAL Equation 76) define, respectively, the percentage rates of change in the regional and national private investment price indices. Equations *E_i_rr* (FEDERAL Equation 62) and *E_i_real* (FEDERAL Equation 63) then define, respectively, the percentage rates of change in real regional and real national private investment budgets by deflating the nominal measures of such by these price deflators. The percentage rate of change in the real aggregate economy-wide investment budget is defined in FEDERAL-F by adding Equation *E_i_aust_R*, which deflates the nominal aggregate investment budget by the appropriate price deflator.

2.7 REGIONAL GOVERNMENT FINANCES

2.7.1 Overview

The FEDERAL model distinguishes two levels of government: the Commonwealth Government, operating economy-wide; and regional governments, whose jurisdiction is limited to the region in which they are located. This division is maintained in FEDERAL-F. Regional governments represent an amalgam of the taxing and spending activities of the state and local government levels. Table 2.7.1 provides a convenient listing of these taxing and spending powers, as they are summarised within the FEDERAL-F model. As is clear from this table, FEDERAL-F distinguishes eleven categories of regional government receipt, and five categories of regional government outlay. The equations in Section 6 of Appendix A describe the determination of the aggregate values for each of these receipts and outlays, and the rates of tax and levels of real outlays that underpin them. Full accounting of the year-on-year change in the net asset position of each regional government is also undertaken, with this then linked to the net value of their outstanding debt. The structure of the equations describing Commonwealth and regional government debt accumulation is very similar, and so both sets of equations are dealt with jointly in Section 2.9 of this chapter.

2.7.2 Regional government borrowing requirements

Equation *E_cb1r* calculates the change in the nominal public sector borrowing requirement of region r in the simulation year ($cb1r_r$). The form of this equation is unchanged from that which served the same function in the original FEDERAL model, Equation 124. A measure of the change in the real value of regional government r's borrowing requirement is evaluated by Equation *E_real_cb1r* by deflating both revenues and outlays by the regional government consumption price deflator ($p5reg_r$).

Table 2.7.1: Categories of the regional government accounts

Transaction	*Matrix*	*Dimensions*
Receipts:		
1. Payroll Tax	SGR1	2x1
2. Residential taxes	SGR2	2x1
3. Commercial land taxes	SGR3	2x1
4. Fees, fines, etc	SGR4	2x1
5. Commonwealth payments	SGR5	2x1
6. Commodity taxes	SGR6	2x1
7. Production taxes	SGR7	2x1
8. Other receipts	SGR8	2x1
9. Exogenous foreign receipts	SGR9	2x1
10. Receipts from GBE's	$\sum_j MV1_{sgov,j,r}$	2x1
11. Receipts from phantom taxes	(various)	na.
Outlays:		
1. Current outlays	SGO1	2x1
2. Capital formation	SGO2	2x1
3. Transfers to persons	SGO3	2x1
4. Exogenous foreign outlays	SGO4	2x1
5. Net foreign interest payments	OSIR	2x1

2.7.3 Nominal aggregate regional government outlays

Equation *E_b5r* is the percentage change form of the accounting relationship between aggregate regional government *r* outlays, and the individual outlays of which it is the sum. Aggregate regional government *r* outlays are the sum of expenditures on: i. current consumption expenditure; ii. capital expenditure; iii. transfers to persons; iv. net interest on the government's net debt; and v. residual outlays. The form of this equation is little changed from FEDERAL Equation 111. The chief differences between the two equations are that Equation *E_b5r* now contains explicit treatment of net interest outlays in a manner which links them to the current stock of regional government r net debt, and the category of exogenous foreign outlays has been added.

2.7.4 Nominal aggregate regional government receipts

Equation *E_sgrev_tot* defines the percentage change in the aggregate receipts of regional government r ($sgrev\_tot_r$) as the weighted sum of the percentage changes in its component parts. These component parts are: payroll tax receipts ($sgptr_r$); residential land tax receipts ($rltax_r$); commercial land tax receipts ($cltax_r$); receipts from household income-reducing taxes ($b34r_r$); transfers from the Commonwealth Government ($b36r_r$); production tax receipts ($b37r_r$); other regional government receipts ($b38r_r$); profits from government business enterprises ($sgbedpi_r$); residual receipts (r_rcpts_r); and phantom tax receipts ($phant\_rgov_r$). Equation *E_sgrev_tot* is little changed from Equation 114 in the FEDERAL model. The chief differences are that Equation *E_sgrev_tot* now includes in the total receipts of regional government r returns from their ownership of physical capital, the regional government's share of phantom tax receipts, and exogenous foreign receipts.

2.7.5 Payroll tax receipts

Equation 111 in the FEDERAL model calculates the percentage change in regional government r's payroll tax receipts as the weighted sum of the percentage changes in the payroll tax receipts collected on each skill class in each industry within region r. This equation is adopted unchanged in FEDERAL-F, and is represented by Equation *E_sgptr* in Section 6 of Appendix A.

2.7.6 Residential land tax receipts

Residential land tax in both FEDERAL and FEDERAL-F is levied on the capital stock of the Dwellings industry. Equation *E_rltax* equates the percentage change in residential land tax receipts to the sum of the percentage changes in the residential land tax rate and the percentage change in the stock of capital in the Dwellings industry. This treatment is unchanged from that in the FEDERAL model, as represented by Equation 116 in Madden (1990).

2.7.7 Commercial land tax receipts

Equation *E_cltax* defines the percentage change in the commercial land tax receipts of regional government *r*. This equation is identical to Equation 117 in the FEDERAL model. Like Equation 117, the percentage change in current capital stocks ($cap\_at\_t_{j,r}$) appears in Equation *E_cltax* as a proxy for the percentage change in the quantity of commercial land. Hence, the percentage change in commercial land tax receipts for any given regional industry is equal to the sum of the percentage rates of change in the current capital stock of that industry and the commercial land tax per unit of that capital. The percentage change in the commercial land tax receipts of regional government *r* is equal to the weighted sum of the percentage changes in the commercial land tax collected from each industry within its region of jurisdiction. The share weights are given by the share in the total commercial land tax collections of regional government *r* of commercial land tax collections from regional industry *j*,*r*.

2.7.8 Receipts of other income-reducing taxes

Other income reducing taxes cover those regional government revenue sources that either operate directly to reduce household disposable income or are otherwise not levied on a base that finds convenient expression as an existing FEDERAL variable. These taxes are principally composed of fees and fines. Like their treatment in FEDERAL (Equation 118), Equation *E_b34r* indexes the value of the receipts of such revenue by regional government *r* to the nominal gross income of the households of region *r*. Unlike Equation 118, a general regional government tax shifter (tax_shiftr_r) is appended to Equation *E_b34r* to facilitate certain closures of the regional government accounts during forecasting and policy simulations of the model.

2.7.9 Receipts of Commonwealth grants

FEDERAL Equation 119 equates the percentage change in regional government *r*'s receipts of Commonwealth grants to the percentage change in the Commonwealth's outlays on such grants to region *r*. FEDERAL Equation 119 is reproduced in FEDERAL-F as Equation *E_b35r*.

2.7.10 Commodity tax receipts

Equation *E_b36r* calculates the percentage change in regional government *r*'s total collections of commodity tax revenue as the weighted sum of the commodity tax collections on transactions associated with purchasers by current producers, capital creators, and households. This equation is essentially unchanged from FEDERAL Equation 120.

2.7.11 Production tax receipts

FEDERAL Equation 121 calculates the percentage change in regional government *r*'s production tax receipts as the weighted sum of the percentage rates of change in the production tax paid by each industry within its jurisdiction. FEDERAL Equation 121 is reproduced in FEDERAL-F as Equation *E_b37r*. The percentage change in the production tax payable by regional industry *j,r* is equal to the sum of the percentage rates of change in both the per-unit production tax faced by the regional industry ($spptax_{j,r}$) and the "demand" for regional government production tax units by that regional industry ($xsptax_{j,r}$). The weights in Equation *E_b37r* represent the share in total production tax collections of regional government *r* of production tax collections from regional industry *j,r*.

2.7.12 Other regional government receipts

FEDERAL Equation 122 indexes the percentage change in regional government *r*'s receipts of other revenue to the percentage change in the national consumer price index. This equation is reproduced in FEDERAL-F as Equation *E_b38r*. The sole difference between FEDERAL Equation 122 and FEDERAL-F Equation *E_b38r* is that appended to the latter is the general regional government tax shifter (tax_shiftr_r). This variable facilitates the establishment of certain closures of the regional government accounts during forecasting and policy simulations of the model.

2.7.13 Dividend receipts from regional government business enterprises.

Equation *E_sgbedpi* calculates the percentage change in regional government *r*'s receipts from its ownership of capital as the weighted sum of the percentage changes in the gross rentals accruing on the capital in each industry in *r*. The weights are given by the share of regional government *r*'s rental receipts from regional industry *j,r* in the total rental receipts of regional government *r*.

2.7.14 Residual regional government receipts

The category of residual regional government receipts has been added to the FEDERAL-F model to facilitate the tracking of regional government financing requirements. The database value for these receipts is set in the base-year so that aggregate regional government receipts accord with the ABS data on the same. The percentage change in the foreign currency value of these receipts is defined by Equation *E_r_rcpts*. This equation simply defines r_rcpts_r as the sum of two shift variables: one ($f\_r\_rcpts_r$) which is unique to this equation, and another (fni_shift_r) which also appears (with a reverse sign) on the equation defining residual regional government outlays (*E_res_out*). Both of these shift variables are typically exogenous under the standard comparative static closure of the model. However, under the historical closure, when *cb1r* is determined exogenously, the shift variable *fni_shift* is determined endogenously.

2.7.15 Current consumption spending by regional government *r*

In the original FEDERAL model, the demands by regional government *r* for commodities for current consumption were treated as exogenous variables. To provide more flexibility in the closure options available for the regional government accounts during historical and forecasting simulations, it is convenient in the FEDERAL-F model to determine the percentage change in regional government current consumption outlays on source-specific commodities ($x\_sg_{i,s,r}$) endogenously via Equation *E_x_sg*, as the sum of the percentage changes in: a general shifter on regional government *r* expenditures, (exp_shift_r); a general shifter on government *r*'s consumption expenditure, ($f\_x\_sg_r$); a government-wide current consumption shift variable (f_govcon_gen) and commodity- and source-specific shift variables, ($x\_sgcon_{i,s,r}$).

2.7.16 Regional government *r* capital outlays

Gross fixed capital expenditure by regional government *r* in regional industry *j,r* in the FEDERAL model is determined by Equation 60, which specifies an indexing relationship between such investment and real regional private sector investment. Equation 60 is omitted from FEDERAL-F. Instead, the percentage change in regional government *r*'s gross fixed capital formation in regional industry *j,r* ($y\_sgk_{j,r}$), is determined endogenously via Equation *E_y_sgk* as the sum of a regional industry specific shift variable on capital formation by regional government *r* ($f\_y\_sgk_{j,r}$); an industry-wide shift variable on real gross fixed capital expenditure by regional government *r* ($f\_sg\_invest_r$); and a general shifter on regional government *r* expenditures (exp_shift_r).

2.7.17 Transfers to persons by regional government *r*

In the FEDERAL model, the percentage change in regional government *r*'s nominal outlays on transfers to persons is defined by Equation 112. This specifies an indexing relationship between such outlays and the national consumer price index. Equation 112 remains largely unchanged in FEDERAL-F as Equation *E_t51*, the sole change being the addition to the equation of the general regional government *r* expenditure shift variable (exp_shift_r).

2.7.18 Residual regional government outlays

The category of residual regional government outlays has been added to the FEDERAL-F model to facilitate the exogenous determination of regional government financing requirements. The database value for these outlays is set in the base-year so that aggregate regional government outlays accord with the ABS data on the same. Equation *E_res_out* defines the percentage change in the foreign currency value of these outlays. This equation simply defines res_out_r as the sum of two shift variables. The first of these ($fres\_out_r$) is unique to Equation *E_res_out*. The second (fni_shift_r) also appears in Equation

E_r_rcpts, although with the opposite sign to that with which it appears in Equation *E_res_out*. The latter shift variable is determined endogenously in historical simulations of the model, when regional government net financing requirements (*cb1r*) are determined exogenously.

2.7.19 Specific and general determination of sales tax rates

The FEDERAL model recognises regional government commodity taxes levied on intermediate input users (Equation 48), capital creators (Equation 49), and households (Equation 50). These are reproduced in FEDERAL-F as Equations *E_g_sint* and *E_g_stax*. The terms allowing for ad-valorem treatment of sales taxes in each of these equations ($ts0\_ind_{i,s,r,k}$ and $ts\_hous_{i,s,r}$) are exogenous in the standard closure of the FEDERAL model. Equations *E_ts0_ind* and *E_ts_hous* have been added to FEDERAL-F to allow for the endogenous determination of these sales tax terms. The first of these ($salestax_r$) allows for uniform shocks to the ad-valorem sales tax rates applying to all source specific commodities used within region *r*. Each equation also has a shift term with the same dimensions as that equation's sales tax shift term ($fts0\_ind_{i,s,r,k}$ and $fts\_hous_{i,s,r}$ in Equations *E_ts0_ind* and *E_ts_hous* respectively).

Under the structural closure the ad-valorem sales tax terms $ts0\_ind_{i,s,r,k}$ and $ts\_hous_{i,s,r}$ are endogenous, and the shift terms $salestax_r$, $fts0\_ind_{i,s,r,k}$, and $fts\_hous_{i,s,r}$ are exogenous.

In historical simulations the variables measuring regional government commodity tax receipts ($b36r_r$) are set exogenous, and the region-wide ad-valorem sales tax rate shift terms ($salestax_r$) are set endogenous. These variables then impart uniform shifts to the rates of sales tax faced by all users on all commodities from all sources.

2.7.20 Regional government *r* production tax rate

The regional government production tax rate per unit of output ($spptax_{j,r}$) is determined by Equation 87 in the FEDERAL model via an indexing relationship with the regional consumer price index. This relationship has been retained in FEDERAL-F Equation *E_spptax*. However to this has been added a regional industry wide shift term ($fprodr_r$) in order to facilitate the exogenous determination of the total production tax receipts of regional government r ($b37r_r$), the general regional government tax rate shift variable (tax_shift_r), and the regional industry specific shift term ($fprodrj_{r,j}$).

Under the structural closure $spptax_{j,r}$ and $b37r_r$ are endogenous, and $fprodrj_{j,r}$, $fprodr_r$, and tax_shift_r are exogenous. In an historical simulation, $b37r_r$ is set exogenous, and the production tax rate shift variables $fprodr_r$ are set endogenous.

2.7.21 Residential and commercial land taxes per unit of current capital

In the FEDERAL model, residential and commercial land taxes paid per unit of current capital in each regional industry are determined by equations 95 and 96 respectively via an indexing relationship with the regional industry rental price of capital. These equations have been retained largely unchanged in FEDERAL-F as equations *E_pres_tax* and *E_pcom_tax* respectively (Section 6 of Appendix A). The chief difference between the form of these equations is the addition to each in FEDERAL-F of the uniform shift variable on the rates of all regional government r's taxes (tax_shiftr_r). An industry-wide shifter ($fcom\_taxr_r$) on the per-unit commercial land tax payable has also been added to Equation *E_pcom_tax* to facilitate the exogenous determination of total receipts of commercial land taxes by regional government r ($cltax_r$) during the historical simulations.

2.7.22 Flexible determination of regional government sales taxes

The FEDERAL model contains two equations (48 and 50) that allow the model user to choose whether the per-unit value of regional government sales taxes are to be set in real, ad-valorem, or specific terms. These equations are retained unchanged in FEDERAL-F. FEDERAL-F Equation *E_g_sint* corresponds to FEDERAL Equation 48, and FEDERAL-F Equation *E_g_stax* corresponds to FEDERAL Equation 50. The manner of setting the form of tax is identical in each equation: one of the three coefficients is set equal to 1, with the remaining two set equal to zero. Setting the first coefficient equal to 1 corresponds to maintaining the real value of the per unit tax. Setting the second coefficient equal to 1 corresponds to establishing an ad-valorem treatment of the tax. Setting the third coefficient equal to 1 establishes the specific treatment of the per unit tax. The reader is referred to Madden (1992) for a more detailed discussion of the operation of these equations.

2.7.23 Regional government *r*'s debt to GRP ratio

In the levels, regional government *r*'s debt to gross regional product (GRP) ratio is given by:

$$\Psi_r = \frac{G(t+1)_r}{D^r} \qquad \text{(E2.7.1)}$$

where:

Ψ_r : is the ratio of regional government *r*'s debt to GRP;

$G(t+1)_r$: is the foreign currency value of regional government *r*'s debt at the end of the simulation year;

D^r : is the real GRP of region *r* in the simulation year.

Converting (E2.7.1) to a percentage rate of change form yields:

$$\varphi_r = g(t+1)_r - d^r \qquad \text{(E2.7.2)}$$

Which, upon making the obvious notational translations, is Equation *E_debt_grp* in Section 6 of Appendix A.

During some policy simulations, it might be desirable to set φ_r exogenously. In the absence of any change to the structure of the model, this would require that some shift variable on either the expenditure or revenue side of the regional government accounts be determined endogenously. For example, either a revenue instrument (such as the general regional government revenue shifter, tax_shift_r), or an expenditure instrument (such as the general regional government expenditure shifter exp_shift_r), could be set endogenously.

To allow for the endogenous determination of *both* the outlays and expenditure of regional government *r*, Equations *E_tax_shiftr* and *E_exp_shiftr* have been added to FEDERAL-F. The common shift term on these equations (n_shift_r) allows for equal percentage rates of change (although of opposite sign) to be delivered to both aggregate regional government own-source revenue and aggregate regional government outlays, such that the exogenously determined debt to GRP ratio is achieved.

2.7.24 Accumulation of regional government debt

The discussion of Equations *E_del_debtr*, *E_debtr_t1* and *E_net_os_r* in Section 6 of Appendix A is reserved for Section 2.9 of this chapter.

2.7.25 Indexing of regional government real consumption and investment expenditure

Equations *E_fx5reg*, *E_r_sginv*, and *E_fr_sginv* provide for the option of determining real regional government consumption and investment expenditure via indexing relationships with the measures of regional private outlays on the same. These equations are used in the forecasting simulations, towards the end of the forecast period, for which forward estimates of real government outlays are not available (See Section 5.6). The equations can also be used to determine real regional government outlays in long-run comparative static simulations.

Equation *E_fx5reg* allows real regional government consumption expenditure ($x5reg_r$) to be indexed to real regional private consumption expenditure. Typically, Equation *E_fx5reg* will be rendered inoperative via the endogenous determination of *fx5reg*. The equation can be brought into operation by setting *fx5reg* exogenously, and determining the general shift variable on regional government consumption (*f_x_sg*) endogenously.

Equation *E_r_sginv* calculates the percentage change in real investment expenditure by regional government *r* (r_sginv_r). This is defined as the share-weighted sum of the percentage changes in real investment expenditure by regional government *r* in industry *i*. The share weights are given by the share of total regional government investment accounted for by investment in industry *i*.

Equation *E fr_sginv* allows real regional government investment expenditure (r_sginv_r) to be indexed to real regional private investment expenditure. Typically, Equation *E_fr_sginv* will be rendered inoperative via the endogenous determination of *fr_sginv*. The equation can be brought into operation by determining *fr_sginv* exogenously, and determining the general shift variable on regional government capital outlays (*f_sg_invest*) endogenously.

2.8 THE COMMONWEALTH GOVERNMENT FINANCES

2.8.1 Overview

FEDERAL-F maintains the distinction established in FEDERAL between the modelling of a Commonwealth Government operating economy-wide and region-specific regional governments. Table 2.8.1[50] provides a convenient listing of the taxing and spending activities of the Commonwealth Government, as they are summarised within the FEDERAL-F model. As is clear from this table, FEDERAL-F distinguishes nine categories of Commonwealth Government receipt, and seven categories of Commonwealth Government outlay. The equations in Section 7 of Appendix A describe the determination of the aggregate values for each of these receipts and outlays, and the rates of tax and levels of real outlays that underpin them. Full accounting of the year-on-year change in the net asset position of the Commonwealth Government is also undertaken, with this then linked to the net value of their outstanding debt. The structure of the equations describing Commonwealth and regional government debt accumulation is very similar, and so both sets of equations are dealt with jointly in Section 2.9.

2.8.2 Commonwealth borrowing requirement

Equation *E_cb2* calculates the change in the nominal Commonwealth public sector borrowing requirement in the simulation year (*cb2*). The form of this equation is unchanged from that in the original FEDERAL model, Equation 123. A measure of the change in the real value of the Commonwealth's borrowing requirement is evaluated by

[50] Updated from Table 3.1 in Madden (1990).

Equation *E_real_cb2* by deflating both revenues and outlays by the Commonwealth Government price deflator (*p6nat*).

Table 2.8.1: Commonwealth Government Accounts

Transaction	*Matrix*	*Dimensions*
Receipts		
1. PAYE taxes	CGR1	1x1
2. Other income taxes	CGR2	1x1
3. Import duties	CGR3	1x1
4. Production taxes	CGR4	1x1
5. Commodity taxes	CGR5	1x1
6. Export taxes	CGR6	1x1
7. Other receipts	$CGR7_r$	2x1
8. Receipts from GBE's	$\sum_j MV1_{Cgov,j,r}$	2x1
9. Receipts from phantom taxes	(various)	na.
Outlays		
1. Current outlays	CGO1	1x1
2. Capital formation	CGO2	1x1
3. Unemployment benefits	$CGO3_r$	2x1
4. Transfers to regional governments	$CGO4_r$	2x1
5. Other transfers to domestic agents	$CGO5_r$	2x1
6. Exogenous Commonwealth foreign outlays	CGO6	1x1
7. Net foreign interest payments	OSIF	1x1

2.8.3 Nominal aggregate Commonwealth government outlays

Equation *E_b6* is a percentage change form of an equation stating the accounting relationship between aggregate Commonwealth outlays and its individual components. Aggregate Commonwealth outlays are comprised of: i. current consumption spending; ii. capital expenditure; iii. outlays on unemployment benefits; iv. transfers to regional governments; v. other transfers to households; vi. net interest on the Commonwealth's net debt; and vii. exogenous Commonwealth foreign outlays. The form of this Equation is little changed from Equation 97 in the original FEDERAL model. The chief difference is that Equation *E_b6* now contains explicit treatment of net interest outlays, with these outlays being linked to the current stock of Commonwealth foreign debt (See Equation *E_net_os_f*). The equation also includes an exogenous net foreign outlay item (*t64*). This variable is determined endogenously during historical simulations of the model in which the change in the Commonwealth net financing requirement (*cb2*) is determined exogenously.

2.8.4 Nominal aggregate Commonwealth government receipts

Aggregate Commonwealth Government receipts are comprised of: i. PAYE tax receipts; ii. other income tax receipts; iii. import duties; iv. production tax receipts; v. commodity tax receipts; vi. net export taxes; vii. other Commonwealth Government receipts; and viii. dividend receipts from government business enterprises. Equation *E_b4* is simply the percentage change form of the accounting relationship between the sum of these individual components and aggregate Commonwealth Government receipts. Equation *E_b4* is little changed from Equation 101 in the original FEDERAL model. The chief differences are that Equation *E_b4* now includes in total Commonwealth Government receipts the returns on that physical capital which is owned by the Commonwealth Government, and the Commonwealth's share of phantom tax revenue[51]

2.8.5 PAYE tax receipts

Equations *E_b41r* and *E_b41* define the percentage rates of change in the Commonwealth's collection of PAYE income tax receipts from each region, and nationally, respectively. These equations are unchanged from the original FEDERAL model equations 103 and 102 respectively. Equation *E_b41r* defines the percentage change in PAYE taxes collected from region *r* ($b41r_r$) as the weighted sum of the percentage changes in PAYE taxes collected from labour of each occupational type employed in each industry in *r*. Equation *E_b41* calculates the percentage change in aggregate PAYE receipts (*b41*) as the weighted sum of the percentage changes in PAYE receipts from each region.

[51] See Section 2.17.9

2.8.6 Other income tax receipts

Equations *E_b42r* and *E_b42* define the percentage rates of change in the Commonwealth's collection of other income tax receipts from each region, and nationally, respectively. These equations are little changed from the original FEDERAL model equations 105 and 104 respectively. Equation *E_b42r* calculates the percentage change in the Commonwealth's collection of other income taxes from region *r* ($b42_r$) as the weighted sum of its collections of such taxes from the various owners of both capital and land in region *r*. The coefficient $BTL\_INC_{t,j,r}$ in Equation *E_b42r* is the share of income taxes collected on land and capital rentals in regional industry *j,r* owned by owner *t*, in the total of all such taxes collected in region *r*. The coefficients $BK\_INC_{t,j,r}$ and $BL\_INC_{t,j,r}$ are the shares in the total other income taxes paid by owner *t* of the income taxes paid on capital and land rentals respectively in regional industry *j,r*. Equation *E_b42* defines the percentage change in economy-wide collections of other income tax (*b42*) as the weighted sum of such collections from each region ($b42r_r$) .

2.8.7 Import duties

Equation *E_b43* defines the percentage change in the Commonwealth's collection of import duties. This equation is unchanged from Equation 106 in the original FEDERAL model. The percentage change in revenue from import duties is simply the weighted sum of the percentage changes in the tariff receipts on each commodity import, with the weights being given by the share of the total duty collected on each commodity in the total duty collected on all commodities.

2.8.8 Net production tax receipts

Equation *E_b44* calculates the percentage change in the Commonwealth's collection of net production tax receipts. This equation is unchanged from FEDERAL model Equation 107. The percentage change in net production tax receipts is given by the weighted sum of the percentage rates of change in the net production tax payments of each regional industry.

2.8.9 Commodity tax receipts

Equation *E_b45* gives the percentage change in the Commonwealth's collection of net commodity taxes. This equation is unchanged from FEDERAL Equation 108. The percentage change in the Commonwealth's net commodity tax receipts is equal to the weighted sum of the percentage changes in the individual net commodity tax receipts on sales of each type of commodity, from each source, to each type of user (other than government users), in each region.

2.8.10 Net export taxes

Equation *E_b46* defines the percentage change in the Commonwealth's collection of export taxes as the weighted sum of the percentage changes in the collection of export taxes on each individual type of commodity export.

2.8.11 Other Commonwealth Government receipts

Equation *E_b47* calculates the percentage rate of change in other Commonwealth receipts via an indexing relationship to the national consumer price index and a shift variable. This equation remains unchanged from FEDERAL Equation 110. Equation *E_b47R* calculates the real value of other receipts by deflating the nominal value of such receipts by the national gross domestic product deflator.

2.8.12 Dividend receipts from government business enterprises.

Equation *E_cgbedpi* calculates the percentage change in the Commonwealth's receipts from GBE's in region *r* ($cgbedpi_r$) as the weighted sum of the percentage rates of change in its capital rental receipts from each industry in region *r*.

2.8.13 Current consumption spending by the Commonwealth Government

In the original FEDERAL model, Commonwealth government demands for commodities for current consumption were treated as exogenous variables. To provide more flexibility in the determination of Commonwealth current consumption outlays in historical and forecasting simulations, it is convenient in the FEDERAL-F model to determine

Commonwealth current consumption outlays on source-specific commodities, ($x\_cg_{i,s}$) endogenously via Equation *E_x_cg*, as the sum of general (f_x_cg), source-specific ($f\_xr\_cg_s$), government-wide (f_govcon_gen), and commodity- and source-specific ($x\_cgcon_{i,s}$) government current consumption shift variables.

2.8.14 Commonwealth Government capital outlays

Commonwealth Government gross fixed capital expenditure in industry *j* in the FEDERAL model is determined by Equation 61, which specifies an indexing relationship between such investment and real national private sector investment. Equation 61 is omitted from FEDERAL-F. Instead, the percentage change in Commonwealth Government gross fixed capital formation in regional industry *j,r* ($y\_cgk_{j,r}$) is determined endogenously via Equation *E_y_cgk* as the sum of a regional industry specific shift variable on Commonwealth capital formation ($f\_y\_cgk_{j,r}$); a region-specific shift variable on Commonwealth capital formation ($f\_fed\_capr_r$); and an economy-wide shift variable on Commonwealth capital formation (f_fed_cap).

2.8.15 Outlays on unemployment benefits.

In undertaking the historical simulations, data are typically available from official statistics on the nominal value of the Commonwealth's outlays on unemployment benefits. So that this information can be used in the historical simulation, the following equation is added to FEDERAL-F, defining nominal outlays by the Commonwealth Government on unemployment benefits:

$$h^{(6,3)} = S_r^{(6,3)}[p^{(6,3)} + x^{(6,3)r}] \qquad \text{(E2.8.1)}$$

where:

$h^{(6,3)}$: is nominal outlays on unemployment benefits by the Commonwealth;

$S_r^{(6,3)}$: is the share of unemployment benefits paid to region r residents in total unemployment benefit outlays;

$p^{(6,3)}$: is unemployment benefits paid per person; and

$x^{(6,3)r}$: is the number of unemployed persons in region r.

Making the obvious notational translations to Equation (E2.8.1) provides Equation *E_u_benefit* in Section 7 of Appendix A.

In FEDERAL, the percentage change in unemployment benefits per person is calculated by an indexing relationship with the percentage change in the CPI by Equation 94. This relationship is retained in FEDERAL-F, however to facilitate certain closures during historical simulations, a shift term that is common to both the unemployment benefit rate (Equation *E_punb*) and transfers to persons (Equation *E_t62*), is added to Equation 94, producing the following equation:

$$p^{(6,3)} = h^{(6,3)}\xi^{(3)} + f^{(6,3)} + f^{(6,(3,5))} \qquad \text{(E2.8.2)}$$

where:

$h^{(6,3)}$: is an indexing parameter fixing the relationship between the national CPI and the unemployment benefits paid per person;

$\xi^{(3)}$: is the national consumer price index;

$f^{(6,3)}$: is a shift term on the unemployment benefits rate; and

$f^{(6(3,5))}$: is a shift term common to the unemployment benefit rate and transfers to persons.

Making the obvious notational translations to Equation (E2.8.2) provides Equation *E_punb* in Section 7 of Appendix A.

Under the structural closure, nominal outlays by the Commonwealth Government on unemployment benefits, $b^{(6,3)}$, is endogenous, and the shift term on the unemployment benefits rate, $f^{(6,3)}$, is exogenous. Under the historical closure, $b^{(6,3)}$ is set exogenous, and $f^{(6,3)}$ is set endogenous. The variable $b^{(6,3)}$ is then shocked by the value it is observed to have attained over the period of the historical simulation.

The shift term $f^{(6(3,5))}$ can be employed in the forecasting closure to facilitate the exogenous determination of Commonwealth outlays on personal benefit payments, a variable for which government-supplied forward estimates are often available (see Section 2.8.18).

2.8.16 Commonwealth Government transfers to the states.

The percentage change in Commonwealth transfers to regional governments is defined in FEDERAL by Equation 98. This equation is reproduced in FEDERAL-F as Equation *E_t61r*. This equation indexes the percentage change in Commonwealth transfers to regional government r to the percentage change in the national consumer price index. For simulations conducted after the introduction of the GST, this treatment is replaced by that given by Equation *E_ft61* (see Section 2.8.26).

2.8.17 Commonwealth Government transfers to persons

Historical data on Commonwealth Government outlays on transfers to individuals are available from official statistics. So that use can be made of these data in historical simulations, it is convenient to include the following equation in FEDERAL-F, defining the percentage change in nominal outlays by the Commonwealth Government on transfers to individuals (other than unemployment benefits):

$$b^{(6,5)} = \sum_r S_r^{\prime(6,5)} t_2^{(6)r} \qquad \text{(E2.8.3)}$$

where:

$b^{(6,5)}$: is the percentage change in nominal outlays by the Commonwealth Government on transfers to individuals (other than unemployment benefits);

$S_r^{\prime(6,5)}$: is the share of transfers (other than unemployment benefits) to individuals in region r, in total Commonwealth outlays on transfers (other than unemployment benefits) to individuals; and

$t_2^{(6)r}$: is the percentage change in the value of transfers (other than unemployment benefits) to persons in region r.

Making the obvious notational translations to Equation (E2.8.3) provides Equation *E_transfers* in Section 7 of Appendix A.

Transfers to persons in a region (other than unemployment benefits) $t_2^{(6)r}$ was defined in FEDERAL by Equation 99. This equation indexed the percentage change in such transfers to the percentage change in the national consumer price index. The essential form of this equation is retained in FEDERAL-F, and is expressed by:

$$t_2^{(6)r} = h^{(6,5)r}\xi^{(3)} + f^{(6,5)r} + f^{(6,5)} + f^{(6,(3,5))} \qquad \text{(E2.8.4)}$$

Where:

$h^{(6,5)r}$: is an indexing parameter fixing the relationship between Commonwealth transfers to persons and the national consumer price index;

$\xi^{(3)}$: is the national consumer price index;

$f^{(6,5)r}$: is a shift term on the real value of Commonwealth transfers to persons in a region;

$f^{(6,5)}$: is a shift term on the real value of Commonwealth transfers to persons economy-wide; and

$f^{(6(3,5))}$: is a shift term on Commonwealth personal benefits payments in general.

Making the obvious notational translations to Equation (E2.8.4) provides Equation *E_t62* in Section 7 of Appendix A.

Nominal outlays by the Commonwealth Government on transfers to individuals, $b^{(6,5)}$, is endogenous under the structural closure, and the shift term $f^{(6,5)r}$ is exogenous. This closure is reversed under the historical closure. The variable $b^{(6,5)}$ is then shocked by the value it is observed to have attained over the period of the historical simulation.

The shift term $f^{(6(3,5))}$ can be employed under the forecasting closure to facilitate the exogenous determination of the Commonwealth's outlays on personal benefit payments of all types (see Section 2.8.18).

2.8.18 Commonwealth Government outlays on personal benefits payments

The Commonwealth Government prepares forward estimates of revenues and outlays, and presents these under the Australian Bureau of Statistics' Government Finance Statistics format in the Budget Papers. Some data provided in the Commonwealth Government forward estimates are too aggregated for input to the model under a forecasting closure of the Commonwealth accounts that would be similar in structure to that used in the historical closure. On the outlays side, sufficient detail is provided in Table D1 of Budget Paper No. 1 to separately identify current outlays (CGO1), capital outlays (CGO2), and transfers to State and local governments (CGO4). Table D1 contains forward estimates for the expenditure item "personal benefit payments". This category subsumes the FEDERAL Government Account categories CGO5 - Transfers to persons, and CGO3 - Unemployment benefits. Interest payments (CGO6) are determined endogenously in the forecasting simulation on the basis of the stock of outstanding debt.

Commonwealth Government nominal outlays on personal benefit payments is defined in FEDERAL-F by adding the following equation to the model:

$$b_{(3+5)}^{(6)} = S_{(3+5)}^{(6,3)} b^{(6,3)} + S_{(3+5)}^{(6,5)} b^{(6,5)} \qquad \text{(E2.8.5)}$$

Where:

$b_{(3+5)}^{(6)}$: is the percentage change in Commonwealth Government nominal outlays on personal benefit payments;

$b^{(6,3)}$: is the percentage change in Commonwealth Government nominal outlays on unemployment benefit payments;

$b^{(6,5)}$: is the percentage change in Commonwealth Government nominal outlays on transfers to persons;

$S_{(3+5)}^{(6,3)}$: is the share of unemployment benefit payments in total Commonwealth personal benefit payments; and

$S_{(3+5)}^{(6,5)}$: is the share of transfers to persons in total Commonwealth personal benefit payments.

Making the obvious notational translations to the above equation provides Equation *E_pbp_nom* in Section 7 of Appendix A.

Commonwealth Government real outlays on personal benefit payments are calculated by Equation *E_pbp_real* in Section 7 of Appendix A by deflating nominal personal benefit outlays by the GDP deflator.

2.8.19 General and specific determination of Commonwealth Government rates of taxation and other revenues

In the FEDERAL model, the rates of the various Commonwealth Government taxes, and the real values of other revenues, are treated as exogenous variables. More flexibility in the determination of these variables is required in some applications of the FEDERAL-F model, particularly under some forecasting and policy simulations. In particular, under a closure in which both the outlays of the Commonwealth Government and its borrowing requirement are determined exogenously, it is useful to be able to determine the percentage change in all revenue instruments endogenously via movements in a common endogenous shift variable. To facilitate such a closure, Equations E2.8.6 to E2.8.12 (Equations *E_fpaye* through to *E_f47* in Section 7 of Appendix A) were added to the model. These equations allow for the endogenous determination of income taxes, import duties, production taxes, sales taxes on industry purchases, sales taxes on household purchases, export taxes, and other receipts respectively. These equations are set out below.

The endogenous determination of PAYE taxes in FEDERAL-F is facilitated by the addition of the following equation to the model:

$$f^{(1)2}_{(g+1,1)} = f^{(1)2*}_{(g+1,1)} + f^{(4)} + f^{(4)}_{(1-6)} \qquad \text{(E2.8.6)}$$

where:

$f^{(1)2}_{(g+1,1)}$: is the percentage change in the shift variable for PAYE taxes per unit of labour;

$f_{(g+1,1)}^{(1)2*}$: is the percentage change in the variable allowing switching between the general and specific determination of PAYE taxes;

$f^{(4)}$: is the percentage change in the general Commonwealth Government revenue shift term; and

$f_{(1-6)}^{(4)}$: is the percentage change in the shift term on revenues from all "taxes, fees, and fines".

Making the obvious notational translations, Equation (E2.8.6) is Equation *E_fpaye* in Section 7 of Appendix A.

The endogenous determination of commodity-specific import duties in FEDERAL-F is facilitated by the addition of the following equation to the model:

$$t(i3,0) = f_{t(i3,0)}^{*} + f_{t3}^{*} + f^{(4)} + f_{(1-6)}^{(4)} \qquad \text{(E2.8.7)}$$

where:

$t(i3,0)$: is the percentage change in the term allowing for ad-valorem treatment of import duties;

f_{t3}^{*}: is the percentage change in the shift variable for determining the average rate of import duty;

$f_{t(i3,0)}^{*}$: is the percentage change in the variable allowing for switching between the general and specific determination of import duties;

$f^{(4)}$: is the percentage change in the general Commonwealth Government revenue shift term; and

$f_{(1-6)}^{(4)}$: is the percentage change in the shift term on revenues from all "taxes, fees, and fines".

Making the obvious notational translations, Equation (E2.8.7) is Equation *E_t3* in Section 7 of Appendix A.

The endogenous determination of Commonwealth net production tax rates in FEDERAL-F is facilitated by the addition of the following equation to the model:

$$f^{(1)}_{(g+3,j)} = f^{(1)*}_{(g+3,j)} + f^{(1)*}_{(g+3,*)} + f^{(4)} + f^{(4)}_{(1-6)} \qquad \text{(E2.8.8)}$$

where:

$f^{(1)}_{(g+3,j)}$: is the percentage change in the shift variable for changing the real component of Commonwealth government net production tax rates by industry;

$f^{(1)*}_{(g+3,*)}$: is the percentage change in the shift variable determining the average rate of production tax across industries.

$f^{(1)*}_{(g+3,j)}$: is the percentage change in the variable that facilitates switching between general and specific determination of production taxes.

$f^{(4)}$: is the percentage change in the general Commonwealth Government revenue shift term; and

$f^{(4)}_{(1-6)}$: is the percentage change in the shift term on revenues from all "taxes, fees, and fines".

Making the obvious notational translations, Equation (E2.8.8) is Equation *E_fprodj* in Section 7 of Appendix A.

The endogenous determination of Commonwealth sales tax rates on intermediate inputs in FEDERAL-F is facilitated by the addition of the following equation to the model:

$$t(i2) = f^{*}_{t(i2)} + f^{*}_{i2} + f^{(4)} + f^{(4)}_{(1-6)} \qquad \text{(E2.8.9)}$$

where:

$t(i2)$: is the percentage change in the term allowing for ad-valorem treatment of Commonwealth government sales taxes on industry purchases;

f^{*}_{i2}: is the percentage change in the general shift variable on Commonwealth commodity tax rates;

$f^{*}_{t(i2)}$: is the percentage change in a variable allowing for switching between the general and the specific determination of Commonwealth government sales taxes on industry purchases;

$f^{(4)}$: is the percentage change in the general Commonwealth Government revenue shift term; and

$f^{(4)}_{(1-6)}$: is the percentage change in the shift term on revenues from all "taxes, fees, and fines".

Making the obvious notational translations, Equation (E2.8.9) is Equation *E_tc0_ind* in Section 7 of Appendix A.

The endogenous determination of Commonwealth sales tax rates on purchases by households in FEDERAL-F is facilitated by the addition of the following equation to the model:

$$t(is,32) = f^{*}_{t(is,32)} + f^{*}_{t2} + f^{(4)} + f^{(4)}_{(1-6)} \qquad \text{(E2.8.10)}$$

where:

$t(is,32)$: is the percentage change in the term allowing for ad-valorem treatment of Commonwealth taxes on household purchases;

$f^{*}_{t(is,32)}$: is the percentage change in the variable which facilitates the switching between the general and the specific determination of household sales tax rates;

f^{*}_{t2}: is the percentage change in the general shift variable on commodity tax rates;

$f^{(4)}$: is the percentage change in the general Commonwealth Government revenue shift term; and

$f^{(4)}_{(1-6)}$: is the percentage change in the shift term on revenues from all "taxes, fees, and fines".

Making the obvious notational translations, Equation (E2.8.10) is Equation *E_tc_hous* in Section 7 of Appendix A.

The endogenous determination of Commonwealth export tax rates in FEDERAL-F is facilitated by the addition of the following equation to the model:

$$t(ir,4) = f^{\bullet}_{t(ir,4)} + f_{t4} + f^{(4)} + f^{(4)}_{(1-6)} \qquad \text{(E2.8.11)}$$

where:

$t(ir,4)$: is the percentage change in the term allowing for ad-valorem treatment of export taxes;

$f^{\bullet}_{t(ir,4)}$: is the percentage change in the variable that facilitates switching between the general and the specific determination of export tax rates;

f_{t4}: is the percentage change in the uniform shift variable on ad valorem export tax rates;

$f^{(4)}$: is the percentage change in the general Commonwealth Government revenue shift term; and

$f^{(4)}_{(1-6)}$: is the percentage change in the shift term on revenues from all "taxes, fees, and fines".

Making the obvious notational translations, Equation (E2.8.11) is Equation *E_t4* in Section 7 of Appendix A.

The endogenous determination of real other Commonwealth receipts in FEDERAL-F is facilitated by the addition of the following equation to the model:

$$f^{(4,7)} = f^{\bullet}_{b(4,7)} + f^{(4)} \qquad \text{(E2.8.12)}$$

where:

$f^{(4,7)}$: is the percentage change in the shift variable on the real component of other Commonwealth Government receipts;

$f^{\bullet}_{b(4,7)}$: is the percentage change in the variable that facilitates switching between the general and the specific determination of other Commonwealth Government receipts; and

$f^{(4)}$: is the percentage change in the general Commonwealth Government revenue shift term.

Making the obvious notational translations, Equation (E2.8.12) is Equation *E_f47* in Section 7 of Appendix A.

2.8.20 Commonwealth revenue from "taxes, fees, and fines"

The Commonwealth Government prepares forward estimates of revenues and outlays, and presents these under the Australian Bureau of Statistics' Government Finance Statistics format in the Commonwealth Budget Papers. As already discussed in Section 2.8.18 above, the detail provided in these statistics can be too aggregated to allow for the use of a forecasting closure of the Commonwealth accounts that is similar in structure to that used during the historical simulations. On the revenue side, forward estimates are provided with sufficient detail to separately identify the revenue item "Taxes, fees and fines". This covers the FEDERAL Commonwealth account categories CGR1 through to CGR6.

Commonwealth real tax revenue from "Taxes, fees, and fines" can be determined exogenously in the forecasting simulation, and a general shifter common to the equations determining rates of PAYE taxes, other income taxes, import duties, production taxes, commodity taxes, and export taxes, can then be determined endogenously.

The Commonwealth Government revenue from "Taxes, fees and fines" is calculated by Equation (E2.8.13):

$$b^{(4)}_{(1-6)} = \sum_{i=1}^{6} S^{(4,i)}_{(1-6)} b^{(4,i)} \qquad (2.8.13)$$

where:

$b^{(4)}_{(1-6)}$: is the percentage change in Commonwealth Government revenue from taxes, fees, and fines;

$S^{(4,t)}_{(1-6)}$: is the share of "taxes, fees, and fines" revenue type t in total revenue from "taxes, fees, and fines"; and

$b^{(4,t)}$: is the percentage change in Commonwealth Government "taxes, fees, and fines" revenue of type t.

Making the obvious notational translations, Equation (E2.8.13) is Equation *E_b1 6* in Section 7 of Appendix A.

Commonwealth Government real receipts from "taxes, fees and fines" are defined by Equation *E_b1_6R*, which deflates the nominal receipts by the GDP deflator.

2.8.21 Rates of other Commonwealth income taxes

"Other income taxes" consist of income taxes on capital and land rentals. Nominal Commonwealth Government receipts from other income taxes ($b^{(4,2)}$) is endogenous in the standard closure of the model. Commonwealth income taxes per unit of capital and land are determined by FEDERAL Equations 90 and 91[52]. Both a common shift variable ($f^{(4)}_{(g+1,\bullet)}$) and the general Commonwealth Government revenue shift term ($f^{(4)}$) have been added to both these equations in FEDERAL-F, providing:

$$p^{(4)r}_{(g+1,2)j} = h^{(4)}_{(g+1,2)j} p^{(1)r}_{(g+1,2)j} + f^{(4)}_{(g+1,2)j} + f^{(4)}_{(g+1,\bullet)} + f^{(4)}_{(1-6)} \tag{E2.8.14}$$

$$p^{(4)r}_{(g+1,3)j} = h^{(4)}_{(g+1,3)j} p^{(1)r}_{(g+1,3)j} + f^{(4)}_{(g+1,3)j} + f^{(4)}_{(g+1,\bullet)} + f^{(4)}_{(1-6)} \tag{E2.8.15}$$

Which, upon making the obvious notational translations, are Equations *E_p_kaptax* and *E_p_landtax* respectively.

[52] See Madden(1990) p.89

The variable $f^{(4)}_{(g+1,*)}$ is set endogenous in the historical simulation. This variable then provides equal percentage rates of change to the per unit income tax paid on both capital and land rentals, while aggregate Commonwealth Government Other Income Tax receipts ($b^{(4,2)}$) is determined exogenously and shocked equal to its observed value over the historical period under investigation. The variable $f^{(4)}_{(1\ 6)}$ is a shift term common to the rates of all Commonwealth taxes. This variable facilitates the exogenous determination of Commonwealth "taxes, fees and fines" in the forecasting closure.

2.8.22 Flexible handling of the per-unit rates of various Commonwealth Government taxes

The FEDERAL model contained equations that allowed the model user to choose whether various per-unit Commonwealth taxes would be set in real, ad valorem, or specific terms. These equations are retained unchanged in FEDERAL-F. Hence, Equation *E_g_tar* corresponds to FEDERAL Equation 39; Equation *E_g_extax* corresponds to FEDERAL Equation 41; Equation *E_g_cint* corresponds to FEDERAL Equation 49; and Equation *E_g_ctax* corresponds to FEDERAL Equation 51. The manner of establishing the form of the tax is identical in each equation: one of the three coefficients is set equal to 1, with the remaining two set equal to zero. Setting the first coefficient equal to 1 corresponds to maintaining the real value of the per unit tax. Setting the second coefficient equal to 1 corresponds to establishing an ad valorem treatment of the tax. Setting the third coefficient equal to 1 establishes the specific treatment of the per unit tax. The reader is referred to Madden (1992) for a more detailed discussion of the operation of these equations.

2.8.23 Commonwealth Government production tax rate

Equation *E_cpptax* corresponds to FEDERAL Equation 88. This equation indexes the value of the per unit production tax on regional industry *j,r's* output to the regional consumer price index, in addition to allowing for real movements in the value of the per unit tax via shifts in the $fprodj_j$.

2.8.24 Commonwealth debt to GDP ratio

In the levels, the Commonwealth Government debt to GDP ratio is given by:

$$\Psi_F = \frac{G(t+1)_F}{D} \qquad \text{(E2.8.16)}$$

Where:

Ψ_F : Ratio of Commonwealth debt to GDP;

$G(t+1)_F$: Foreign currency value of Commonwealth debt at the end of the simulation period; and

D : Real GDP.

Converting (E2.8.16) to a percentage rate of change form yields:

$$\varphi_F = g(t+1)_F - d \qquad \text{(E2.8.17)}$$

Which, upon making the obvious notational translations, is Equation *E_debt_gdp* in Section 7 of Appendix A.

2.8.25 Accumulation of Commonwealth Government debt

The discussion of Equations *E_del_debtF*, *E_debtF_t1* and *E_net_os_f* in Section 7 of Appendix A is reserved for Section 2.9 of this chapter.

2.8.26 Indexing of Commonwealth grants to Commonwealth consumption tax collections.

The introduction of the goods and services tax by the Commonwealth Government provided for the state governments receiving all the revenue from this tax as of 1 July 2000 (Treasurer of the Commonwealth of Australia 1998). The way this is handled in the forecast simulations discussed in Chapter 5 is to first adjust the level of inter-governmental transfers with the introduction of the GST in 2000/01, and then in future periods index the percentage change in Commonwealth transfers to the states to changes in Commonwealth consumption tax collections.

Equation *E_cw3tax* calculates the percentage change in Commonwealth consumption tax collections (*cw3tax*) as the share-weighted sum of the percentage changes in Commonwealth consumption tax collections on source-specific commodities consumed in each region. Equation *E_ft61* provides for the percentage change in Commonwealth transfers to regional government *r* ($t61_r$) to be indexed to the percentage change in Commonwealth consumption tax collections (*cw3tax*). In the standard short-run comparative static closure, Equation *E_ft61* is rendered inoperative via the endogenous determination of *ft61*. However in the forecasts undertaken in Chapter 5 for the period 2001/02 onwards, this equation is brought into operation by determining *ft61* exogenously, and determining endogenously the shift variable *f64r* in Equation *E_t61r*. The equation is also operational in the deviation or policy simulations reported in Chapter 6.

2.9 The Accumulation of Regional and Commonwealth Government Debt

2.9.1 Introduction

The FEDERAL model's theoretical structure embodies detailed treatment of the taxing and spending powers of the two tiers of government. The inclusion of government debt accumulation relationships is a natural extension of this side of the model. Given that in some jurisdictions a major regional government outlay - interest payments - is a function of the level of debt, a proper treatment of government finances in the model must recognise that the public sector borrowing requirement in the base year data for any given simulation may not be zero.

A second reason for including debt accumulation relationships in the model is that the level of government debt, particularly that of regional governments, is considered to be an important policy target by a number of regional governments. This is particularly the case in those State jurisdictions that were exposed to the collapse of government owned or guaranteed financial institutions in the late eighties and early nineties.

From the perspective of using the model to analyse the consequences of regional and Commonwealth government policy, the second of the above two reasons is the more important. Hence, in modelling the accumulation of regional and Commonwealth government debt, the main concern is to both account for changes in the stock of debt, and model the impact of such changes on the level of government interest payments. That is, the focus is on the regional and Commonwealth government accounts. The question of who holds the debt is simplified by assuming that changes in the level of regional government and Commonwealth net indebtedness are accommodated by changes in the level of net debt held by foreigners.

2.9.2 Regional and Commonwealth Government Debt

2.9.2.1 The level of regional and Commonwealth Government debt at the beginning of the simulation year

The database values for the level of regional and Commonwealth government debt pertain to the commencement of the database year. The database values for expenditures and revenues, and therefore the level of the public sector borrowing requirement (PSBR), relate to the duration of the database year.

Hence we can write, in the levels, Equation (E2.9.1) and Equation (E2.9.2) to describe, respectively, the level of regional and Commonwealth government net debt at the commencement of period *t*. The variable $G(t)_g$ is the foreign currency value of net foreign debt held by government *g* at the commencement of period *t*, and $PSBR_g(t)$ is the foreign currency value of the PSBR of government *g* during period *t*.

$$G(t)_r = G(t-1)_r + PSBR_r(t-1) \quad \text{(E2.9.1)}$$

$$G(t)_F = G(t-1)_F + PSBR_F(t-1) \quad \text{(E2.9.2)}$$

The initial solution for year *t* net foreign debt is the value of year *t*-1 net foreign debt:

$$G(t)_r = G(t-1)_r$$

$$G(t)_F = G(t-1)_F$$

Which is equivalent to stating that $PSBR_r(t-1)=0$ and $PSBR_F(t-1)=0$ in the initial solution. A convenient expression for Equations (E2.9.1) and (E2.9.2) is then:

$$G(t)_r = G(t-1)_r + PSBR_r(t-1) + PSBR_r(t-1)Q_r \quad \text{(E2.9.3)}$$

$$G(t)_F = G(t-1)_F + PSBR(t-1)_F + PSBR(t-1)_F Q_F \quad \text{(E2.9.4)}$$

Where Q = -1 in the control solution, thus establishing $G(t)_g = G(t-1)_g$ as the initial solution for $G(t)_g$.

Converting Equations (E2.9.3) and (E2.9.4) to a rate of change form provides:

$$\Delta G(t)_r = PSBR(t-1)_r \Delta Q_r \quad \text{(E2.9.5)}$$

$$\Delta G(t)_F = PSBR(t-1)_F \Delta Q_F \quad \text{(E2.9.6)}$$

When the model is simulated, the Q variables are shocked by 1, thereby establishing the accumulation relationships given by (E2.9.1) and (E2.9.2). Making the obvious notational translations, Equations (E2.9.5) and (E2.9.6) provide Equations *E_del_debtr* (Section 6 of Appendix A) and *E_del_debtF* (Section 7 of Appendix A) respectively.

2.9.2.2 The level of regional and Commonwealth Government debt at the end of the simulation year

The levels of regional and Commonwealth Government debt at the end of the simulation year are given by Equations (E2.9.7) and (E2.9.8) respectively:

$$G(t+1)_r = G(t)_r + PSBR_r(t) \quad \text{(E2.9.7)}$$

$$G(t+1)_F = G(t)_F + PSBR_F(t) \quad \text{(E2.9.8)}$$

The control solutions for $G(t+1)_r$ and $G(t+1)_F$ are set equal to the levels of debt of the respective governments at the commencement of the simulation period, that is, $G(t)_r$ and $G(t)_F$ respectively. Hence the control solution for Equations (E2.9.1), (E2.9.2), (E2.9.7) and (E2.9.8) is:

$$G(t+1)_r = G(t-1)_r + PSBR_r(t-1)$$

$$G(t+1)_F = G(t-1)_F + PSBR_F(t-1)$$

$$G(t)_r = G(t-1)_r$$

$$G(t)_F = G(t-1)_F$$

$$PSBR_r(t) = PSBR_r(t-1)$$

$$PSBR_F(t) = PSBR_F(t-1)$$

Substituting these values into (E2.9.7) and (E2.9.8), we find that they are legitimate elements of the control solution for the model.

I do not calculate within FEDERAL-F a variable that explicitly measures the percentage change in the foreign currency value of government borrowings. Hence, before converting Equations (E2.9.7) and (E2.9.8) to a percentage rate of change form, it is convenient to rewrite them as follows:

$$G(t+1)_r = G(t)_r + PSBR(t)_r/\Phi \tag{E2.9.9}$$

$$G(t+1)_F = G(t)_F + PSBR(t)_F/\Phi \tag{E2.9.10}$$

Where $PSBR(t)_g$ is now the *domestic currency* value of the government g's borrowing requirement in period t. Linearising Equations (E2.9.9) and (2.9.10) and solving for the percentage rate of change in $G(t+1)_g$ gives:

$$g(t+1)_g = \left[\frac{100}{G(t-1)_g + PSBR(t-1)_g/\Phi}\right]\Delta G(t)_g + \left[\frac{100}{G(t-1)_g\Phi + PSBR(t-1)_g}\right]\Delta PSBR(t)_r - \left[\frac{PSBR(t-1)_g}{G(t-1)_g\Phi + PSBR(t-1)_g}\right]\varphi \tag{E2.9.11}$$

Making the obvious notational translations, Equation (E2.9.11) provides Equation *E_debtr_t1* and Equation *E_debtF_t1* in Appendix A, Sections 6 and 7 respectively.

2.9.3 Regional and Commonwealth Government outlays related to outstanding debt

Changes in regional government and Commonwealth Government net outlays on interest payments to foreign holders of their debt are a function of changes in the size of the outstanding net foreign debt. The foreign currency value of the net interest paid by each government on its net foreign debt can be calculated as follows:

$$T_r^{os} = G(t)_r E_r \qquad \text{(E2.9.12)}$$

$$T_F^{os} = G(t)_F E_F \qquad \text{(E2.9.13)}$$

Where:

T_r^{os} : Foreign currency value of the net interest payments made by regional government r on its net foreign debt

T_F^{os} : Foreign currency value of the net interest payments made by the Federal government on its net foreign debt

E_r : Average interest rate paid by regional government r on its net foreign debt

E_F : Average interest rate paid by the Commonwealth Government on its net foreign debt.

Converting equations (E2.9.12) and (E2.9.13) to percentage change form, and noting that $G(t-1)_g$ is the base solution for $G(t)$ yields (E2.9.14) and (E2.9.15):

$$t_r^{(os)} = \Delta G(t)_r \left[\frac{100}{G(t-1)_r} \right] + e^r \qquad \text{(E2.9.14)}$$

$$t_F^{(os)} = \Delta G(t)_F \left[\frac{100}{G(t-1)_F} \right] + e^F \qquad \text{(E2.9.15)}$$

Making the obvious notational translations to Equations (E2.9.14) and (E2.9.15) provides Equations *E_net_os_r* and *E_net_os_f* in Appendix A, Sections 6 and 7 respectively.

The percentage change in the rate of interest paid by both levels of government is treated as an exogenous variable. This variable can be shocked to reflect changes in the average interest rate faced by either level of government. The calculation of such shocks would be based on information about the maturation profile of each government's stock of net foreign debt, expected increments to that debt, and the expected future levels of interest rates.

2.10 FOREIGN EXPORT DEMANDS

FEDERAL allows for two treatments of commodity export demands. The first specifies foreign demands for Australian commodity *i*, regardless of source (FEDERAL Equation 24). Australian commodity *i* is then assumed to be a CES composite of commodity *i* sourced from each of the domestic supplying regions (FEDERAL Equation 25). The second treatment specifies region-specific foreign export demands for each commodity (FEDERAL Equation 27) (Madden 1990: 35-36).

It is the second treatment that is developed in FEDERAL-F. Hence there are no equations corresponding to FEDERAL Equations 24 and 25 in FEDERAL-F. Four sets of equations determine commodity export demands in FEDERAL-F: *E_xr_expT*, *E_xr_expN1*, *E_xr_expN2*, and *E_xr_expX*. These four equations together distinguish three separate categories of export commodities ("traditional", "non-traditional", and "exogenous" exports), and two separate treatments for one of those categories ("non -traditional" exports).

Distinguishing the two categories of "traditional" and "non-traditional" exports follows a similar approach to that in the MONASH model[53]. In the main, traditional exports are comprised mostly of agricultural and mining exports, and non-traditional exports are comprised mostly of manufacturing and service exports. The set of exogenous export commodities is comprised of those commodities that are assumed not to be responsive to changes in their foreign currency export prices.

[53] MONASH also identifies a set of tourism export commodities: air transport, entertainment and leisure, restaurants and hotels, and personal services. Like the treatment of NTRAD, demands for tourism commodities move as a block in response to changes in the aggregate foreign export price index for tourism exports.

Equation *E_xr_expT* defines export demands for traditional export commodities. Like FEDERAL Equation 27, it is the linearisation of a constant-elasticity export demand function. The two quantity shift terms: $f\_eq24t\_ir_{i,r}$ and $feq\_generalr_r$ facilitate the exogenous determination of traditional export and aggregate export volumes respectively in both the historical and forecasting closures. In historical and forecasting simulations of the model, the volumes for regional traditional commodity exports ($xr\_exp_{i,r}$ $i \in$ TRAD) will typically be determined exogenously, with the corresponding elements of $f\_eq24t\_ir_{i,r}$ being endogenous. The quantity shift variable $feq\_generalr_r$ appears on the right hand side of each of the export demand equations. While it is endogenous in the standard comparative-static short-run closure (See Equation *E_feq_generalr*) it is itself the sum of shift variables that are exogenous under this closure, and so this variable exerts no influence on the positions of individual commodity export demand functions under the comparative-static short-run closure.

Equations *E_xr_expN1* and *E_xr_expN2* allow for alternative treatments for the determination of non-traditional export volumes. With the variables $f\_eq24n\_ir_{i,r}$ exogenous, equation *E_xr_expn1* allows for the volume of exports of non-traditional export commodity *i* from region *r* to be determined by its own foreign currency export price. However, a practical problem with this approach arises from the fact that export volumes for many of these commodities comprise a relatively small share of their total output. It is possible that the actual cost structures of those firms within each non-traditional export industry who are themselves significant exporters, differ markedly from the cost structure of the industry as a whole. Under these circumstances, changes in the cost conditions for any single non-traditional export industry will be a relatively poor proxy for changes in the cost conditions for those firms that are actually significant exporters within that industry (Dixon and Rimmer 1999a). Hence, following the approach in MONASH, rather than allow the volume of exports for each non-traditional export commodity to be determined by its own foreign currency export price, an alternative is to have their volumes moving as a single block in response to changes in the aggregate foreign currency price index for non-traditional export commodities. This is the purpose of Equation *E_xr_expN2*. Equation *E_xr_expN2* is made operational by setting exogenous the variables $f\_ntrad_{i,r}$ ($i \in$ NTRAD, $r \in$ REG) and setting endogenous the variables $f\_eq24n\_ir_{i,r}$

(i∈NTRAD, r∈REG). Note that the price index for aggregate non-traditional exports carries a regional subscript. Equation *E_xintrad* calculates the percentage change in the regional foreign-currency price index for non-traditional exports (xi_ntrad_r) as a share-weighted sum of the percentage changes in the foreign currency prices of the individual non-traditional exports from region *r*. While it might be considered inappropriate for individual regional industry cost conditions to be determining export volumes for individual non-traditional export commodities, because of the possibility that the cost conditions for the export-oriented firms within each non-traditional export industry are quite different from those of the industry as a whole, it is nonetheless reasonable to expect that regional cost conditions will have a bearing on the costs of these export firms.

Equation *E_xr_expX* calculates the percentage change in the volume of individual exogenous export commodities from region *r*. The percentage change in the volume of exogenous export commodities is simply the sum of a commodity and region specific shift term ($f\_xfordem_{i,r}$) and the regional export demand shifter, ($feq\_generalr_r$).

Equation *E_feq_generalr* translates economy-wide export demand shifts into region-specific export demand shifts. In historical and forecasting simulations of the model, the aggregate national volume of exports (*x4nat*) can be determined exogenously by setting endogenous the uniform economy-wide shift variable *feq_general*. This then provides identical horizontal shifts to the positions of all export demand functions in all regions. Alternatively, any *r* of the aggregate volume of national exports (*x4nat*) and the aggregate volumes of the *r* regional exports ($x4reg_r$) can be determined exogenously by setting endogenous the shift variables $ffeq\_generalr_r$. Regardless of which option is chosen, the shift variables that ultimately operate on the individual export demand equations ($feq\_generalr_r$) have a regional dimension. This is useful in simulations under the structural and policy closures, since it enables the separate identification of the impacts of the regional export demand shifts on the outcomes for individual regions.

2.11 MARGIN DEMANDS

The modelling of margins in FEDERAL-F follows that of its parent model, FEDERAL. In the absence of technical change, margins are assumed to be required in fixed proportions with the underlying commodity flow that they are facilitating. Equations *E_xmar1* through to *E_xmar6* in Section 9 of Appendix A correspond with FEDERAL Equations 28 - 32. Given the assumption of a fixed proportions requirement for margin usage on each transaction, these equations define the percentage change in the usage of margin type u on each transaction to be equal to the percentage change in the commodity flow that is being facilitated.

The "a" terms on the right hand side of equations *E_xmar1* through to *E_xmar6* allow for technical change in the usage of margins. A positive (negative) value for these terms indicates a rise (fall) in the quantity of margin services required for each unit of the underlying transaction that is facilitated by the margin service. These technical change terms are defined by Equations *E_a1mar* through to *E_a6mar*. Each of these equations has the same general form. In each case, the percentage change in margin service required per unit transacted is the sum of the percentage changes in three types of shift variable. In each equation, the first of these shift variables is specific to the margin in question (for example, $fa1mar_{u,r,i,s,j,t}$ in Equation *E_a1mar*). The second two are common to each of the margin technical change equations, and also appear elsewhere in the model. These are the commodity-specific technical change terms (ai_u) and the commodity and region-specific technical change terms ($ais_{u,r}$). The former operate economy wide to implement technical change in the usage of commodity u across all users, while the latter operate only in region r to implement technical change in the usage of u. Clearly, by including these technical change terms in these equation, I allow commodity u specific technical change to affect both margin and non-margin requirements for commodity u.

2.12 MISCELLANEOUS EQUATIONS

3.12.1 Overview

This section covers a number of important equations that cannot be conveniently summarised within other sections of this chapter. The first set of equations includes an equation for facilitating the exogenous determination of foreign currency import prices, equations defining a measure of the real exchange rate, and equations defining a number of national variables pertaining to imports and exports at the commodity level. The second set of equations defines various ratios of macroeconomic variables. These equations are important in establishing different macroeconomic closures for the model. A third set of equations in this section define the user prices of labour by occupation and regional industry, in addition to the post-tax wages and tax components of which they are comprised. Both nominal and real regional pre-tax wages are also defined. Two sets of equations deal with utility pricing, allowing for the implementation of a "CPI-X" rule. A final set of equations calculate various measures which facilitate the interpretation of results from the model. These include equations which summarise key industry and commodity level results into a broad 12 sector categorisation; equations which decompose changes in household gross income and net taxes into the contributing changes in their component parts; and equations which decompose changes in industry outputs among the various changes in the demands by the users of those outputs.

2.12.2 Commodity import prices

Equation *E_pmp* defines the percentage change in the foreign currency prices of individual commodity imports as the sum of the percentage changes in general (*f_pmp*) and commodity-specific (f_pmp_i) shift variables. This equation facilitates the exogenous determination of individual commodity import prices under most closures of the model. In conjunction with Equation *E_pMnat_fc*, this equation is useful for facilitating the exogenous determination of import prices under the historical and forecasting closures of the model. Equation *E_pMnat_fc* calculates the foreign currency value of the national c.i.f import price index (*pMnat_fc*) by converting the domestic currency equivalent (*pMnat*) at the current exchange rate (*x_rate*).

Under the historical closure, movements in the general foreign currency price index are modelled by determining *pMnat_fc* exogenously and setting the shift variable *f_pmp* endogenous. Movements in individual commodity import prices relative to the national index are then determined by shocking those elements of *f_pmp_i*$_i$ for which extraneous historical data are available.

2.12.3 The real exchange rate

A common definition for the real exchange rate ($Q^{(1)}_{\$A/FC}$) in Australian CGE studies is the ratio of the domestic currency value of the GDP deflator ($P^{\$A}_{G}$) to the domestic currency value of the foreign GDP deflator ($P^{FC}_{G} \times E_{\$A/FC}$). While this is a useful index of the real exchange rate for the majority of simulations, in some simulations it fails to provide the proper sign to explain movements in the real balance of trade. In particular, some shocks to the model that are directed at industries producing goods that primarily are either exported or compete with imports, can be associated with an apparent appreciation (depreciation) of the real exchange rate index defined by $Q^{(1)}_{\$A/FC}$, and a decrease (increase) in the real balance of trade surplus. This result arises because the price impact of the shock is expressed as a significant change in the prices of traded goods relative to the GDP deflator. Since it is the relative prices of domestic and foreign traded goods that determine movements in the real balance of trade in the model, it is useful to define an index for the real exchange rate that explicitly takes account of such price movements. Hence, an alternative measure of the real exchange rate is also defined in FEDERAL-F ($Q^{(2)}_{\$A/FC}$) as the ratio of the domestic currency price of tradeables ($P^{\$A}_{T}$) to the domestic currency price of the foreign tradeable goods price index ($P^{FC}_{T} \times E_{\$A/FC}$) (Claasen 1996).

A proxy for the foreign currency price index for foreign tradeable goods (P^{FC}_{T}) can be provided by an existing variable in the model: the foreign currency import price index (*pMnat_fc*). However, a new variable must be created to represent the domestic tradeables price index. This price index must reflect the domestic costs of producing both exportables and import substitutes. Following Claasen (1996), I define the domestic tradeable goods price index as $P^{\$A}_{T} = P_X^{\alpha_X} P_M^{\alpha_M}$, where P_X is the domestic currency price of exportables, P_M

is the domestic currency price of importables, α_X is the domestic weight of exportables in total traded goods, and α_M is the domestic weight of importables in total traded goods.

An equation describing the domestic currency export price index (*E_p4nat*) already exists in FEDERAL-F. However, a new equation describing the P_M index must be added to the model. This index must have two properties. First, it must express the domestic costs of producing import competing goods. Second, as a proxy for the domestic cost of producing aggregate imports, it must reflect the commodity composition of total imports. Defining P_M as $\prod_i \prod_r {P_{i,r}^{(0)}}^{\alpha_{(i,r)}^{(M)}}$, where $P_{i,r}^{(0)}$ is the basic price of commodity i produced in region r, and $\alpha_{(i,r)}^{(M)}$ is the ex-duty share of imports of i into region r in total imports into the country, satisfies both these requirements.

Choosing the appropriate values for α_X and α_M provides a number of practical difficulties. Industries in FEDERAL-F do not readily divide into those only producing exportables, and those only producing importables. Rather, most commodities record some volume of exports, and the output of most industries is subject to some level of import competition. To implement an equation defining $P_T^{\$A}$ in FEDERAL-F, I set α_X as the value share of exports in total trade, and α_M as the value share of imports in total trade. In practice, given that the balance of trade is a relatively small proportion of total trade, this translates to giving approximately equal weight to movements in P_M and P_X in the determination of $P_T^{\$A}$.

Equations *E_pMdom*, *E_p_tg*, and *E_xrate_r* in Section 10 of Appendix A, define the percentage change expressions for P_M, $P_T^{\$A}$, and $Q_{\$A/FC}^{(2)}$ respectively.

2.12.4 Economy wide commodity export volumes and prices

Equations *E_x_exp* and *E_p_exp* define, respectively, the percentage changes in both national export volumes and foreign currency export prices for commodity i. Equation *E_x_exp* calculates the percentage change in the national volume of exports of commodity i as the weighted sum of the percentage changes in the volume of exports of the commodity from each region. Equation *E_p_exp* corresponds to FEDERAL Equation 26, and calculates the percentage change in the foreign currency price of commodity *i*, economy-wide, as the weighted average of the percentage change in the export price of the commodity from each region.

2.12.5 Demand for imported commodity *i*

Equation 69 of the FEDERAL model calculates the percentage change in total domestic usage of imported commodity *i*. This is reproduced in FEDERAL-F as Equation *E_x_imp*. The percentage change in national demand for imported commodity *i* is defined as the weighted sum of the percentage changes in the demand for that commodity both nation-wide by the Commonwealth Government, and in each region by intermediate users, capital creators, households, and regional governments. Following their treatment in FEDERAL, imports are not used as margins in FEDERAL-F, and so this type of usage does not appear on the right hand side of Equation *E x_imp*.

2.12.6 Regional imports of commodity *i*

Equation *E_ximp_r* defines the percentage change in the volume of imports of commodity *i* into region *r* ($ximp\_r_{i,r}$). The coefficient on the left hand side of this equation is the base value of the c.i.f value of commodity imports of *i* into region *r* (the coefficient $TARF_i$ is the share of the c.i.f value of each commodity import in its duty-inclusive value). The coefficients on the right hand side of the equation are the base values of the c.i.f imports of *i* into *r* by each type of user. Hence, Equation *E_ximp_r* calculates $ximp\_r_{i,r}$ as the weighted sum of the percentage changes in imports of commodity *i* by each type of user within region *r*.

2.12.7 Equations to facilitate changes in macroeconomic closure

The closure options for a selection of macroeconomic variables under both the standard comparative static and structural closures are summarised in Table 2.12.1. The first column portrays a standard macroeconomic closure used in comparative static simulations. This closure is characteristic of a typical macroeconomic closure of the FEDERAL model. A standard macroeconomic closure for the FEDERAL model features endogenous private absorption (with real private investment indexed to real private consumption), exogenous real consumption and capital expenditure by all levels of government, and an endogenous balance of trade. In Equation *E_omega*, this requires *finv_com* to be exogenous.

The structural closure (column 2) requires a number of swaps in the endogenous / exogenous status of the variables summarised in Table 2.12.1. These swaps institute a macroeconomic closure in FEDERAL-F that is very similar to that of the MONASH model structural closure. A number of equations from the MONASH model that facilitate the establishment of the structural closure have thus been incorporated into FEDERAL-F.

The first step in establishing the structural closure is to break the link between real national private consumption spending and household disposable income through the endogenous determination of the economy-wide average propensity to consume (*f_eq19*). Instead, the percentage change in real national consumption spending is indexed to the percentage change in real gross national expenditure via the exogenous determination of the ratio of real consumption to real GNE (*r_cr_rgne*). This variable is defined by Equation *E_r_cr_rgne*. Second, the link between real economy-wide private investment expenditure and real consumption is broken via the endogenous determination of *finv_com*. Instead, real aggregate investment expenditure is indexed to real GNE via the exogenous determination of the ratio of real investment to real GNE (*r_cr_rgne*). This variable is defined by Equation *E_r_ir_rgne*.

The final swap sets the change in the ratio of the domestic currency balance of trade to GDP ratio exogenously, and determines endogenously real government consumption spending. To allow this, Equation *E_del_bt_gdp* defines the change in the ratio of the domestic currency balance of trade to GDP. This equation is a linearized version of the ratio of the balance of trade to GDP. This linearised version expresses both the BOT/GDP ratio and the balance of trade as rate of change variables, while expressing nominal GDP as a percentage change variable. The change in the domestic currency balance of trade (*del_B*) is defined by Equation *E_del_B*, as the weighted difference between the percentage changes in the Australian dollar values of foreign exports and imports. The weights are given by the base values of each, divided by 100.

Table 2.12.1: Macroeconomic closure of FEDERAL and FEDERAL-F: Selected variables

Variable	Description	FEDERAL Comparative Static Closure (1)	FEDERAL-F Structural Closure (2)
finv_com	Ratio of real private investment to real consumption	X	N
r_cr_rgne	Ratio of real consumption to real GNE	N	X
r_ir_rgne	Ratio of real investment to real GNE	N	X
f_eq19	Economy-wide APC	X	N
del_bt_gdp	Balance of trade to GDP ratio	N	X
f_govcon_gen	Real economy-wide government consumption	X	N

2.12.8 Wages by occupation and regional industry

Equation *E_plab* corresponds to FEDERAL model Equation 81. Both equations define the percentage change in the gross labour cost faced by regional industry *j,r* for labour of occupational type *m* ($plab_{m,j,r}$) as the weighted sum of the labour cost components of which the gross labour cost is comprised. These cost components are the post tax wage ($postwage_{m,j,r}$), PAYE tax ($paye_{m,j,r}$) and payroll tax ($p\_roll_{m,j,r}$). The weights on the right hand side of Equation *E_plab* represent the share in the gross labour cost of each of these component costs.

Equation 82 in the FEDERAL model indexes post tax wages ($postwage_{m,j,r}$) to either the regional or national CPI. Equation *E_prewage* in FEDERAL-F has the same structure as FEDERAL Equation 82, but indexes pre-PAYE tax wages (rather than post-PAYE tax wages) to either the national or regional CPI. This is a more accurate representation of wage determination in Australia. The possible introduction of such an equation to replace Equation 82 is discussed in Madden (1990). The standard implementation of Equation *E_prewage* has $HW1R_{m,j,r}$ set equal to zero and $HW1_{m,j}$ set equal to 1, thereby indexing pre-tax wages for each occupational class in each industry in each region to the national CPI. Employment, at any level of aggregation, can be determined exogenously by setting endogenous the appropriate real pre-tax wage shifter on the right hand side of Equation *E_prewage*.

Equations *E_paye* and *E_p_roll* correspond to FEDERAL Equations 84 and 85. These equations link, respectively, PAYE taxes and payroll taxes per labour unit to the nominal pre-PAYE tax wage per labour unit. Equation *E_postwage* corresponds to FEDERAL

Equation 86. This equation defines the percentage change in the pre-PAYE/post-payroll-tax wage as a weighted-sum of the percentage changes in post-tax wages and PAYE taxes per labour unit.

2.12.9 Regional nominal and real pre-tax wages

Equation *E_prewage_nr* calculates the percentage change in the regional nominal pre-tax (but post payroll tax) wage ($prewage\_nr_r$) as the weighted sum of the percentage changes in occupation and industry specific pre-tax wages of region *r* ($prewage_{m,j,r}$). Equation *E_prewage_rr* calculates the percentage change in the real (national CPI discounted) pre-tax wage for region *r* ($prewage\_rr_r$).

2.12.10 Output pricing for utility industries

During historical simulations of the model (covering the 1990's), the regional utility industries are found to experience significant productivity improvements. In the absence of some intervention into the model, this translates into significant reductions in the basic prices of their outputs. This can lead to either significant reductions in the purchasers' prices for these goods (for intermediate users) or significant increases in the phantom taxes on these goods (for households)[54]. Most of the firms in these industries began the 1990's as government agencies. Even by the end of the decade, while many were corporatised and privatised, significant areas of their activities remained subject to price regulation. The wholesale electricity market in the south-east of Australia in the mid to late 90's may be one of the few segments of the national utility market where the competitive assumption is a realistic way of modelling prices. Hence, Equations *E_fp_utility* and *E_prod_n_util* have been added to the model. These equations allow the usual assumption of price determination via perfect competition to be over-ridden for the utility industries.

Equation *E_fp_utility* allows a "CPI minus X" rule to govern the setting of basic prices for utility commodities. This also effectively determines the percentage rates of change in purchasers' prices (in the absence of changes in phantom taxes), since the rates of normal sales taxation on utility purchases are negligible. In the standard comparative static

[54] Since household purchaser's prices for these commodities are determined exogenously.

closure, Equation *E_fp_utility* is rendered inoperative via the endogenous determination of $fp\_utility_{i,s}$. The equation is brought into operation by setting $fp\_utility_{i,s}$ ($i \in$ UTILITY) exogenous, and determining endogenously the corresponding elements of $fprodrj_{j,r}$ ($j \in$ UTILITY). Alone, this closure links regional utility prices to the regional CPI. The coefficient X_UTE_r has a value equal to the "X" component of the pricing formula. It is then brought into effect by shocking del_x_r equal to 1.

Equation *E_prod_n_util* calculates the percentage change in the receipts of production taxes from industries other than utilities. This equation facilitates the exogenous determination of regional government production tax receipts under closures in which *E_fp_utility* is operational. In this case, it is no longer appropriate to exogenously specify aggregate regional production taxes ($b37r_r$) since the calculation of this variable includes the production tax revenue accruing on the output of utility industries. This production tax revenue is really a proxy for super-normal profits accruing to the regional government owners of capital in the utility industries. Hence it is not appropriate for the production tax revenues from these industries to be included in the measure of production tax revenue that is determined exogenously. Instead, $prod\_n\_util_r$ is determined exogenously, and shocked equal to the observed value for the percentage change in aggregate regional production tax receipts. Setting this variable exogenously (rather than $b37r_r$) has very little impact on the results, since the starting values for production taxes on the utility industries represent a small share of aggregate regional production taxes.

2.12.11 Summary results for a 12-sector categorisation

The implementation of FEDERAL-F discussed in Chapters 3 - 6 features 37 industries / commodities in two regions. While this is smaller than some previous implementations of the FEDERAL model[55], and hence likely future implementations of the FEDERAL-F model, it is nevertheless a sufficiently high number to add complexity to the task of interpreting, summarising and presenting the commodity and industry level results of the model. Hence, to facilitate the interpretation of results, eight sets of equations are added to the model, which aggregate the commodity and industry level results into a broad 12-sector

[55] For example, Giesecke, Madden and Pant (1998) implement a two region 104 sector version featuring Western Australia as the region of focus. Giesecke (2000) implements a three region 50 sector version featuring Tasmania and Victoria as the regions of focus.

aggregation. Despite this aggregation, as will be seen in Chapter 4, the classification system nevertheless retains sufficient detail to allow the user to identify the major mechanisms influencing the industry level results. This is so because movements in variables pertaining to these sectors are typically readily understandable by reference to major mechanisms in the model. The twelve sectors are:

1. Agriculture
2. Mining
3. Manufacturing
4. Utilities
5. Construction
6. Margins
7. Communications
8. Finance
9. Ownership of Dwellings
10. Public Administration
11. Community Services
12. Entertainment and Recreation

Equations *E_emp_12* through to *E_kstj_12* then calculate the following variables:

i. Percentage changes in sectoral employments ($emp\_12_{s,r}$) are defined by Equation *E_emp_12* as the (wage bill) share-weighted sum of the percentage changes in industry employments within each sector.

ii. Percentage changes in sectoral value added ($zact\_12_{s,r}$) are defined by Equation *E_zact_12* as the (value added) share-weighted sum of the percentage changes in industry activity levels within each sector.

iii. Percentage changes in sectoral production costs ($costs\_12_{s,r}$) are defined by Equation *E_costst_12* as the (sales revenue) share-weighted sum of the percentage changes in commodity basic prices within each sector.

iv. Percentage changes in sectoral export volumes ($exp\_12_{s,r}$) are defined by Equation *E_exp_12* as the (export value) share-weighted sum of the percentage changes in commodity export volumes within each sector.

v. Percentage changes in household consumption by sector ($hous\_12_{s,r}$) are defined by Equation *E_hous_12* as the (household purchaser's-value) share-weighted sum of the percentage changes in household consumption by commodity within each sector.

vi. Percentage changes in gross fixed capital formation by sector ($invest\_12_{s,r}$) are defined by Equation *E_invest_12* as the (investment value) share-weighted sum of the percentage changes in industry investments within each sector.

vii. Percentage changes in sectoral foreign currency export prices ($prexp\_12_{s,r}$) are defined by Equation *E_prexp_12* as the (export value) share-weighted sum of the percentage changes in commodity export prices within each sector.

viii. Percentage changes in sectoral capital stocks ($kstj\_12_{s,r}$) are defined by Equation *E_kstj_12* as the (capital value) share-weighted sum of the percentage changes in industry capital stocks within each sector.

2.12.12 Decomposition of changes in the household budget constraint

Regional household consumption expenditure is by far the largest component of regional domestic absorption, and so changes in this variable exert an important influence on the model results. Real household consumption expenditure is determined by real household disposable income, which in turn is determined by 14 types of gross incomes, taxes, and transfers[56]. Section 2.5 contains a detailed discussion of the determination of real household disposable income. Since real consumption plays an important role in influencing the results of the model, and because the determination of real consumption is itself complex, it is useful to add equations to the model to facilitate the interpretation of changes in the household income accounts. This is the purpose of Equations *E_ginc_wage*

[56] Many of which can in turn be decomposed further to distinguish industry and source (for capital receipts) and even commodity, use, and source (for phantom tax receipts).

through to *E_dtax_51*. While it may appear that these equations add a certain degree of redundancy to the model, they nevertheless prove very useful in facilitating a more rapid understanding of the origins of changes in household consumption. Use is made of these equations in the discussions of results presented in Chapters 4, 5 and 6.

Equations *E_ginc_wage* through to *E_ginc_xnfi* calculate the contribution (in percentage points) of each of the six broad components of gross income, to the percentage point change in total gross income. In essence, these six equations divide the RHS of Equation *E_ginc* into its component parts. For example, we can write a stylised version of *E_ginc* as

$$g_r = \sum_{t=1}^{6} S_t^r h_t^r \qquad \text{(E2.12.1)}$$

Where g_r is the percentage change in household r's gross income, S_t^r is the share of gross income type t in the total gross income of household r, and h_t^r is the percentage change in receipts of gross income type t by household r. It can be seen then that each of Equations *E_ginc_wage* through to *E_ginc_xnfi* has the general form:

$$g_t^r = S_t^r h_t^r \qquad \text{(E2.12.2)}$$

Where g_t^r is the contribution (in percentage point terms) of the percentage change in gross income type t, to the total percentage change in household gross income.

Equations *E_dinc_ginc* and *E_dinc_dtax*, and Equations *E_dtax_kaptax* through to *E_dtax_t51* have the same underlying form and serve the same function as Equation (E2.12.2) above. Equations *E_dinc_ginc* and *E_dinc_dtax* divide the percentage change in household disposable income into the individual contributions of the percentage changes in household nominal gross income (Equation *E_dinc_ginc*) and net direct taxes (Equation *E_dinc_dtax*). Similarly, Equations *E_dtax_kaptax* through to *E_dtax_t51* divide the percentage change in net household direct taxes into the individual contributions of the percentage changes in its component parts.

2.12.13 Decomposition of changes in industry and sectoral outputs

Changes in the prospects for individual industries are determined by changes in the demand for their output, in addition to changes in their costs of production. When interpreting the industry and commodity level results, and investigating the causes of the change in the activity level of a given industry, it is often useful to consider how changes in the pattern of demand for the industry's output have contributed to the total change in the industry's activity level. Since the current implementation of FEDERAL-F features unique product industries, this is simply a matter of dividing the RHS of Equations *E_p_basicMAR* and *E_p_basicNMAR* into appropriate parts. This is the purpose of Equations *E_dzact1* through to *E_dzact7m*. These equations divide the total percentage change in an industry's output into the individual contributions to that percentage change of:

i. purchases by intermediate input users in each region (Equation *E_dzact1*)
ii. purchases by capital creators in each region (Equation *E_dzact2*)
iii. purchases by households in each region (Equation *E_dzact3*)
iv. purchases by foreigners (Equation *E_dzact4*)
v. purchases by regional governments in each region (Equation *E_dzact5*)
vi. purchases by the Commonwealth Government (Equation *E_dzact6*); and
vii. purchases for use as a margin service (Equation *E_dzact7*).

Each of these equations has the same general form. If we were to write a stylised version of Equations *E_p_basicMAR* and *E_p_basicNMAR* as:

$$q_j^r = \sum_{a=1}^{n} S_{j,a}^r x_{j,a}^r \qquad \text{(E2.12.3)}$$

where q_j^r is the percentage change in activity of industry j in region r, $S_{j,a}^r$ is the share of the output of industry j in region r sold to user type a, and $x_{j,a}^r$ is the percentage change in the demand for the output of j in region r by user type a; then each of the Equations *E_dzact1* through to *E_dzact7m* has the general form:

$$q_j^{r(a)} = S_{j,a}^{r} x_{j,a}^{r} \qquad \text{(E2.12.4)}$$

where $q_j^{r(a)}$ is the percentage point contribution to the total percentage change in the output of regional industry *j,r*, of changes in the demand for its output by user type *a*.

Finally, to further assist in the task of interpreting the industry and sectoral results, a second set of equations (Equations *E_dzact1_12* to *E_dzact7_12*) have been added to the model. These aggregate the industry level results produced by Equations *E_dzact1* through to *E_dzact7m* into the 12-sector classification discussed in Section 2.12.11. Hence, these equations allow the model user to divide the total percentage change in a given sector's output into the individual contributions to that change of the movements in its sales to each of the seven user types.

2.12.14 Labour market adjustment

In deviation simulations FEDERAL-F allows the level of employment to depart only temporarily from its base-case value. Eventually, changes in economy-wide labour demand are fully reflected in changes in the real wage, with aggregate employment returning to its base-case value. This allows the labour market to exhibit a transition period of sticky wages and endogenous employment, but with the eventual attainment of the long-run position of flexible wages and exogenous aggregate employment. The mechanism that imposes this labour market adjustment is identical to that used in the MONASH model (Dixon and Rimmer 1999a). MONASH assumes that in policy/deviation simulations, the deviation in the real wage rate from its base value increases in proportion to the deviation in aggregate employment from its base value. The strength of the relationship between the deviation in the real wage and the deviation in aggregate employment is set so that, after about five years, the employment effects of a shock are almost fully realised as changes in the real wage. The MONASH labour market adjustment mechanism, as it is introduced into FEDERAL-F[57], can be expressed algebraically as:

[57] The original MONASH equation upon which Equation 2.12.5 is based also includes a term allowing for long-run changes in the aggregate supply of labour. This term is omitted from Equation 2.12.5.

$$\left(\frac{W_t^{[Dev]}}{W_t^{[Base]}}-1\right)=\left(\frac{W_{t-1}^{[Dev]}}{W_{t-1}^{[Base]}}-1\right)+\alpha\left(\frac{E_t^{[Dev]}}{E_t^{[Base]}}-1\right) \qquad \text{(E2.12.5)}$$

Where W_t is the real pre-tax wage in period t, E_t is economy-wide employment in period t, and the superscripts [Dev] and [Base] designate the value of the variables in the deviation / policy simulation, and the base historical / forecast run, respectively. The parameter α is assigned the value 0.6, which is sufficient to return employment to very near its base level after about five years. Linearising (E2.12.5) provides:

$$\frac{W_t^{[Dev]}}{W_t^{[Base]}}\left(w_t^{[Dev]}-w_t^{[Base]}\right)=d\left(\frac{W_{t-1}^{[Dev]}}{W_{t-1}^{[Base]}}\right)100+\alpha\frac{E_t^{[Dev]}}{E_t^{[Base]}}\left(e_t^{[Dev]}-e_t^{[Base]}\right) \qquad \text{(E2.12.6)}$$

Since the first term on the RHS of (E2.12.6) is the change in the ratio of the lagged values for the real wage, it is convenient to calculate this using the relevant coefficient values from the database post-multiplied by a homotopy variable as follows:

$$d\left(\frac{W_{t-1}^{[Dev]}}{W_{t-1}^{[Base]}}\right)=\left(\frac{W_{t-1}^{[Dev]}}{W_{t-1}^{[Base]}}-\frac{W_{t-2}^{[Dev]}}{W_{t-2}^{[Base]}}\right)\times\Delta H \qquad \text{(E2.12.7)}$$

Where ΔH is shocked equal to 1 during the policy / deviation simulations. Substituting (E2.12.7) into (E2.12.6) and making the obvious notational translations provides Equation *E_del_f_wage_c* in Section 10 of Appendix A. Under the comparative static closure, Equation *E_del_f_wage_c* is rendered inoperative via the endogenous determination of *del_f_wage_c*. In the deviation simulation, Equation *E_del_f_wage_c* is brought into operation by setting *del_f_wage_c* exogenous and determining the shift variable on the real pre-tax consumer wage (*fpre*) endogenously. The variables *real_wage_c_o* and *emp_w_wgts_o* are determined exogenously. In each year of the deviation simulation *real_wage_c_o* is shocked equal to the value originally attained by *r_prewage* in the base historical / forecast simulation. Similarly, in each year of the deviation simulation *emp_w_wgts_o* is shocked equal to the value originally attained by *l_emp* in the base historical / forecast simulation. The real economy-wide consumer pre-tax wage (*r_prewage*) is defined by Equation *E_r_prewage* as the wage bill weighted-sum of the percentage changes in the real pre-tax wages of each occupational type in each regional industry.

2.12.15 Regional shares in national GDP

Equation *E_grp_sh* calculates the percentage change in regional shares in national GDP. This equation is used in Chapter 6, in which a policy simulation is undertaken which examines the feasibility of state government action to hold constant Tasmania's share of national GDP.

2.13 REGIONAL ACCOUNTS

2.13.1 Introduction

The equations in Section 11 of Appendix A provide detailed accounting of regional level macroeconomic aggregates. A convenient summary of the major elements of the regional accounts that are defined in FEDERAL-F is provided by Table 2.13.1. Aggregate regional consumption and investment are calculated from the commodity accounts side. This is in addition to the calculations of these variables from the investment budget and household expenditure budget side of the model. Both real and nominal gross regional product at market prices are calculated. These calculations are undertaken from both the income (GRP(I)) and expenditure (GRP(E)) sides. Three definitions of both real and nominal gross regional product at factor cost GRP(FC) are also calculated. These definitions are: i. GRP(E) less indirect taxes; ii. the income approach; and, iii. the production approach. What might at first appear to be redundant calculations (ie. the evaluation of gross regional product from both the income and expenditure sides, and the evaluation of three definitions for gross regional product at factor cost) actually form an important part of the process of validating the computer implementation of the model. Any deviations in the results for consumption and investment as given by the household expenditure constraints and investment budgets and as given by the commodity accounts side; any deviation between GRP(I) and GRP(E); and any deviations in the results for the three definitions of GRP(FC), will all indicate a problem with the implementation of the model.

2.13.2 Gross regional product at market prices – expenditure side

Equations *E_r_grpe* and *E_n_grpe* calculate indices of real and nominal gross regional product from the expenditure side (GRP(E)). Both equations have the familiar form of expressing gross product at market prices as the sum of final expenditures less imports. The only complicating factor at the regional level is the need to also account for inter-regional net exports in addition to international net exports. The percentage change in the constant price measure of gross regional product (r_grpe_r) is given by Equation *E_r_grpe* as the weighted sum of the percentage changes in the constant price measures of the components of GRP(E). Similarly, the current price measure of GRP(E) is given by Equation $E\_n\_grpe_r$ as the weighted sum of the percentage changes in the current price measures of the components of GRP(E). Equation *E_gsp_def* calculates the gross regional product price deflator (gsp_def_r) as the weighted sum of the price deflators for each of the components of GRP(E). For each of these equations the relevant share weights are given by the shares of the value of the components of gross regional product (regional consumption, investment, consumption by two levels of government, exports (both inter-regional and international), and imports (both inter-regional and international)) in the gross regional product at market prices of region *r*.

2.13.3 Gross regional product at market prices – income side

Equation *E_n_grpi* calculates the percentage change in nominal gross regional product at market prices from the income side (n_grpi_r) as the share weighted sum of the movements in the components of GRP(I) – broadly: wages, gross profits, land rentals, state and Commonwealth production taxes, other cost tickets, and various indirect taxes including phantom taxes. Equation *E_r_grpi* calculates real gross regional product at market prices from the income side by deflating the nominal estimate for GRP(I) by the gross regional product deflator (*gsp_def*). A direct estimate of real gross regional product at market prices from the income side is not calculated, since it is not possible to construct a price

Table 2.13.1: Major Categories of the FEDERAL-F regional accounts

Variable Description	Variable Name		
	Real	Nominal	Price Index
Gross regional product (market prices) - expenditure approach	r_grpe_r	n_grpe_r	gsp_def_r
Gross regional product (market prices) - income approach	r_grpi_r*	n_grpi_r	n.a.
Gross regional product (factor cost) - market prices less indirect tax	r_grpfc1_r*	n_grpfc1_r	n.a.
Gross regional product (factor cost) - income approach	r_grpfc2_r	n_grpfc2_r	p_grpfc2_r
Gross regional product (factor cost) - production approach	r_grpfc3_r	n_grpfc3_r*	n.a.
Gross fixed capital formation	$x2reg_r$	$n2reg_r$	$p2reg_r$
Household consumption	$x3reg_r$	$n3reg_r$	$p3reg_r$
Foreign exports	$x4reg_r$	$n4reg_r$	$p4reg_r$
Regional government consumption	$x5reg_r$	$n5reg_r$	$p5reg_r$
Commonwealth Government consumption	$x6reg_r$	$n6reg_r$	$p6reg_r$
Interstate exports	x_isx_r	n_isx_r	p_isx_r
Interstate imports	x_ism_r	n_ism_r	p_ism_r
Foreign imports	$xMreg_r$	$nMreg_r$	$pMreg_r$

n.a. This variable cannot be calculated

* This variable cannot be calculated directly. However an estimate is defined for comparative purposes by combining results across different GRP definitions.

deflator for every component of GRP(I). For this reason the Australian Bureau of Statistics also calculate their constant price estimates of gross product at market prices from the income side by deflating their current price estimate for the same by the implicit price deflator for gross product from the expenditure side. This is the approach underlying Equation *E_r_grpi*.

2.13.4 Gross regional product at factor cost

Three definitions of gross regional product at factor cost are calculated. As discussed in Section 2.13.1, confirming after each simulation that the results for these three definitions are identical forms an important part of validating the computer implementation of the model. The first of the three approaches deducts indirect taxes from gross regional product at market prices (Equations *E_n_grpfc1* and *E_r_grpfc1*). The second method uses the income approach (Equations *E_n_grpfc2* and *E_r_grpfc2*). The third method uses the production approach (Equations *E_n_grpfc3* and *E_r_grpfc3*). The equations implementing each of these approaches are discussed in turn below.

Equation *E_n_grpfc1* is the percentage change form of the expression for nominal gross regional product at factor cost as GRP(E) less indirect taxes. A real measure of gross regional product at factor cost cannot be calculated using this approach because it is not possible to calculate a deflator for indirect taxes. Instead, a real estimate for this first definition of GRP(FC) is calculated by deflating the nominal estimate by the deflator for gross regional product at factor cost calculated by Equation *E_p_grpfc2*. This equation calculates the percentage change in the region-wide price of value-added for region r (p_grpfc2_r) as the share weighted sum of the percentage changes in the effective prices of the components of value-added in the region. Equation *E_r_grpfc1* then calculates r_grpfc1_r as the difference between n_grpfc1_r and p_grpfc2_r.

Equations *E_r_grpfc2* and *E_n_grpfc2* calculate gross regional product at factor cost using the income approach. Equation *E_r_grpfc2* calculates the percentage change in real GRP(FC) for region r as the share weighted sum of the percentage changes in the effective units of primary factors (including other costs) used within region r. Equation *E_n_grpfc2* calculates the percentage change in nominal GRP(FC) for region r as the share weighted sum of the percentage changes in the gross primary factor incomes (including other costs) used within region r.

Equations *E_r_grpfc3* and *E_n_grpfc3* calculate gross regional product at factor cost using the production approach. Equation *E_r_grpfc3* calculates the percentage change in real gross regional product at factor cost for region r as the value-added weighted sum of the percentage changes in the output of the industries located within region r. The calculation of nominal gross regional product at factor cost based on the production approach (Equation *E_n_grpfc3*) is undertaken by inflating the real estimate (r_grpfc3_r) by the index for the price of value added within region r (p_grpfc2_r).

2.13.5 Real regional gross fixed capital expenditure

Equation *E_x2reg* calculates the percentage change in real region r gross fixed capital expenditure ($x2reg_r$) as the share weighted sum of the percentage changes in the usage of effective[58] units of source specific commodities by industries in region r.for use in capital formation. The relevant shares are those of the purchaser's value of source-specific

[58] "Effective" in the sense that it includes the augmenting or deteriorating effects on the productivity of these inputs of shifts in the productivity variables $a\_in2_{j,r}$ and $a2isjr_{i,s,j,r}$.

commodities used by individual industries in region *r* ($PV2_{i,s,j,r}$) in total gross fixed capital expenditure in region *r* ($\sum_i \sum_s \sum_j PV2_{i,s,j,r}$).

2.13.6 Real regional household consumption

Equation *E_x3reg* calculates the percentage change in real household consumption in region *r* as the share weighted sum of the percentage changes in individual source-specific commodity purchases by households in *r*. The relevant shares are those of the purchaser's value of the consumption of each individual source-specific commodity ($PV3_{i,s,r}$) in total regional household consumption (CON_R_r). The solution for *x3reg* should be the same as the measure for real regional consumption spending representing the household's real budget constraint, crR_r (see Equation *E_crR*). This equality provides a useful check on the computer implementation of the model.

2.13.7 Real overseas exports from region *r*

Equation *E_x4reg* calculates the percentage change in real overseas exports from region *r* as the share weighted sum of the percentage changes in the quantities of exports of commodity *i* from region *r*. The relevant weight for the percentage change in the quantity of each individual commodity export is the share of its purchaser's value in the total purchaser's value of all exports from region *r*.

2.13.8 Real consumption spending by regional government *r*

Equation *E_x5reg* calculates the percentage change in regional government *r*'s real consumption spending as the share weighted sum of the percentage changes in the quantities of source-specific commodities purchased by that government for current consumption. The relevant shares are the purchaser's value of individual source specific commodities consumed by regional government *r* for current consumption purposes ($PV5_{i,s,r}$) in the total current consumption spending of regional government *r* ($\sum_{i \in COM} \sum_{s \in SOU} PV5_{i,s,r}$).

2.13.9 Commonwealth real consumption spending by region

In order to calculate regional domestic absorption, it is necessary to allocate Commonwealth government consumption spending among the regions. This is relatively straightforward for domestically-sourced commodities. For such commodities, the basic value (plus any associated phantom taxes[59]) of the purchase is considered a component of absorption in the region in which the purchase takes place. In the case of margins, these are allocated to the region supplying the margin, regardless of the source of the commodity with which the margin is associated. However, imports cannot be so readily allocated to individual regions. A share of national Commonwealth government imports is allocated to each region on the basis of the region's share in national GDP at factor cost. This share is given by the coefficient $CGOV\_SH_r$ in Equation *E_x6reg*. Given these assumptions, Equation *E_x6reg* calculates the percentage change in Commonwealth Government consumption allocated to region *r* as the share weighted sum of the percentage changes in: purchases of commodity-specific commodities produced in region *r* by the Commonwealth for current consumption; usage of margins produced in region *r* on Commonwealth current consumption purchases, regardless of source; and, the share of imports of commodity *i* by the Commonwealth Government for current consumption imputed to region *r*.

2.13.10 Real inter-regional exports from region *s*

Equation *E_x_isx* calculates the percentage change in real inter-regional exports from region *s*. The arithmetic underlying the accounting for inter-regional exports in Equation *E_x_isx* is the same as that underlying Equation *E_n_isx* (see Section 2.13.18). However, as an index of real exports, the price variables that appear in Equation *E_n_isx* do not appear in *E_x_isx*. The structure of this equation is otherwise identical to the former.

2.13.11 Real inter-regional imports into region *r*

Equation *E_x_ism* calculates the percentage change in real inter-regional imports into region *r*. The accounting for inter-regional imports that underlies Equation *E_x_ism* is identical to that underlying Equation *E_n_ism* (see Section 2.13.19). However, as a

[59] Phantom taxes are the only indirect taxes levied on Commonwealth purchasers.

measure of quantity changes, no price variables appear on the right hand side of Equation *E_x_ism*.

2.13.12 The volume of foreign imports into region *r*

Equation *E_xMreg* calculates the percentage change in the aggregate volume of foreign imports into region *r*. This is given by the weighted sum of the percentage changes in the volume of commodity and user-specific demands for imports by all agents within the region. The relevant weights are given by the share of the c.i.f value of each commodity import by each type of agent within the region, in the aggregate c.i.f value of all imports into the region (IMP_R_r). The c.i.f value of each type of import is calculated by multiplying the basic value of each commodity import by each user type (which is inclusive of duty), by the coefficient $TARF_i$. The latter is the share of the c.i.f value of each commodity import in its duty-inclusive value.

2.13.13 Regional nominal gross fixed capital expenditure

Equation *E_n2reg* calculates the percentage change in region *r*'s nominal gross fixed capital expenditure as the share weighted sum of the percentage changes in the value of purchases by individual regional industries of source-specific commodities as inputs to capital formation. The relevant shares are those of the purchaser's value of the source specific commodities used by regional industry *j,r* for capital formation, in the total value of gross fixed capital expenditure in region *r*.

3.13.14 Nominal regional household consumption spending

Equation *E_n3reg* calculates the percentage change in nominal household consumption spending in region *r* as the share weighted sum of the percentage change in the values (at purchaser's prices) of household *r*'s consumption of individual source-specific commodities. The relevant weights are given by the share of the purchaser's value for commodity *i* from source *s* consumed by household *r* ($PV3_{i,s,r}$) in the total consumption of household *r* (CON_R_r). In checking the computer implementation of the model, the value for *n3reg* should correspond to that for the nominal regional household budget constraint, cnr_r (see Equation *E_cnr*).

2.13.15 Nominal overseas exports from region *r*

Equation *E_n4reg* calculates the percentage change in nominal overseas exports valued in domestic currency from region *r* as the share weighted sum of the percentage changes in the purchaser's value, in Australian dollars, of the exports of commodity *i* from region *r*. The relevant weights are the shares of the purchaser's value of the individual commodity exports from region *r* in the total purchaser's value of exports from region *r*.

2.13.16 Nominal regional government *r* consumption spending

Equation *E_n5reg* calculates the percentage change in total nominal regional government *r* consumption spending as the share weighted sum of the percentage changes in the value of the purchases by that regional government of source-specific commodities for current consumption. The relevant weights are the purchaser's value of individual source specific commodities consumed by the regional government ($PV5_{i,s,r}$) in the total of all current consumption spending by that regional government ($\sum_{k \in COM} \sum_{t \in SOU} PV5_{k,t,r}$).

2.13.17 Commonwealth nominal consumption spending by region

Equation *E_n6reg* calculates Commonwealth nominal consumption spending by region. Again, domestically sourced commodities are allocated to the region from which they are purchased, as are any phantom taxes associated with that purchase. Margins attached to Commonwealth purchases are allocated to the region supplying the margin. Imports are allocated among regions on the basis of their base shares in national gross domestic product at factor cost. The percentage change in Commonwealth nominal consumption spending in region *r* is then equal to the share weighted sum of the percentage changes in: the basic value of the purchases of commodity *i* from region *r* by the Commonwealth Government for current consumption purposes; the percentage change in the value of any phantom taxes associated with the purchase of commodity *i* from region *r* by the Commonwealth Government for current consumption purposes; the percentage change in the value of margin *u* supplied by region *r* for the purpose of facilitating commodity flows associated with Commonwealth current consumption expenditure; and the percentage change in the value of Commonwealth imports of commodity i that have been allocated to region r.

2.13.18 Nominal inter-regional exports from region s

Equation *E_n_isx* calculates the percentage change in nominal inter-regional exports from region s. The arithmetic underlying Equation *E_n_isx* is that the value of inter-regional exports from region s can be calculated by subtracting from the value of domestic sales of the output of region s those sales that are made to users within region s. This idea defines the structure of the right hand side of the equation. In succession, for each user type, total usage of goods sourced from region s is first summed for users of that type located in all domestic regions, and from this is then subtracted usage by users of that type located within the source region s. There is no inter-regional transportation of commodities for Commonwealth current consumption purposes.

2.13.19 Nominal inter-regional imports into region r

Equation *E_n_ism* calculates the percentage change in nominal inter-regional imports into region r. The assumption underlying Equation *E_n_ism* is that inter-regional imports to region r are equal to the difference between the total usage of domestically-sourced commodities within region r, and the usage of region-r sourced commodities within region r. On the right hand side of Equation *E_n_ism*, this idea is applied to each type of user within region r in succession: first their total usage of Australian produced commodities is calculated, and from this is subtracted their usage of locally sourced commodities. Since there is no inter-regional transportation of commodities for Commonwealth current consumption purposes, this user type does not appear in the equation.

2.13.20 The Australian dollar c.i.f value of foreign imports into region r

Equation *E_nMreg* calculates the percentage change in the aggregate Australian dollar value of foreign imports into region r. This is given by the weighted sum of the percentage changes in the value of commodity and user-specific demands for imports by all agents within the region. The relevant weights are given by the share of the c.i.f value of each commodity import by each type of agent within the region, in the aggregate c.i.f value of all imports into the region (IMP_R_r). The c.i.f value of each type of import is calculated by multiplying the basic value of each commodity import by each user type (which is inclusive of duty), by the coefficient $TARF_i$. The latter is the share of the c.i.f value of each commodity import in the duty-inclusive value of each commodity import. The percentage change in the value of each commodity and user-specific import demand is found by summing the percentage change in the volume of the commodity and user-specific import demand (eg. $x1_{i,RoW,j,r}$), the commodity's foreign currency price (pmp_i), and the \$A / \$FC exchange rate (*x_rate*).

2.13.21 Price index for regional gross fixed capital formation

Equation *E_p2reg* calculates the percentage change in the regional gross fixed capital formation price index as the share weighted sum of the percentage changes in the effective prices of source-specific commodities used by individual industries in region *r* for the purpose of capital formation. Again, the relevant shares are those of the purchaser's value of source-specific commodities used by individual industries in region *r* ($PV2_{i,s,j,r}$) in total gross fixed capital expenditure in region *r*.

2.13.22 Regional consumer price index

Equation 73 in FEDERAL calculates the percentage change in the consumer price index for region *r* as the weighted sum of the percentage changes in the prices paid by consumers in region *r* for commodities from each of the three sources. FEDERAL Equation 73 is reproduced in FEDERAL-F as Equation *E_p3reg*.

2.13.23 Australian dollar price index for overseas exports from region *r*

Equation *E_p4reg* calculates the percentage change in the index of Australian dollar export prices for region *r* as the share weighted sum of the percentage changes in the Australian dollar prices of the individual commodity exports from region *r*. The weight for each individual commodity export price for region *r* is given by its base value share in the total value (at purchasers' prices) of overseas exports from region *r*.

2.13.24 Index of regional government *r* consumption prices

Equation *E_p5reg* calculates the percentage change in regional government *r*'s index of consumption prices as the share weighted sum of the percentage changes in the prices of source-specific commodities purchased by that government for current consumption. The relevant shares are those of the purchaser's value of individual source specific commodities consumed by regional government *r* ($PV5_{i,s,r}$) in the total current consumption spending of regional government *r* ($\sum_{i\in COM}\sum_{s\in SOU} PV5_{i,s,r}$).

2.13.25 Price index of Commonwealth regional consumption spending.

Equation *E_p6reg* calculates the regional price index for Commonwealth consumption spending. Again, domestically sourced commodities are allocated to the region from which they are purchased, as are any phantom taxes associated with that purchase. Margins attached to Commonwealth purchases are allocated to the region supplying the margin. Imports are allocated among regions on the basis of their base share in national gross domestic product at factor cost. The percentage change in the regional price index of Commonwealth consumption spending is then equal to the share weighted sum of the percentage changes in: the basic price of commodity *i* from region *r* purchased by the Commonwealth Government for current consumption purposes; the percentage change in the per-unit phantom taxes associated with the purchase of commodity *i* from region *r* by the Commonwealth Government for current consumption purposes; the percentage change in the price of margin *u* supplied by region *r* for the purpose of facilitating commodity flows associated with Commonwealth current consumption expenditure; and the percentage change in the price of Commonwealth imports of commodity *i* that have been allocated to region *r*.

2.13.26 Price Index of inter-regional exports from region *s*

Equation *E_p_isx* calculates the percentage change in the price index for inter-regional exports from region *s*. The arithmetic underlying the accounting for inter-regional exports in Equation *E_p_isx* is the same as that underlying Equation *E_n_isx*. However, as a price index, the quantity variables that appear in Equation *E_n_isx* do not appear in *E_p_isx*. The structure of this equation is otherwise identical to the former.

2.13.27 Price index for inter-regional imports into region *r*

Equation *E_p_ism* calculates the percentage change in the price index for inter-regional imports into region *r*. The accounting for inter-regional imports that underlies Equation *E_p_ism* is identical to that underlying Equation *E_n_ism*. However, as a price index, no quantity variables appear on the right hand side of Equation *E_p_ism*.

2.13.28 The domestic currency c.i.f price index for foreign imports into region *r*

Equation *E_pMreg* calculates the percentage change in the domestic currency c.i.f price index for foreign imports into region *r*, $pMreg_r$. The potential form of this equation is simplified by the fact that foreign currency commodity import prices do not vary across either users or regions. Hence $pMreg_r$ can be represented as the share weighted sum of the percentage changes in the Australian dollar c.i.f prices of individual commodity imports, where the relevant weights are given by the share of the c.i.f value of commodity *i* imported into region *r* ($IMPI\_R_r$) in the total c.i.f. value of imports into region *r* (IMP_R_r).

2.13.29 Change in the nominal trade surpluses of region *r*

Equation *E_is_surplus* defines the change in the interstate trade surplus of region *r* as the weighted difference between the percentage changes in the values of the interstate exports and interstate imports of region *r*. Since $is\_surplus_r$ is a rate of change variable, the weights are given by the absolute values of the interstate exports and interstate imports of region *r*, each divided by 100. Equation *E_os_surplus* calculates the change in the nominal Australian dollar value of region *r*'s overseas trade surplus as the weighted difference between the percentage changes in the values of overseas exports out of, and interstate imports into, region *r*. Again, since $os\_surplus_r$ is a rate of change variable, the weights are given by the absolute values of the foreign exports and foreign imports of region *r*, each divided by 100.

2.13.30 Indirect tax revenue by region

Equation *E_itrev_r* defines the percentage change in indirect tax revenue collections in region *r* ($itrev\_r_r$). This is given as the weighted sum of the percentage changes in the collections of each type of indirect tax within region *r* by each level of government, and the percentage change in phantom tax collections in region *r*. Total indirect tax collections in region *r* are given by the sum of Commonwealth Government tariff, production tax, sales tax, and export tax revenues; Regional government *r*'s commodity and production tax revenues; and phantom tax revenues.

Equation *E_itrev_r* introduces variables that define Commonwealth Government indirect tax collections by region. These variables are defined by Equations *E_b43_r*, *E_b44_r*, *E_b45_r* and *E_b46_r*. Equation *E_b43_r* calculates the percentage change in Commonwealth tariff revenue by region as the weighted sum of the percentage changes in tariff revenue on commodity *i* imported into region *r*. Equation *E_b44_r* defines the percentage change in Commonwealth net production tax receipts in region *r* as the weighted sum of the percentage changes in Commonwealth net production tax receipts by industry in region *r*. The percentage change in net production tax payments by regional industry *j,r* is the sum of the percentage changes in both the per-unit production tax rate ($cpptax_{j,r}$) and *j,r*'s usage of Commonwealth production tax units ($xcptax_{j,r}$). Equation *E_b45_r* calculates the percentage change in Commonwealth sales tax receipts in region *r* as the weighted sum of such taxes collected on purchases by agents in region *r* of intermediate inputs, inputs to capital formation, and inputs to consumption. Finally, Equation *E_b46_r* defines the percentage change in Commonwealth export tax collections from region *r* as the weighted sum of the percentage changes in export tax collections by commodity exported from region *r*.

2.13.31 Real gross regional expenditure

Equation *E_rgre* defines the percentage change in the real gross regional expenditure of region *r*. This is given as the weighted sum of the percentage changes in the real values of the component parts of gross regional expenditure: real regional consumption ($x3reg_r$), real regional investment ($x2reg_r$), real regional government consumption expenditure ($x5reg_r$), and real Commonwealth expenditure in region *r* ($x6reg_r$). The weights are given by the share of the base values of these components in the base value of region *r*'s gross expenditure.

2.14 NATIONAL ACCOUNTS

2.14.1 Introduction

The equations in Section 12 of Appendix A provide detailed accounting of national macroeconomic aggregates. The macroeconomic aggregates that are evaluated by this set of equations mirror those discussed in reference to the accounting for regional macroeconomic variables in Section 2.13. A convenient summary of the major elements of the national accounts that are defined in FEDERAL-F is provided by Table 2.14.1. Again, both (national) consumption and investment are calculated from the demand side. Real and nominal gross domestic product at market prices are calculated from both the income (GDP(I)) and expenditure (GDP(E)) sides. Three definitions of real and nominal gross domestic product at factor cost are calculated: the first deducts indirect taxes from GDP(E), the second uses the income approach, and the third uses the production approach. As was discussed in Section 2.13.1, what might at first appear to be some redundancy in the number of national macroeconomic variables evaluated is actually an important means of checking the implementation of the model after each simulation. The results for alternative definitions of the same variable should be identical. Should this not be the case, an error in the implementation of the model has occurred and must be remedied.

2.14.2 Gross domestic product at market prices - expenditure side

Equations *E_r_gdpe* and *E_n_gdpe* calculate, respectively, real and nominal gross domestic product from the expenditure side. Both equations have the familiar form of expressing gross domestic product at market prices as the sum of final expenditures less imports. The percentage change in the constant price measure of gross domestic product (*r_gdpe*) is defined by Equation *E_r_gdpe* as the weighted sum of the percentage changes in the constant price measures of the components of GDP(E). Similarly, the current price measure of GDP(E) is given by Equation *E_n_gdpe* as the weighted sum of the percentage changes in the current price measures of the components of GDP(E). Equation *E_gdp_def*

Table 2.14.1: Major Categories of the FEDERAL-F national accounts

Variable Description	Variable Name		
	Real	Nominal	Price Index
Gross domestic product (market prices) - expenditure approach	*r gdpe*	*n gdpe*	*gdp_def*
Gross domestic product (market prices) - income approach	*r_gdpi*	*n_gdpi*	n.a
Gross regional product (factor cost) - market prices less indirect tax	*r_gdpfc1*	*n_gdpfc1*	n.a.
Gross regional product (factor cost) - income approach	*r_gdpfc2*	*n_gdpfc2*	
Gross regional product (factor cost) - production approach	*r_gdpfc3*	*n_gdpfc3*	n.a.
Gross fixed capital formation	*x2nat*	*n2nat*	*p2nat*
Household consumption	*x3nat*	*n3nat*	*p3nat*
Foreign exports	*x4nat*	*n4nat*	*p4nat*
Regional government consumption	*x5nat*	*n5nat*	*p5nat*
Commonwealth Government consumption	*x6nat*	*n6nat*	*p6nat*
Foreign imports	*xMnat*	*nMnat*	*pMnat*

n.a. This variable cannot be calculated

calculates the GDP deflator as the weighted sum of the price deflators for each of the components of GDP(E). For each of these equations, the relevant share weights on the right hand side variables are given by the shares of the values of the components of GDP (household consumption, investment, consumption by two levels of government, exports, and imports) in GDP.

2.14.3 Gross domestic product at market prices - income side

Equations *E_n_gdpi* and *E_r_gdpi* calculate the percentage change in nominal and real GDP(I) respectively. Both equations calculate the percentage changes in their respective measures of GDP(I) as the share weighted sum of the percentage rates of change in the corresponding measures of GRP(I). Equation *E_n_gdpi* calculates the percentage change in nominal GDP(I) as the share weighted sum of the percentage rates of change in nominal GRP(I). Equation *E_r_gdpi* calculates the percentage change in real GDP(I) as the share weighted sum of the percentage rates of change in real GRP(I). In both equations, the relevant share weights are given by the shares in GDP(I) of the gross products (from the income side) of each region.

2.14.4 Gross domestic product at factor cost

Three definitions of gross domestic product at factor cost are calculated. The first approach (underpinning Equation *E_n_gdpfc1*) calculates nominal gross domestic product at factor cost by deducting indirect taxes from gross domestic product at market prices. As discussed in Section 2.13.4, using this approach, it is necessary to find an indirect means of calculating the percentage change in real gross domestic product at factor cost. Hence, at the national level, the percentage rate of change in real GDP at factor cost under the first approach is calculated by Equation *E_r_gdpfc1* as the share weighted sum of the percentage rates of change in the corresponding regional values for this definition of gross product at factor cost (r_grpfc1_{r}.). Equations *E_n_gdpfc2* and *E_r_gdpfc2* calculate, respectively, the percentage changes in nominal and real gross domestic product at factor cost using the income approach. Both equations calculate the national value for this measure of GDP at factor cost as the share weighted sum of the corresponding regional measure of GRP at factor cost. Similarly, Equations *E_n_gdpfc3* and *E_r_gdpfc3* calculate the percentage rates of change in, respectively, nominal and real GDP at factor cost, using the production approach. Again, both equations calculate the national value for this measure of GDP at factor cost as the share weighted sum of the percentage rates of change in the corresponding regional measures for this definition of gross product at factor cost.

2.14.5 Real national gross fixed capital expenditure

Equation *E_x2nat* calculates the percentage change in real economy-wide gross fixed capital expenditure, *x2nat*. This is given by the share weighted sum of the percentage changes in the purchases of effective units of source-specific commodities by individual regional industries for the purpose of capital formation. The relevant shares are those of the purchaser's value of individual commodity purchases for capital formation ($PV2_{i,s,j,r}$) in total national gross fixed capital expenditure, ($\sum_i \sum_s \sum_j \sum_r PV2_{i,s,j,r}$). The solution for *x2nat* should be the same as that for the measure of real national gross fixed capital expenditure given by the national investment budget, *i_aust_r* (see Equation *E_i_aust_r*). This equality provides a useful check on the computer implementation of the model.

2.14.6 Real of national household consumption

Equation *E_x3nat* calculates the percentage change in real national household consumption expenditure (*x3nat*) as the share weighted sum of the percentage changes in real regional household consumption expenditure ($x3reg_r$). The relevant shares are those of regional consumption in total national consumption. Again, the solution for *x3nat* should be the same as that provided by the economy-wide real household budget constraint, *cR* (see Equation *E_cR*) thus providing a check on the computer implementation of the model.

2.14.7 Real national exports

Equation *E_x4nat* calculates the percentage change in the quantity index of Australian exports as the share weighted sum of the percentage changes in the quantity indices of foreign exports from each region. The share weights are given by the base shares of each region in total Australian exports.

2.14.8 Economy-wide regional government real consumption spending

Equation *E_x5nat* calculates the percentage change in economy-wide real regional government consumption spending as the share weighted sum of the percentage changes in the quantities purchased by all regional governments of source-specific commodities for current consumption. The relevant weights are the purchaser's value of individual source specific commodities consumed by each regional government ($PV5_{i,s,r}$) in aggregate national state current consumption spending by regional governments ($\sum_{k \in COM} \sum_{t \in SOU} \sum_{r \in REG} PV5_{k,t,r}$).

2.14.9 Commonwealth real consumption spending: economy wide

Equation *E_x6nat* calculates the percentage change in economy-wide real Commonwealth Government current consumption spending as the share weighted sum of the percentage changes in the quantities of the individual source-specific commodities purchased by the Commonwealth Government for that purpose. The relevant weights are given by the share of the value (at purchaser's prices) of the individual source-specific commodities purchased by the Commonwealth for current consumption purposes ($PVCG_{i,s}$) in total economy-wide Commonwealth consumption spending ($\sum_{k \in COM} \sum_{t \in SOU} PVCG_{k,t}$).

2.14.10 National import volume index

Equation *E_xMnat* calculates the percentage change in the national import volume index (*xMnat*) as the share weighted sum of the percentage changes in the regional import volume indices ($xMreg_r$). The relevant share weights are given by the shares of the c.i.f value of imports into each region (IMP_R_r) in the aggregate c.i.f value of imports into Australia ($\sum_{r \in REG} IMP\_R_r$).

2.14.11 National nominal gross fixed capital expenditure

Equation *E_n2nat* calculates the percentage change in national nominal gross fixed capital expenditure as the share weighted sum of the percentage changes in the value of purchases by individual regional industries of source-specific commodities as inputs to capital formation. The relevant shares are those of the purchaser's value of the source-specific commodities *i,s* used by regional industry *j,r* for capital formation, in the total value of national gross fixed capital expenditure.

2.14.12 National nominal household consumption expenditure

Equation *E_n3nat* calculates the percentage change in national nominal household consumption expenditure (*n3nat*) as the share weighted sum of the percentage changes in regional nominal consumption expenditure ($n3reg_r$).

2.14.13 National nominal overseas exports

Equation *E_n4nat* calculates the percentage change in the nominal Australian dollar value of exports from Australia as the share weighted sum of the percentage changes in the nominal values of regional foreign exports. The relevant share weights are given by the base shares of each region in total Australian exports.

2.14.14 Nominal aggregate consumption spending by regional governments

Equation *E_n5nat* calculates the percentage change in economy-wide nominal regional government consumption spending as the share weighted sum of the percentage changes in the value of the purchases of source-specific commodities for current consumption purposes by all regional governments. The relevant weights are given by the shares of the purchaser's values of the individual source specific commodities consumed by each regional government ($PV5_{i,s,r}$) in aggregate national regional government current consumption spending ($\sum_{r \in REG} \sum_{k \in COM} \sum_{t \in SOU} PV5_{k,t,r}$).

2.14.15 Commonwealth nominal consumption spending, economy wide

Equation *E_n6nat* calculates the percentage change in economy-wide nominal Commonwealth Government current consumption spending as the share weighted sum of the percentage changes in the value of the individual source-specific commodities purchased by the Commonwealth Government for this purpose. The relevant weights are given by the share of the value (at purchaser's prices) of the individual source-specific commodities purchased by the Commonwealth for current consumption purposes ($PVCG_{i,s}$) in total economy-wide Commonwealth consumption spending ($\sum_{k \in COM} \sum_{t \in SOU} PVCG_{k,t}$).

2.14.16 The Australian dollar c.i.f value of imports into Australia

Equation *E_nMnat* calculates the percentage change in the Australian dollar c.i.f value of aggregate imports into Australia (*nMnat*) as the share weighted sum of the percentage changes in the regional c.i.f import value indices ($nMreg_r$). The relevant share weights are given by the shares of the c.i.f value of imports into each region (IMP_R_r) in the aggregate c.i.f value of Australian imports ($\sum_{r \in REG} IMP\_R_r$).

2.14.17 National price index for economy-wide gross fixed capital formation

Equation *E_p2nat* calculates the percentage change in the national price index for gross fixed capital formation as the share weighted sum of the percentage changes in the effective prices of the individual source-specific inputs to capital formation purchased by the individual regional industries. The relevant shares are those of the purchaser's value of the source specific commodities used by each regional industry, ($PV2_{i,s,j,r}$) in total national gross fixed capital expenditure ($\sum_{r\in REG}\sum_{i\in COM}\sum_{s\in SOU}\sum_{j\in IND} PV2_{i,s,j,r}$).

2.14.18 National consumer price index

Equation 74 in FEDERAL calculates the percentage change in the national consumer price index as the weighted sum of the percentage changes in the regional consumer price index. FEDERAL Equation 74 is reproduced in FEDERAL-F as Equation *E_p3nat*.

2.14.19 National Australian dollar export price index

Equation *E_p4nat* calculates the percentage change in the Australian dollar price index for national exports as the share weighted sum of the percentage changes in the Australian dollar export price indices for each region. The share weights are given by the base shares of each region in total Australian exports.

2.14.20 National index of regional government consumption prices

Equation *E_p5nat* calculates the percentage change in the price index of economy-wide regional government consumption spending as the share weighted sum of the percentage changes in the prices of the purchases by all regional governments of source-specific commodities for current consumption. The relevant weights are given by the shares of the purchaser's values of the individual source specific commodities consumed by each regional government ($PV5_{i,s,r}$) in aggregate national regional government current consumption spending ($\sum_{r\in REG}\sum_{k\in COM}\sum_{t\in SOU} PV5_{k,t,r}$).

2.14.21 National price index of Commonwealth current consumption spending

Equation *E_p6nat* calculates the percentage change in the economy-wide price index of Commonwealth Government current consumption spending as the share weighted sum of the percentage changes in the prices of the individual source-specific commodities purchased by the Commonwealth Government for that purpose. The relevant weights are given by the share of the value (at purchaser's prices) of the individual source-specific commodities purchased by the Commonwealth for current consumption purposes ($PVCG_{i,s}$) in total economy-wide Commonwealth consumption spending ($\sum_{k \in COM} \sum_{t \in SOU} PVCG_{k,t}$).

2.14.22 The national domestic currency c.i.f import price index

Equation *E_pMnat* calculates the percentage change in the Australian c.i.f import price index (*pMnat*) as the share weighted sum of the percentage changes in the regional c.i.f import price indices ($pMreg_r$). The relevant share weights are given by the shares of the c.i.f value of imports into each region (IMP_R_r) in the aggregate c.i.f value of Australian imports ($\sum_{r \in REG} IMP\_R_r$).

2.14.23 National indirect tax revenue collection

Equation *E_itrev* defines the percentage change in aggregate indirect tax revenue collections at the national level (*itrev*). This is calculated as the weighted sum of the percentage changes in indirect tax revenue collections at the regional level ($itrev\_r_r$). The weights are given by the share in national indirect tax collections of indirect taxes collected in each region.

2.14.24 Quantity and price indices of real gross national expenditure

Equation *E_real_gne* defines the percentage change in real gross national expenditure (*real_gne*) as the weighted sum of the percentage changes in its component parts: real household consumption (*x3nat*), real investment (*x2nat*), state government consumption expenditure (*x5nat*), and Commonwealth government consumption expenditure (*x6nat*). The weights are given by the share in gross national expenditure of each of these component parts. The price index for gross national expenditure (*p_gne*) is calculated by Equation *E_p_gne*. The price index for GNE is given by the weighted sum of the percentage changes in the price indices of its component parts: real household consumption price index (*p3nat*), real investment price index (*p2nat*), state government consumption price index (*p5nat*), and Commonwealth government consumption price index (*p6nat*). Again, the weights are given by the share in gross national expenditure of each of these component parts.

2.15 OTHER MACROECONOMIC AGGREGATES

2.15.1 Overview

The equations in Section 13 of Appendix A define a number of macroeconomic variables that are not readily categorised under either the regional or national accounts described in Sections 11 and 12 of Appendix A. These include the terms of trade, which is defined in FEDERAL-F so that it can be determined exogenously under the historical closure, and a number of macroeconomic variables that are defined in the original FEDERAL model. The latter include the foreign currency value of national imports and exports, which allow for the calculation of the change in the foreign currency balance of trade, and aggregate capital and labour usage at both the national and regional levels.

2.15.2 Terms of trade

The terms of trade is defined as the quotient of the export price index and the import price index. Equation *E_toft* gives the percentage change version of this definition.

2.15.3 Change in the foreign currency balance of trade

FEDERAL Equation 70 calculates the percentage change in the foreign currency value of national imports as the weighted sum of the percentage changes in the foreign currency value of imports of each commodity. Equation 70 is reproduced in FEDERAL-F as Equation *E_imports*. FEDERAL Equation 71 calculates the percentage change in the foreign currency value of national exports as the weighted sum of the percentage changes in the foreign currency value of exports of each commodity from each region. Equation 71 is reproduced in FEDERAL-F as Equation *E_e*. FEDERAL Equation 72, which defines the change in the foreign currency balance of trade, is also reproduced in FEDERAL-F, as Equation *E_ChB*.

2.15.4 Aggregate employment

Equations 77 and 78 in FEDERAL define the percentage change in aggregate employment at the regional and national levels respectively. These equations are reproduced in FEDERAL-

F as Equations *E_lr_emp* and *E_l_emp* respectively. The percentage change in aggregate regional employment is calculated as the weighted sum of the percentage change in employment of each occupational type within the region. The percentage change in aggregate national employment is calculated as the weighted sum of the percentage change in employment in each region.

2.15.5 Aggregate capital stock

Equations 79 and 80 in FEDERAL define the percentage change in aggregate current period capital stocks at the regional and national levels respectively. These equations are reproduced in FEDERAL-F as Equations *E_k_krst* and *E_kst* respectively. The percentage change in aggregate capital stocks at the regional level is calculated as the weighted sum of the percentage changes in the current period capital stocks of each industry in the region. The percentage change in the aggregate national capital stock is calculated as the weighted sum of the percentage changes in the capital stocks of each region.

However, both Equation *E_k_krst* and *E_kst* use regional industry shares in aggregate capital rentals to weight the movements in individual regional industry capital stocks. While this is the appropriate weighting regime to use for the purpose of calculating the contribution of changes in the aggregate capital stock to, say, real gross product at factor cost, it is not such a useful regime for other purposes. In particular, the task of discerning the connection between changes in the aggregate capital stock and changes in aggregate investment over time requires a measure of the aggregate capital stock that is based on asset value weights. These are provided by Equations *E_k_rst_a* and *E_kst_a*.

2.15.6 National number of unemployed

Equation *E_nat_unemp* calculates the percentage change in the number of unemployed persons nationally. This is defined as the weighted sum of the percentage changes in the number of unemployed persons in each region. The weights are given by the share of the number of unemployed within each region in the total number of unemployed nationally.

2.16 REGIONAL POPULATION AND LABOUR FORCE

2.16.1 Regional labour forces and unemployed

Equation *E_x_unemp* is the percentage change form for the definition of the number of unemployed persons in a region; where the number of unemployed is simply equal to the regional labour force less the level of regional employment. This equation corresponds to Equation 129 in the original FEDERAL model.

In short-run comparative static simulations and year on year simulations, it is assumed that the regional labour force is determined by exogenous changes in the size of the regional population (pop_15_r) and the regional participation rate ($p\_pp\_rate_r$) (Equation *E_lr_force*). Hence, any changes in regional employment will be reflected in changes in the numbers unemployed in each region, and hence changes in the regional unemployment rate. The percentage change in the regional unemployment rate ($p\_ue\_rate_r$) is defined by Equation *E_p_ue_rate*.

However in long-run simulations of the model, it is assumed that the number of unemployed persons in each region does not deviate from its base solution. With national employment exogenous this requires that changes in regional employment be accommodated through inter-regional migration. Hence, under the long-run closure, the percentage change in the size of the labour force in each region (lr_force_r) is determined endogenously (via the endogenous determination of pop_15_r), and the numbers of unemployed in each region (x_unemp_r) are set exogenously. Regional employments (lr_emp_r) are endogenous, but the national level of employment, (l_emp) is exogenous. Changes in employment in each region are then accommodated through changes in the shares of each region in the Australian labour force (Madden 1990).

2.16.2 Number of households in region *r*

Under the standard short-run and long-run closures of the FEDERAL model, the number of households in each region ($qhous_r$) is typically set exogenously (Madden, 1990). However, retaining $qhous_r$ as exogenous in long-run comparative static simulations, and year-on-year simulations in which interregional migration leads to changes in regional populations, will lead to a mis-specification of household demands. As already discussed, under the standard long-run closure, the assumption is made that inter-regional migration adjusts in response to exogenously specified numbers of unemployed in each region. In the FEDERAL-F model, inter-regional migration responds to changes in expected regional per-capita incomes. FEDERAL does not currently contain a link between the percentage change in the number of households, ($qhous_r$) and the percentage change in the regional labour force (lr_force_r). This link is established by adding equation *E_qhous* to the FEDERAL-F model.

In the short-run closure, $qhous_r$ is determined endogenously by *E_qhous*, although both of the RHS variables in this equation, pop_15_r and the ratio of the regional population to the number of households (a_qhous_r) are exogenous. In moving to the long-run closure, the endogenous / exogenous status of x_unemp_r and pop_15_r are swapped. With the participation rate ($p\_pp\_rate_r$) exogenous, this establishes the long-run link between the percentage change in the number of households in the region ($qhous_r$) and the percentage change in the labour force of each region (lr_force_r). The same closure for Equation *E_qhous* is used in the year-on-year simulations, allowing movements in regional population numbers to be reflected in movements in regional household numbers.

2.16.3 Inter-regional migration in year-on-year simulations

2.16.3.1 Overview

The starting point for the theory governing inter-regional migration in FEDERAL-F is the assumption that individuals in each region differ in the intensity of their preferences regarding the region in which they might reside. This preference is reflected in an ongoing utility penalty which the individuals are assumed to incur if they reside in a region other than their initial home region. This locational penalty varies across individuals. Individuals base their decision on the region in which to locate by weighing the locational penalty associated with migrating against a measure of the additional real income they might receive if they were to migrate. This measure of income excludes those components of income that are invariant to the region in which the individual resides (such as returns on capital). However, the measure includes real per-capita expected wages, real per-capita fiscal variables (namely: current regional government consumption spending per capita, Commonwealth transfer payments, regional government transfers to persons, regional income and other taxes, and other Commonwealth taxes) and real per-capita expected unemployment benefits. Individuals calculate expected wages and expected unemployment benefits using the unemployment rate in each region as an indicator of their probability of employment.

If the relevant relative measure of expected real per-capita income between the two regions changes, then some number of those individuals who both: (a) reside in the region experiencing the relative decline in per-capita income; and (b) have the weakest preference (ie. incur the lowest penalty from migrating) for their home region; will now desire to live in the other region. This establishes the desired level of inter-regional migrants. Some proportion of the gap between the actual and desired level of inter-regional migrants is assumed to be closed in each period through inter-regional migration.

This treatment of inter-regional migration in FEDERAL-F builds on a similar treatment in Jones and Whalley (1989). A brief overview of the treatment of inter-regional migration in Jones and Whalley (1989) is provided in Section 2.16.3.2 below. The manner in which inter-regional migration is modelled in FEDERAL-F is then discussed in Sections 2.16.3.3 to 2.16.3.8.

2.16.3.2 Jones and Whalley (1989)

Jones and Whalley (1989) construct a multi-regional computable general equilibrium model in which they assume that there is a distribution of individuals within each region who differ only by their intensity of location preference. The parameters of the utility functions of these individuals reflect this difference in a systematic way across the original (pre-policy change) population in each region.

The key assumptions of Jones and Whalley's inter-regional migration theory can be summarised as follows:

i. Labour is homogenous across all regions in all respects other than their having a preference to reside in the region in which they are originally located.

ii. Labour incurs a utility penalty if it leaves its home region. This is expressed by m_i^r, the negative of the income variation required to compensate for the utility penalty, where $m_i^r = u^r \cdot i$. The parameter u^r reflects the intensity of locational preference in region *r*, and *i* indicates the i^{th} individual.

iii. Individuals are ranked by their locational preference. The marginal individual (in terms of their preference for remaining or leaving) in the benchmark equilibrium is denoted $i = 0$.

iv. The measure of the income of individuals in the home region which influences their migration decision is $\bar{I}_i^H$. It is the sum of incomes from labour, natural resource taxes, and federal government transfers to the region. The individuals in each region have identical $\bar{I}_i^H$'s.

v. The migration decision of the individual is based on a comparison of its income in its home region ($\bar{I}^H$) and a weighted average of incomes in other regions ($\bar{I}^F$), where

$$\bar{I}^F = \sum_{s \neq r} \alpha^s \bar{I}^s$$

and where $\bar{I}^s$ is the per-capita income measure for an outside region, *s*, and α^s is a fixed weight.

The individual's migration decision is a function of $\bar{I}^H$, $\bar{I}^F$, and *u*. The marginal individual[60] in the benchmark year is indexed as $i = 0$, so that their relocation penalty is $m_0 = u \cdot 0 = 0$.

If we denote net-of-penalty income for individual *i*, $\hat{I}_i^F$, as $\hat{I}_i^F = \bar{I}^F - (u \cdot i)$, then for the marginal individual we have:

$$\hat{I}_0^F = \bar{I}^F - (u \cdot 0)$$

[60] That is, the individual who is indifferent between leaving the region and remaining.

And since this individual is marginal then it must be that $\hat{I}_0^F = I^H$. Hence in the initial benchmark situation we have $\bar{I}^F = \bar{I}^H$.

All other individuals will suffer a penalty if they leave their region. Hence they will remain within their home region. Their net-of-penalty income is given by:

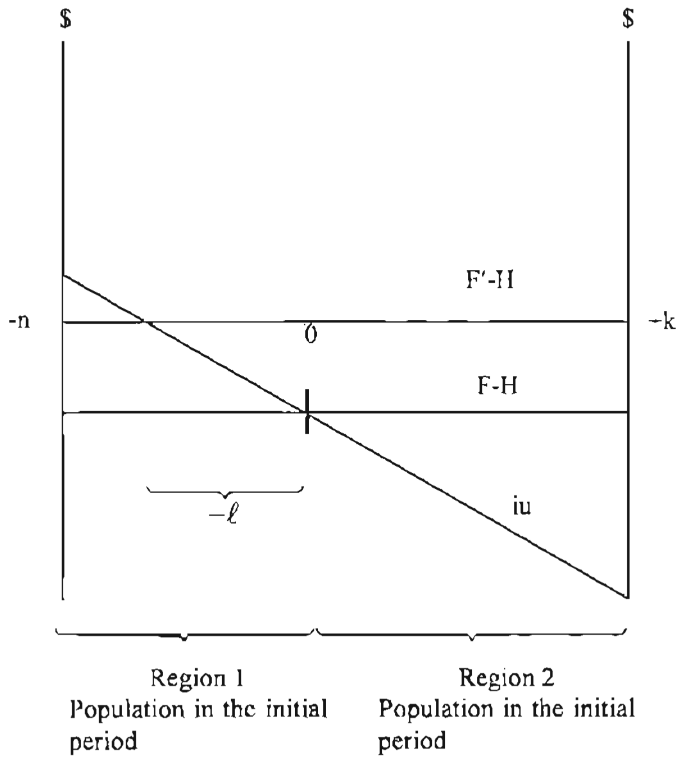
$$\hat{I}_i^F = \bar{I}^F - (u \cdot i)$$

If outside income were to increase following some shock, so that $\bar{I}^H < \bar{I}^F$, then out-migration will occur until $\hat{I}_k^F = \bar{I}^F - u \cdot k = \bar{I}^H$, where k is the new marginal individual. The number of individuals who must migrate to equate home region income and net-of-penalty migration income can be determined by first calculating the new marginal individual from the condition $\bar{I}^H = \bar{I}^F - (u \cdot k)$:

$$k = \frac{\left(\bar{I}^F - \bar{I}^H\right)}{u}$$

The Jones and Whalley migration theory was originally operationalised in a model with more than two regions, with outside income ($\bar{I}^F$) calculated as a fixed-coefficient weighted average of the incomes in other regions. In a two-region model, the Jones and Whalley model can be represented by Figure 2.16.1. The population of the economy is $n + k$, with n individuals in Region 1, and k individuals in Region 2, in the benchmark year. The marginal individual is ranked at position 0 on the horizontal axis. The curve iu measures the income penalty for the i^{th} individual from migrating. That is, the curve iu calculates m_i. The curve F-H measures the gross income difference between the per-capita income in Region 1 and that in Region 2. This curve coincides with the horizontal axis in the benchmark year.

Figure 2.16.1: The operation of the Jones and Whalley migration theory in a two-region model



An increase in Region 2 income shifts the F-H curve up, to say F′-H. This induces ℓ individuals for whom migration costs are lower than the gross income differential to migrate to Region 2.

2.16.3.3 Inter-regional migration in FEDERAL-F: Overview

Following Jones and Whalley (1989), one of the key premises of the migration theory in FEDERAL-F is that the individuals in each region differ in the intensity of their preferences regarding the regions in which they might reside.

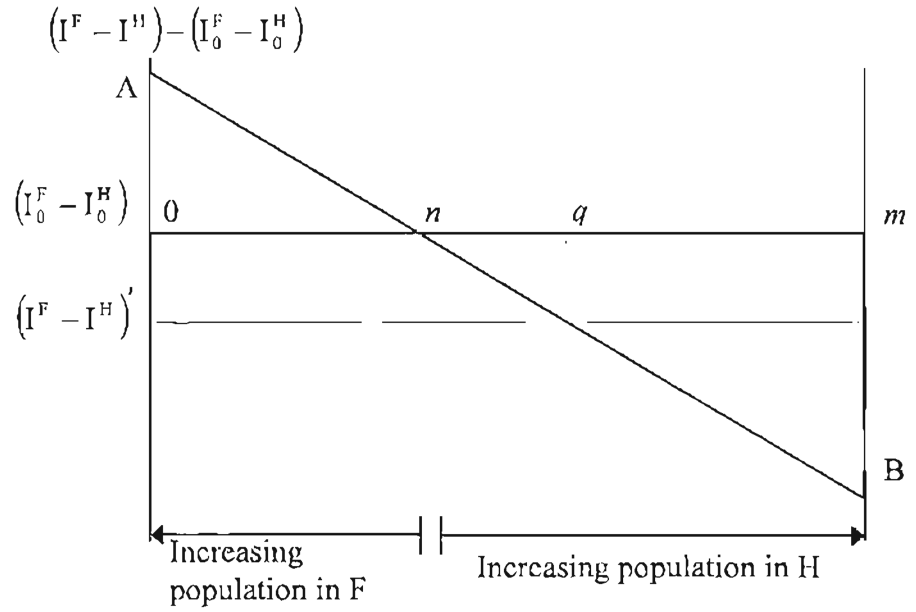
The original residents of a region are assumed to share identical preferences over produced commodities. However, their preferences over the region in which they prefer to reside differ. As in the Jones and Whalley model, individuals are assumed to incur a locational penalty if they leave their initial home region. This locational penalty is assumed to be of increasing severity across an ordering of the individuals in either region in terms of their preference for residing in their home region.

A situation of equilibrium in inter-regional migration is assumed to prevail in the base-year of the model. In addition to the locational penalty, households are assumed to base their migration decision on a particular measure of the expected per-capita real incomes in each of the two regions. Given the two values for this measure in the initial year, the desired level of migration is assumed to be zero. That is, unlike Jones and Whalley (1989), it is not assumed that per-capita incomes in the two regions are identical. Rather, equilibrium is assumed to prevail at the benchmark year expected income differential between the two regions. In each region, there will be one marginal individual who is all but indifferent to remaining in, or leaving behind, their home region. However, all other individuals are assumed to exhibit a distinct preference for remaining in their home region. This preference becomes more marked as the more "intra-marginal" individuals are considered.

A change in the measure of relative real expected incomes in the two regions will make it worthwhile for some number of those with the weakest preference for their home region to move to the region in which relative real expected incomes are rising. In Jones and Whalley (1989), this measure of income is the sum of per-capita wages, resource taxes, and federal transfers. The possibility of a more inclusive definition of migration-relevant income, incorporating all regional taxes and other federal expenditure, is raised by Jones and Whalley, but ruled-out due to computational limitations. Such computational limitations are no longer a constraint, and a broader and more relevant definition of migration-relevant income is computed in FEDERAL-F.

A graphical presentation of the FEDERAL-F migration theory is contained in Figure 2.16.2. The national population of persons aged fifteen plus ($0m$) is arrayed in terms of their preference for residing in each region. Individual 0 has the strongest preference for the home region (H). The gap between the measure of relative incomes in the two regions ($I^F - I^H$) would need to depart from its benchmark year gap ($I_0^F - I_0^H$) by A before this individual was induced to move to the foreign region (F). Individual n is indifferent between the two regions given the benchmark-year differential in migration-relevant income. However, a marginal increase in ($I^F - I^H$) would induce this individual to have a distinct preference for residing in F, and vice-versa. Individual m has the strongest preference for the foreign region. The relative income measure would need to fall from its benchmark value by B or more before this individual was induced to move to region H.

Figure 2.16.2: The operation of the FEDERAL-F migration theory



Given the initial income differential ($I_0^F - I_0^H$), the population of Region H is $0n$, and that of Region F is $0m$-$0n$, or nm. If the measure of foreign income (I^F) were to now fall, so that relative expected incomes were given by $\left(I_1^F - I_0^H\right)$, and $\left(I_1^F - I_0^H\right) - \left(I_0^F - I_0^H\right) = \left(I^F - I^H\right)'$, then the equilibrium population of Region H becomes $0q$, and that of Region F becomes $0m$-$0q$=qm. Of the residents of Region H at the new equilibrium, $0q$-$0n$ were originally residents of Region F in the benchmark, or pre-simulation, period.

Jones and Whalley assume that full adjustment of inter-regional migrant numbers occurs over the simulation period. While this may be appropriate in some applications of a comparative static model, it is not so in a multi-period model such as FEDERAL-F. Hence in FEDERAL-F an assumption has been made that, following some shock to the model, the equilibrium distribution of the nation's population between the two regions is not attained immediately. Let that component of the population that is no longer residing in their original region of residence be designated the "migrant population". The current migrant population, and the desired migrant population will differ when the adjustment to equilibrium is not instantaneous. A simple adjustment rule is imposed in FEDERAL-F, which effectively allows some proportion of the difference between desired and actual migrant populations to be closed each year.

2.16.3.4 Change in the net migrant population

To begin to formalise the treatment of inter-regional migration in FEDERAL-F, let 0*n*, the initial 15+ population of region H, equal $T_{:}^{(t-1)}$. Also, let the level of emigrants aged 15-plus from region H equal M^{*}. Furthermore, designate $\left(I^{F} - I^{H}\right) - \left(I_0^{F} - I_0^{H}\right)$ as D. Then, the function relating the distribution of population between the two regions to the relative expected incomes in the two regions can be written as:

$$D = A - \alpha\left[T_{(1)}^{(t-1)} - M^{*}\right] \qquad \text{(E2.16.1)}$$

Where:

D : is the change in the relative measures of income to which inter-regional migration responds;

A : is the *y* intercept of the migration-income function. This is a fixed parameter set equal to $\alpha\left[T_{(1)}^{(B)} - M^{(B)}\right]$, where $M^{(B)}$ and $T_{(1)}^{(B)}$ are the benchmark period values for inter-regional migration and region 1's population respectively;

α : is the slope of the migration-income function;

$T_{:}^{(t-1)}$: is the base population of persons aged 15+ belonging to region H in the initial year. This is updated by the natural population growth rate in each period;

M^{*} : is the desired level of emigrants from region H aged 15-plus.

Rearranging Equation (E2.16.1) for M*, provides

$$M^{*} = \frac{1}{\alpha}\left[D - A\right] + T_{(1)}^{(t-1)} \qquad \text{(E2.16.2)}$$

This provides the equilibrium level of emigrants from region H given the value for the parameter measuring the intensity of locational preference (α) and the change in the relative measures of income to which inter-regional migration responds.

In FEDERAL-F it has been assumed that the equilibrium stock of emigrants aged 15-plus (M*) at the commencement of the simulation year, is a function of the values for the measure of income to which migration responds in the year prior[61] to the simulation year. Hence M* is calculated as a coefficient in the model. This treatment is consistent with households not basing their location decision on instantaneous knowledge of their prospects in either region. Rather, they respond with (depending on the value of the adjustment parameter, λ) a lag of at least one year between their migration decision, and the deviation in $\left(I^F - I^H\right)$ from its benchmark value. Such a lag is consistent with the idea that the currency of the information that households possess on their prospects in either region will differ across households. It is also consistent with the idea that households cannot execute their migration decisions immediately, but must suffer delays arising from having to sell homes and find new ones, coordinate the completion and commencement of education commitments, find new employments and fulfil existing work and other obligations.

Having assumed that the difference between the actual level of net emigrants (M) and the equilibrium level (M*) is not closed instantaneously, but that some proportion of the gap between the two is closed in each period, then the following adjustment rule can be introduced to the model:

$$\Delta M = \lambda\left[M^* - M\right]\Delta H^{(M)} + \Delta F^{(M)} \qquad \text{(E2.16.3)}$$

Where

ΔM : is the change in the actual level of net emigrants aged 15-plus;

λ : is an adjustment parameter. The setting for this parameter is discussed in Chapter 3 below;

M^* : is the equilibrium level of the stock of emigrants aged 15-plus;

M : is the actual level of the stock of emigrants aged 15-plus;

ΔH^{M} : is the homotopy variable on the migration equation; and

$\Delta F^{(M)}$: is a shift variable unique to this equation.

Making the obvious notational adjustments, Equation (E2.16.3) above provides Equation *E_ch_migrant* in Section 14 of Appendix A.

2.16.3.5 Change in base population of region r via natural population growth

To calculate the percentage change in the resident population aged fifteen plus during the simulation year, it is useful to start by noting that the population growth in region *r* across the simulation year will be the sum of the natural population growth of the residents of the region, plus or minus any movement in migration numbers towards the equilibrium level of migrant numbers. In this sub-section I start by considering the natural population growth.

In the levels, the base population of region r at time t can be written:

$$T_r^{(t)} = T_r^{(t-1)}[1 + G] \qquad r \in REG \qquad (E2.16.4)$$

Where $T_r^{(t)}$ is the base resident population aged fifteen plus in region r in period t and G_r is the natural population growth rate (inclusive of net foreign migration). The base solution to the model requires $T_r^{(t)} = T_r^{(t-1)}$, implying $G_r = 0$. Hence a convenient expression for Equation (E2.16.4) is:

$$T_r^{(t)} = T_r^{(t-1)} + [T_r^{(t-1)} G_r] Q_r^{(T)} \qquad r \in REG \qquad (E2.16.5)$$

Where Q_r^{T} is zero in the base solution to the model, thereby establishing $T_r^{(t-1)}$ as the legitimate base solution for $T_r^{(t)}$. In a simulation, Q is shocked equal to 1, thereby establishing the relationship given by Equation (E2.16.4).

Converting this equation to a rate of change form, and adding a multiplicative (in the levels) shift factor $F_r^{(T)}$, provides:

[61] That is, the data base year.

$$\Delta T_r^{(t)} = \left[T_r^{(t-1)} G_r\right] \Delta Q_r^{(T)} + T_r^{(t-1)} \Delta F_r^{(T)} \qquad r \in REG \qquad (E2.16.6)$$

Making the obvious notational adjustments to Equation (E2.16.6), provides Equation *E_del_basepop* in Section 14 of Appendix A.

2.16.3.6 Population aged 15+ in region r

To calculate the percentage change in the population resident in region r across the simulation year, it is useful to start by noting that in the levels:

$$N_1^{(t)} = T_1^{(t)} - M \qquad (E2.16.7)$$

$$N_2^{(t)} = T_2^{(t)} + M \qquad (E2.16.8)$$

Where $N_r^{(t)}$ is the population aged 15-plus resident in region r.

Converting (E2.16.7) and (E2.16.8) to obtain a term for the percentage rate of change in $N_r^{(t)}$ provides:

$$n_{(1)}^{(t)} = \frac{100}{N_1^{(t-1)}}\left[\Delta T_{(1)}^{(t)} - \Delta M\right] \qquad (E2.16.9)$$

$$n_{(2)}^{(t)} = \frac{100}{N_2^{(t-1)}}\left[\Delta T_{(2)}^{(t)} + \Delta M\right] \qquad (E2.16.10)$$

Making the obvious notational translations to (E2.16.9) and (E2.16.10) above provides Equations *E_pop_15A* and *E_pop_15B* in Section 14 of Appendix A.

2.16.3.7 Regional labour forces

In the levels, the labour force of region r is given by:

$$F^{(6,3)r} = N_r C^{(6,3)r} \qquad (E2.16.11)$$

Where:

$F^{(6,3)r}$: regional labour force;

$C^{(6,3)r}$: participation rate of the regional labour force.

It is assumed that the participation rate is an exogenous variable specific to each region. It is not related to the mix of native and migrant residents within a region. Hence, new immigrants are assumed to acquire the labour force participation rate of the incumbent residents of the region to which they are immigrating.

Converting Equation (E2.16.11) to a percentage rate of change form provides Equation (E2.16.12):

$$f^{(6,3)r} = n_{(r)} + c^{(6,3)r} \tag{E2.16.12}$$

Making the obvious notational adjustments, this provides Equation *E_lr_force* in Section 14 of Appendix A.

2.16.3.8 The measure of per-capita income to which inter-regional migration responds

Individuals are assumed to base their migration decision on a particular measure of expected real per-capita income denoted $Y_r^{(M)}$. This measure is defined as follows:

$$Y_r^{(M)} = \frac{W'_{(r)} + U'_{(r)} + F'_{(r)}}{\Xi^{(3)r}} \tag{E2.16.13}$$

Where

$Y_r^{(M)}$: Is a measure of real per-capita expected income in region *r*, which is exclusive of those components of income (such as returns from capital) that are invariant to the migration decision;

$W'_{(r)}$: Is the expected per-person nominal wage in region *r*;

$U'_{(r)}$: Is the expected per-person nominal unemployment benefit received in region *r*;

$F'_{(r)}$: Is the expected per-person net-fiscal benefit received in region *r*;

$\Xi^{(3)r}$: Is the CPI in region *r*.

Linearizing (E2.16.13), and solving for the rate of change in $Y_r^{(M)}$, provides Equation *E_ch_income* in Section 14 of Appendix A.

The expected per-person nominal wage in region *r* is defined as:

$$W'_{(r)} = \left[\frac{\sum_j \widetilde{U}_{1r}^{j}}{L^r} \right] [1 - U_r] \qquad \text{(E2.16.14)}$$

Where:

$\widetilde{U}_{1r}^{j}$: After tax wages paid by industry *j* in region *r*;

L^r : Employment in region *r*;

U^r : Unemployment rate in region *r*.

The linearized version (E2.16.14) is given by Equation *E_p_exp_wage* in Section 14 of Appendix A.

Equation *E_p_exp_wage* introduces the percentage change in after tax wage income, *wageinc$_r$*, as a variable. This is defined by Equation *E_wageinc*, which calculates the percentage change in after tax wage income in region *r* as the weighted sum of the percentage changes in post-tax wages earned by labour of each occupational type, employed within each industry, in region *r*. The weights are given by the share of post tax wages earned by labour of skill type *m* employed in regional industry *j,r*, in the total of post-tax wages earned in region *r*.

The expected per-person unemployment benefit received in region *r* ($U'_{(r)}$) is defined as:

$$U'_{(r)} = \left[\frac{CGO_3^{(r)}}{U^r \cdot F^{(6,3)r}} \right] U^r \qquad \text{(E2.16.15)}$$

Where $CGO_3^{(r)}$ is the Commonwealth Government outlay on unemployment benefits in region *r* and $F^{(6,3)r}$ is the size of the regional labour force. The bracketed term in this equation provides the per-person unemployment benefit paid in region *r*. Multiplying this by the unemployment rate in *r* provides the expected per-person unemployment benefit in region *r*. The linearized version of (E2.16.15) is Equation *E_p_exp_ueb* in Section 14 of Appendix A.

The level of the net fiscal benefit, $F'_{(r)}$, is defined as follows:

$$F'_{(r)} = \frac{SGO_1^{(r)} + CGO_5^{(r)} + SGO_3^{(r)} - SGR_4^{(r)} - SGR_8^{(r)} - CGR_7^{(r)}}{N_{(r)}} \qquad \text{(E2.16.16)}$$

Where:

$SGO_1^{(r)}$: Current regional government *r* consumption spending;

$CGO_5^{(r)}$: Commonwealth transfers to persons (other than interest and unemployment benefits);

$SGO_3^{(r)}$: Total regional government transfers to persons;

$SGR_4^{(r)}$: Regional government income reducing taxes;

$SGR_8^{(r)}$: Other regional government receipts;

$CGR_7^{(r)}$: Other Commonwealth Government receipts;

$N_{(r)}$: Population aged 15-plus in region *r*.

The linearized version of (E2.16.16) is given by Equation *E_p_net_fiscal* in Section 14 of Appendix A.

Having determined the real level of migration-sensitive income in each region, $Y_r^{(M)}$, the coefficient D, which appears in Equation (E2.16.2), can be evaluated as follows:

$$D = \left(Y_{(t,2)}^{(M)} - Y_{(t,1)}^{(M)}\right) - \left(Y_{(0,2)}^{(M)} - Y_{(0,1)}^{(M)}\right) \qquad \text{(E2.16.17)}$$

Where:

$Y_{(t,2)}^{(M)}$: Is the level of migration-sensitive real income in region 2, in the data base year;

$Y_{(t,1)}^{(M)}$: Is the level of migration-sensitive real income in region 1, in the data base year;

$Y^{(M)}_{(0,2)}$: Is the level of migration-sensitive real income in region 2, in the initial (benchmark) year; and

$Y^{(M)}_{(0,1)}$: Is the level of migration-sensitive real income in region 1, in the initial (benchmark) year.

2.16.4 Limitations of the FEDERAL-F migration theory

The present inter-regional migration theory in FEDERAL-F as outlined above is subject to three broad limitations. The first of these is that it is the only part of the model's theory (and its computer coding) that is explicit about the number of regions in the model (ie. two regions, rather than the general *r* regions in the remainder of the model). This is not a limitation in the context of current applications of the model, which divide Australia into two regions (Tasmania and the rest of Australia). However, future applications of the model involving more than two sub-national regions will face a number of difficulties in generalising this theory to more than two regions. First, with only two regions, it was not necessary to provide a theory to account explicitly for either the destination region or origin region of, respectively, emigrants from or immigrants to a given region. With only two regions in the model, it is self-evident where inter-regional emigrants are going and from where inter-regional immigrants are coming. This facilitated another of the novel features of the inter-regional migration theory in FEDERAL-F (discussed in detail in Sections 2.5.4 and 2.5.5), that is, the maintenance of the original (pre-migration) capital ownership patterns of inter-regional migrants within their new host region.

Like the first limitation, the second limitation also relates more to the manner in which the theory has been implemented, rather than its form. It has been assumed that in the base year, the gap between the relative expected per capita income measures is compatible with zero desired migrants. This assumption of equilibrium in the base year data is not compatible with the evidence, which shows inter-regional emigration from Tasmania in 1992/93. This is not a major issue for two reasons. First, if it were so desired, one could set the database value for the base-year income gap so as to generate (for a given adjustment parameter) the desired level of migrants in the first simulation year. Second, there is enough flexibility in the closure of the migration module in the historical simulations to allow for Equation *E_chmigrants* to be inoperative without restricting the model user's capacity to account for the impact of inter-regional migration on population sizes. One option is to set *ch_migrants* exogenously, and allow Equation *E_chmigrants* to determine *f_chmigrants*. Another option is to set pop_15_r exogenously, and allow Equations $E\_pop\_15_A$ and $E\_pop\_15_B$ determine $f\_pop\_15_r$. While the latter option will yield historically accurate population growth rates, it will not, unlike the former option, keep track of variations in the capital ownership patterns of regional populations as households move between the two regions. However this is not a material issue in simulations over such a short period (1992/93 to the present) when the impact of even large movements of Tasmanians to the rest of Australia will have a negligible impact on the size and composition of the population of the rest of Australia.[62]

The final limitation relates to the form of the schedule linking the distribution of the population to relative income measures. While a linear schedule was chosen, there are no a-priori grounds for such a choice. A linear schedule was chosen simply for computational ease. One can postulate other functional forms that might have better modelled household location preferences. For example, an inverse-logistic function might have been more appropriate, since it would allow one to model that core of the residents of a region who will resist the temptation to relocate regardless of the apparent material advantages of so doing. However, the bounds of such a function are extremely unlikely to be required in any normal simulation of the model. For most simulations, and certainly for those reported in this thesis, the process of inter-regional migration involves small variations in incomes and movements in a small number of people, with the vast bulk of the population remaining within their home region. In these circumstances, a linear migration function is adequate to the task.

2.17 PHANTOM TAXES

2.17.1 Overview

During both historical and forecasting simulations of the model, it will often be desirable to determine exogenously either the price of individual commodities sold to particular

[62] It could be an issue if the population movements were in the opposite direction, since a given inflow of mainland residents to Tasmania would be more likely to alter the capital ownership pattern of Tasmanian residents, given the relatively small size of the Tasmanian population.

users, or the aggregate price deflators relating to the aggregate purchases of particular users. In many of these cases, the cost components determining the purchaser's price (factor prices, input costs, net government taxes, technical change) are also determined exogenously, leaving no (normally) exogenous variable available to determine endogenously. The developers of the MONASH model overcome this problem by introducing endogenous "phantom" taxes, which allow purchaser's prices to be determined exogenously. A similar approach is adopted in FEDERAL-F.

Phantom taxes in FEDERAL-F can accrue on purchaser's by all user types. Phantom taxes on household purchases facilitate the exogenous determination of both household purchaser's prices for individual commodities and regional CPI's. Phantom taxes on purchases by capital creators facilitate the exogenous determination of regional gross fixed capital expenditure deflators. Phantom taxes on exports facilitate the exogenous determination of both the terms of trade and the f.o.b. foreign currency export prices of individual commodities. Phantom taxes can also accrue on purchases by regional governments and the Commonwealth Government. This facilitates the exogenous determination of regional government and Commonwealth Government consumption deflators. Phantom taxes only accrue on purchases for current production in those instances in which a "spreading" phantom tax shift variable is endogenous.

The MONASH model distinguishes between so called "spreading" and "non-spreading" phantom taxes. A similar distinction is retained in FEDERAL-F. Changes in spreading phantom taxes change prices faced by all users of the commodity the price of which is being determined exogenously for one user type. Changes in the non-spreading phantom taxes only affect the prices faced by the specific users for which purchaser's prices are being determined exogenously. The need for non-spreading phantom taxes arises largely from the aggregation of commodities in the MONASH commodity classification system. For example, in the case of the commodity "Fishing", Australia mainly exports crustaceans, while soft fish are consumed domestically (Dixon and Rimmer 1999a). Hence, it was deemed by the developers of MONASH to be inappropriate for the price of domestically produced fish to move with the price of exported fish when the price of "Fishing" exports were determined exogenously. The need for the non-spreading phantom taxes arises in this instance from the aggregation of what are effectively two different commodities under the single category "Fishing". This aggregation problem also exists in the current implementation of FEDERAL-F, and is in some respects more acute since the Tasmania / Mainland version of the model distinguishes 37 commodities. Hence the MONASH distinction between spreading and non-spreading phantom taxes is also adopted in FEDERAL-F.

Phantom taxes collected in the MONASH model are directed as net revenue to the government. A different treatment is adopted in FEDERAL-F. Since these taxes are not real taxes, and the detailed modelling of government income and expenditure is one of the strengths of the FEDERAL-F model, it was not considered appropriate to add them to government revenue. Rather, they are treated as super-normal profits or losses on the capital employed in producing the individual commodities on which the net taxes accrue. These are then allocated to households and governments. This allocation is undertaken on the basis of the ownership shares in the capital of those regional industries producing commodities upon which phantom taxes have accrued.

A further departure in FEDERAL-F away from the treatment of these taxes in MONASH concerns the elimination of these taxes at the commencement of each simulation year. During a simulation under a forecast or historical closure, the spreading and non-spreading phantom taxes that are collected on intermediate, investment, export, household consumption, and government consumption flows, are accumulated in a set of phantom tax revenue matrices. The phantom taxes thus accumulated are allowed to carry forward from year to year in FEDERAL-F. A different approach is followed in the MONASH model. At the start of each forecast year, the phantom taxes are added to the basic flows upon which they accumulated in the previous year. A balancing adjustment is then made to the other costs matrix. The phantom taxes are then zeroed out. Hence, the MONASH database is free of phantom tax entries at the beginning of each forecast year. This approach is not appropriate in FEDERAL-F, given the different treatment of phantom taxes in this model. With phantom taxes in FEDERAL-F essentially treated as a super-normal profit or loss on capital, and directed to household as net income, the database is allowed to carry the accumulated value of these taxes from year to year. To date, my experience with these taxes is that, while they can vary significantly across commodities from year to year, they remain in total a relatively small and stable share of each of the aggregate demand categories upon which they accrue.

2.17.2 Exogenous determination of the terms of trade

Under the historical and forecasting closures, many of the variables that determine the terms of trade may be determined exogenously. The foreign currency price of individual commodity imports is typically determined exogenously in both the standard comparative static, historical, and forecasting closures of the model. Many of the foreign currency prices of traditional export commodities will be determined exogenously under both the historical and forecasting closures via the endogenous determination of the appropriate phantom tax rates. The remaining variables that determine the terms of trade, and which are not otherwise determined exogenously, are the export prices of those commodities in the sets NTRAD and EXOG. The export prices of these commodities are made the potential subject of the common shift variable *fpentrad* by adding Equations *E_p_rexp_exog* and *E_p_rexp_imp* to the model. Under the standard comparative static closure of the model these equations are inoperative due to the endogenous status of $p\_rexp\_exog_{i,r}$ and $p\_rexp\_imp_{i,r}$. Under the historical closure, these equations are brought into operation by setting exogenous all the elements of $p\_rexp\_exog_{i,r}$ and $p\_rexp\_imp_{i,r}$ and setting endogenous the rates of the corresponding components ($i \in$ NTRAD, $i \in$ EXOG) of the non-spreading phantom tax rates on export sales ($tax\_nsph_{i,r}$). The terms of trade can then be determined exogenously by setting endogenous the shift variable *fpentrad*. This variable then operates via Equations *E_p_rexp_exog* and *E_p_rexp_imp* to adjust the prices of all non-traditional and exogenous export commodities so that the overall terms of trade target is met.

2.17.3 Determination of per-unit phantom taxes.

Equations *E_tax_1ph* through to *E_tax_6ph* allow the model user to choose between three alternative possibilities for determining the value of per-unit phantom taxes. This choice is exercised through the value assigned by the user to the coefficients HPHANT1, HPHANT2, and HPHANT3. One of these three coefficients must be assigned a value of 1, with the remaining two assigned a value of 0. With HPHANT1 assigned a value of 1, the per-unit value of phantom taxes is indexed to the regional consumer price index. This setting can be useful when undertaking nominal homogeneity tests of the model. An ad valorem treatment is established by assigning a value of 1 to HPHANT2. Finally, the tax is treated as a specific tax if HPHANT3 is assigned a value of 1. The latter option has been chosen in the simulations undertaken in this thesis. The basic form of each of these equations is similar across each type of sale, although there are small but important differences across user types. The per-unit phantom tax on purchases by current producers ($tax\_1ph_{i,s}$) is only affected by the spreading phantom tax shift variable ($tax\_sph_{i,s}$). Commodity specific non-spreading phantom tax shift variables only appear in Equations *E_tax_3ph* and *E_tax_4ph* ($fphtax3_{i,s,r}$ and $tax\_nsph_{i,s}$) respectively. That is currently, allowance is only made for the exogenous determination of the prices for individual commodities sold to households and foreigners. Commodity-wide phantom tax shifters appear in each of the per unit phantom tax equations other than *E_tax_4ph* and *E_tax_1ph*. These shifters are used to exogenously determine aggregate expenditure deflators. During historical simulations, the price deflators for regional gross fixed capital formation ($p2reg_r$), consumption (for region 1 ($p3reg_1$) and the nation as a whole (*p3nat*), regional government consumption expenditure (*p5reg*), and Commonwealth Government consumption expenditure (*p6reg*) are determined exogenously. The corresponding uniform phantom tax shifters ($fphtax2_r$ for investment prices, $fphtax5_r$ for regional government prices, and $fphtax6_r$ for Commonwealth Government prices) are then determined endogenously.

2.17.4 Total phantom taxes collected

Equations *E_total_phant1* through to *E_total_phant6* calculate the percentage change in the total phantom tax revenue collected on each commodity, from each of the two domestic regions of origin, for each of the six types of final user. Equation *E_total_phant1* calculates the percentage change in phantom tax collections on good *i* from source region *s* used as an intermediate input in either region. This is given by the weighted sum of the percentage changes in the collections of phantom taxes on good *i* from source *s* used by regional industry *j,r*. The weights are given by the share in total phantom tax collections on intermediate input usage of *i* from *s* of that part of those collections attributable to the usage of that source specific commodity by regional industry *j,r*. In a similar fashion, Equation *E_total_phant2* calculates the percentage change in total phantom tax collections on usage of *i* from region *s* as input to capital formation, as the weighted sum of the percentage changes in such collections on usage of *i,s* by industries in both regions. Equation *E_total_phant3* defines the percentage change in total phantom tax collections on sales to households of good *i* from domestic source *s*. The percentage change in phantom tax collections on exports of *i* from *s* is calculated by Equation *E_total_phant4*, with no weights needing to appear in this equation since export sales do not have a location dimension. Similarly, Equation *E_total_phant6* calculates the percentage change in phantom tax collections on sales of *i* from region *s* to the Commonwealth as the sum of the percentage changes in the quantity of such commodities sold to the Commonwealth, $x\_cg_{i,s}$, and the percentage change in the per-unit phantom tax payable on each unit thus sold, $tax\_6ph_{i,s}$. Finally, Equation *E_total_phant5* calculates the percentage change in phantom tax collections on commodity and source -specific sales to regional governments as the weighted sum of such collections arising from sales to each regional government.

Total phantom tax collections, across all user-types, on sales of commodity *i*, sourced from domestic region *s*, are defined by Equation *E_phantotal*. This total is given by the weighted sum of the percentage changes in the phantom tax revenue collected on the sales of the source-specific commodity to each user type. The weights are given by the share in the total phantom tax revenue accruing on sales of *i* from *s* of that revenue attributable to the sales of *i,s* to each particular user type.

The variable $phantotal_{i,s}$ is used in Equation *E_p_housphant* for determining the value of phantom taxes accruing to households in each region. For this purpose, it is the percentage change in the value of phantom taxes *from* region *s* that is relevant. However, for calculating the aggregate indirect tax revenue in region *r* for the purpose of constructing the regional accounts (See Section 2.13.30 and particularly Equation *E_itrev*), it is the total phantom tax revenue accruing *within* region *r* that is relevant. To this end, Equation *E_phantotal2* calculates the percentage change in phantom taxes accruing on commodity *i* purchased within region *r*. This is calculated as the weighted sum across sources and users of the percentage changes in phantom taxes paid on purchases of commodity *i* by users located within region *r*.

2.17.5 Phantom tax revenues accruing to household *r*

As already discussed in Section 2.17.1, phantom tax revenues in FEDERAL-F are assumed to accrue to households in proportion to their ownership of capital in those industries producing the goods upon which the tax accrues. The calculation of the proportion of the tax revenue accruing on i from s that is received by household r is facilitated by there currently being no multi-product industries in the model. Hence the revenue accruing on commodity i from region s can be attributed uniquely to industry j in region s where $i = j$ since no other industry in the region is a producer of i. The proportion of the revenue collected on commodity i from s which accrues to household r is given by the coefficient $HH\_PHANT_{i,s,r}$ in Equation *E_p_housphant*. This equation calculates the percentage change in the phantom tax revenue collected by household r ($p\_housphant_r$). The value of $HH\_PHANT_{i,s,r}$ is equal to household r's share in the capital of industry j (where $j = i$) located in region s. The percentage change in the phantom tax revenue collected by household r is defined as the weighted sum of the percentage changes in the phantom tax revenue accruing on sales of commodity i from region s. The weights are given by the share in the total phantom tax revenue accruing to household r of the phantom tax revenue received by household r that arises from sales of commodity i from region s.

2.17.6 Powers of the phantom tax rates

Equations *E_powtax1ph* through to *E_powtax6ph* calculate the percentage rates of change in the powers of the phantom taxes on source specific commodity purchases by each user type. Suppressing commodity, source, user, and region subscripts, the power of the phantom tax (H) is defined as one plus the value of the per unit tax (F) divided by the basic value ($P^{(0)}$) of the commodity upon which it is levied:

$$H = 1 + \frac{F}{P^{(0)}} \qquad \text{(E2.17.1)}$$

Converting Equation (E2.17.1) to a percentage rate of change form provides:

$$H\,h = \left[\frac{F}{P^{(0)}}\right]\left(f - p^{(0)}\right) \qquad \text{(E2.17.2)}$$

Which, upon making the obvious notational adjustments, provides Equations *E_powtax1ph* through to *E_powtax6ph*.

As already discussed in Section 2.3.1, it is the power of the phantom tax that appears in each of the purchaser's price equations, not the per unit tax. As also discussed in that section, during decomposition simulations, it is the power of the phantom taxes that are determined exogenously, with the per unit taxes remaining endogenous.

2.17.7 Changes in the phantom tax accruing on individual commodity flows

Equations *E_del_tax_1ph* through to *E_del_tax_6ph* calculate the change in the phantom tax accruing on each commodity flow. These taxes are used to update the phantom tax matrices TAX1F through to TAX6F. Suppressing commodity, user, and region subscripts, in the levels the phantom tax accruing on a particular transaction (J) is the product of the quantity of units being transacted (Q) and the per-unit phantom tax (F):

$$J = F \times Q \qquad \text{(E2.17.3)}$$

The linearised expression for (E2.17.3) with the total value of phantom tax collected expressed as a rate of change variable is given by:

$$\Delta J = \left[\frac{F \times Q}{100}\right](f + q) \qquad \text{(E2.17.4)}$$

Which, after making the obvious notational translations, provides Equations *E_del_tax_1ph* through to *E_del_tax_6ph*.

2.17.8 The determination of phantom tax rates in the deviation closure

Equations *E_tax_nsph_old* and *E_tax_sph_old* facilitate the determination of phantom tax rates in the deviation closure. Similar equations appear in the MONASH model, and were added by its developers to reduce the deviations in commodity export volumes from their forecast values that might otherwise arise during deviation simulations.

In all closures of the model other than the deviation closure, Equations *E_tax_nsph_old* and *E_tax_sph_old* determine $tax\_nsph\_old_{i,s}$ and $tax\_sph\_old_{i,s}$ respectively. The variable $xr\_exp\_old_{i,s}$ is determined exogenously. Neither equation serves any function in the model in any closure other than the deviation closure, since the variables $tax\_nsph\_old_{i,s}$ and $tax\_sph\_old_{i,s}$ appear in no other equation in the model.

Under the deviation closure, the export prices that were exogenous in the forecast closure are switched to being endogenous, and the corresponding components of $tax\_nsph\_old_{i,s}$ and $tax\_sph\_old_{i,s}$ are made exogenous and shocked equal to the values acquired by $tax\_nsph_{i,s}$ and $tax\_sph_{i,s}$ during the forecasting closure. The term $\text{DAMP}\times\left(xr\_exp_{i,s} - xr\_exp\_old_{i,s}\right)$ is a dampening factor that operates in the deviation closure to reduce the amount by which the new quantity of exports of each regional export commodity departs from its value during the forecast simulation. The high elasticity of demand for many export commodities means that the cost of an export item in the deviation simulation need only depart from its forecast value by a small amount to induce a relatively large change in export volumes. The dampening factor acts to increase the phantom tax on an export commodity during the deviation closure if the quantity of its exports grows more strongly than it did during the forecast closure. Of course, this dampening factor is an ad-hoc adjustment, and if it is not considered appropriate by the model user, it can be removed by setting DAMP equal to zero. This is done in the simulations reported in Chapter 6.

2.17.9 Allocation of phantom tax revenues to the Commonwealth and regional governments

A share of the phantom tax revenue accruing on each commodity from each region is allocated to the Commonwealth and regional governments. This allocation is undertaken on the basis of their ownership shares in the capital in the industries producing the commodities upon which the taxes are accruing. Equations *E_phant_rgov* and *E_phant_cgov* calculate the percentage changes in aggregate phantom tax receipts accruing to regional and Commonwealth Governments respectively. In the levels, these equations can be represented by Equation E2.17.5:

$$R_g = \sum_i \sum_s H_{i,s,g} P_{i,s} \qquad \text{(E2.17.5)}$$

Where R_g is the phantom tax receipts of government g, $H_{i,s,g}$ is government g's share of the capital in industry i in region s, and $P_{i,s}$ is the phantom tax revenue accruing on commodity i (produced by industry i) from region s. Linearising Equation (E2.17.5) (noting that regional government r owns capital only in its home region, and treating $H_{i,s,g}$ as given) provides Equations *E_phant_rgov* and *E_phant_cgov*.

2.18 IMPORT / LOCAL PREFERENCE TWISTS

2.18.1 Domestic / foreign preference twists

As discussed in Section 2.14.10, the economy-wide volume of imports (*xMnat*) is calculated by Equation *E_xMnat* as the share weighted sum of overseas imports into each region ($xMreg_r$). The latter variables, in turn, are calculated by Equation *E_xMreg* as the share weighted sum over commodities and users of individual demands for foreign-sourced commodities. In the absence of technological change, the demand for imported commodity i by industrial users (Equation *E_x1B*), capital creators (Equation *E_x2B*), and households (Equation *E_xr_housB*) are a function of both an activity-related variable, and the relative prices of imported and domestically produced goods. Government demands for imported commodities are either determined exogenously, or endogenously via the assumption governing the aggregate level of government expenditure (whether that be an assumption of a fixed borrowing requirement, indexation to real private consumption, a given balance of trade, or some other appropriate assumption relating to the macroeconomic closure).

In both historical and forecasting simulations the aggregate volume of imports will be determined exogenously, and shocked equal to either the ABS estimate for its percentage change over the simulation period (in historical simulations) or an independent forecast for its percentage change in future periods (in forecasting simulations). However, since the aggregate price index for imported goods is also set exogenously, and with demands for individual commodity imports determined by relative prices, there is no appropriate exogenous variable in the FEDERAL model that can be determined endogenously in the historical and forecasting closures so as to allow the economy-wide volume of imports to be determined exogenously. In the MONASH model, this problem is overcome through the introduction of a new variable that allows for the endogenous determination of cost-neutral changes (or "twists") in import/domestic usage shares. A similar approach has been followed in developing FEDERAL-F: the demand equations for source-specific commodities for use as intermediate inputs, inputs into capital creation, and inputs to household consumption are all augmented by commodity-specific "twist" terms. These terms allow for the endogenous determination of cost-neutral changes in the preferences for imported and domestically produced goods, thereby allowing for the exogenous determination of the aggregate volume of imports. The derivation of these twist terms is discussed in detail below.

Substitution possibilities between sources of commodities in both FEDERAL and FEDERAL-F are governed by CRESH functions (Hanoch 1971). Given a three-input CRESH production function, to derive the import twist terms we wish to find, for a given set of prices, the combination of technical changes in the usage of the three source-specific inputs to the function that together imply a cost neutral change in preferences away (towards) imports and towards (away from) domestically sourced goods. Specifically, following the general approach of Horridge et al. (1998) in their derivation of the twist term for a two-input CES function, the problem is to find values for $a_1 = a_2 = a_D$ and a_3 which produce a change in the ratio of domestic to imported goods, $S_2^D x_1 + S_2^D x_2 = x_3$,[63] of t per cent, while leaving the price of acquiring an effective unit of x unchanged. That is, find a_D and a_3 such that:

$$S_1 a_D + S_2 a_D + S_3 a_3 = 0 \qquad \text{and} \tag{E2.18.1}$$

$$t = S_1^D x_1 + S_2^D x_2 - x_3 \tag{E2.18.2}$$

For given prices, the linearized CRESH demand function for the source-specific commodity is[64]:

[63] Where S_r^D is the share of the value of domestic source r in the total value of the commodity sourced from all domestic sources.
[64] See Dixon et al. (1992) p.126.

$$x_i = z - \sigma_i\left(a_i - \sum_{k \in sou} S_k^{\bullet} a_k\right) + a_i \qquad \text{(E2.17.3)}$$

Substituting equation (E2.18.3) into condition (E2.18.2) and simplifying provides:

$$t = a_D\beta_D + a_3\beta_3 \qquad \text{(E2.18.4)}$$

where $\beta_D = \sigma_3\left(S_3^{\bullet} - 1\right) - S_3^{\bullet}\left(\sigma_1 S_1^D + \sigma_2 S_2^D\right) + 1$

$$\beta_3 = -\sigma_3\left(S_3^{\bullet} - 1\right) + S_3^{\bullet}\left(S_1^D\sigma_1 + S_2^D\sigma_2\right) - 1 = -\beta_D$$

Solving (E2.18.1) and (E2.18.4) for a_D and a_3 provides:

$$a_D = \frac{S_3 t}{\beta_D} \qquad \text{(E2.18.5)}$$

$$a_3 = \frac{(1 - S_3)t}{-\beta_D} \qquad \text{(E2.18.6)}$$

If we now notionally divide the technical change terms for the source-specific demands for a particular commodity into the technical change attributable to standard technical change (a_s), and the technical change attributable to the preference twists $\left(a_S^T\right)$, then we can append the following twist term to each input demand function relating to:

Domestic source, 1: $$twist_1 = a_D^T - \sigma_1\left(a_D^T - \sum_{s \in SOU} S_S^{\bullet} a_S^T\right) \qquad \text{(E2.18.9)}$$

Domestic source, 2: $$twist_2 = a_D^T - \sigma_2\left(a_D^T - \sum_{s \in SOU} S_S^{\bullet} a_S^T\right) \qquad \text{(E2.18.10)}$$

Foreign source, 3: $$twist_3 = a_3^T - \sigma_3\left(a_3^T - \sum_{s \in SOU} S_S^{\bullet} a_S^T\right) \qquad \text{(E2.18.11)}$$

Where $a_D^T = a_D$, as given by Equation (E2.18.5) above, and $a_3^T = a_3$, as given by Equation (E2.18.6) above.

In a situation where the Armington elasticities of substitution are identical across sources, then β_D reduces to 1-σ, and a_D and a_3 become equal to the CES case as given by Horridge et al. (1998). The CRESH twist terms are also the same as the CES twist terms when $\sigma_1 = \sigma_2$, implying identical Allen elasticities of substitution (AES) between the domestic and imported sources for good *i*. Either of these two cases can apply in the current implementation of FEDERAL-F. However, the advantage of the CRESH function is that it allows different AES between good *i* sourced from either region, and its imported counterpart. Hence, notwithstanding that the Armington parameters on the input demand functions are not currently set to generate differing AES in the current implementation of FEDERAL-F, the CRESH form for the domestic/import twists given by Equations (E2.18.5) (E2.18.9) has been incorporated in FEDERAL-F nevertheless. Future applications of the model may require different AES across sources, and particularly between the various domestic sources and the imported source. Equations (E2.18.5) to (E2.18.9) above anticipate this possibility, and allow for more of the adjustment to meet a given aggregate import target to be met by the domestic source with the higher elasticity of substitution vis-à-vis the foreign source, in such circumstances. Making the obvious notational changes, Equations (E2.18.5) to (E2.18.9) correspond to Equations *E_a1twistD* to *E_twist3* in Section 16 of Appendix A.

Commodity demands by source, by state and Commonwealth governments are typically determined exogenously as part of the closure of the government accounts. Hence the demand for commodities by government for current consumption are not subject to changes in the preference for local goods vis-à-vis imported goods via changes in import twist terms.

The commodity specific twists ($twist\_srcr_{i,r}$) which appear in Equations *E_a1twistD*, *E_a1twistM*, and so on, are determined by Equation *E_ftwist_srcr*. Under the standard comparative-static closure the commodity and region-specific import twist shifters ($ftwist\_srcr_{i,r}$) are endogenous, and $twist\_srcr_{i,r}$, *twist_src_bar*, and $ftwist\_src_i$ are set exogenously equal to zero. In moving to the historical or forecast closures, the volume of aggregate imports (*xMnat*) is swapped from endogenous to exogenous, and the economy-wide import twist shift variable (*twist_src_bar*) is swapped from being exogenous to endogenous. Equation *E_twist_srcr* is then brought into operation by swapping the endogenous/exogenous status of $ftwist\_srcr_{i,r}$ and $twist\_srcr_{i,r}$. The variable *twist_src_bar* then imposes equal percentage point changes on each commodity specific twist variable in order that the exogenous import volume target is met. The term C_TWIST_SRC x $(x\_total_i$ - $gdp\_real)$ imposes an extra cost-neutral twist in favour of imports for those commodities that are experiencing high rates of growth relative to the real growth in GDP. This is a technique employed in the MONASH model which allows, for a given simulation, more of the adjustment to meet an exogenous import volume target to be placed on those commodities that are experiencing more rapid rates of output growth relative to GDP. The strength of the extra twist is governed by the value of the parameter C_TWIST_SRC. The purpose of this term is to capture the idea that a rise in the output of commodity *i* will also be associated with rising imports of *i* - unrelated to changes in relative prices - but arising from shortages and lengthening queues for the domestic product (Dixon, Menon and Rimmer 2000). This parameter can be set equal to zero to remove this dampening term.

2.18.2 Inter-regional preference twists

During historical simulations of the model, it will often be desirable to determine exogenously the commodity outputs of one region. This is facilitated in FEDERAL-F by the introduction of cost-neutral twist terms that change, for domestic agents, the ratio of their usage of region 1-sourced commodities to region 2-sourced commodities. During historical simulations, these variables can be set endogenous, with the output of the corresponding commodities for one of the two regions then being determined exogenously. Across all users, the twist term imparts cost-neutral shifts in the ratio of the purchases of the commodity from the two domestic sources, such that the exogenous output target is achieved.

The derivation of the inter-regional sourcing twists follows a similar logic to that used to derive the Australian / foreign sourcing twists (See Section 2.18.1). The question asked in this case is: what values for a_1, a_2, and a_3 will produce a change in the ratio of the usage of region 1 to region 2 sourced goods of t per cent ($t = x_1 - x_2$) while at the same time leaving unchanged both the price of acquiring an effective unit of x and the demand for x_3. That is, find a_1, a_2, and a_3 such that:

$$S_1a_1 + S_2a_2 + S_3a_3 = 0 \tag{E2.18.12}$$

$$t = x_1 - x_2 \quad \text{and} \tag{E2.18.13}$$

$$a_3 - \sigma_3\left(a_3 - \sum_k S_k^{*}a_k\right) = 0 \tag{E2.18.14}$$

Following the same procedure used to derive the Australian / foreign sourcing twist in Section 2.18.1, the CRESH demand function (at given prices) for source-specific commodities 1 and 2 is substituted into condition (E2.18.13). Simplifying the resulting expression, and expanding condition (E2.18.14), provides the following linear system:

$$S_1a_1 + S_2a_2 + S_3a_3 = 0 \tag{E2.18.15}$$

$$\beta_1a_1 + \beta_2a_2 + \beta_3a_3 = t \tag{E2.18.16}$$

$$\phi_1a_1 + \phi_2a_2 + \phi_3a_3 = 0 \tag{E2.18.17}$$

Where $\beta_1 = S_1^{*}(\sigma_1 - \sigma_2) + 1 - \sigma_1$, $\beta_2 = S_2^{*}(\sigma_1 - \sigma_2) - 1 + \sigma_2$, $\beta_3 = S_3^{*}(\sigma_1 - \sigma_2)$, $\phi_1 = \sigma_3 S_1^{*}$, $\phi_2 = \sigma_3 S_2^{*}$, and $\phi_3 = 1 - \sigma_3 + \sigma_3 S_3^{*}$.

Solving (E2.18.15) - (E2.18.17) for a_1, a_2, and a_3, and then substituting these into the twist equations for the each of the three sources (that is, Equations (E2.18.9) - (E2.18.11) in Section 2.18.1, provides the following twist equations:

Domestic source 1: $$twist_1 = \left(\frac{S_2}{(S_1 + S_2)}\right)t \tag{E2.18.18}$$

Domestic source 2: $$twist_2 = -\left(\frac{S_1}{(S_1 + S_2)}\right)t \tag{E2.18.19}$$

Domestic source 3: $$twist_3 = 0 \tag{E2.18.20}$$

These twist equations have not been introduced into FEDERAL-F as explicit equations. Rather, the right-hand sides of the first two of the above expressions have been appended to the demands for Australian-sourced commodities for use as intermediate inputs, inputs into capital creation, and inputs to household consumption. Specifically, for each of these three users, the demand equations for each domestically sourced commodity are appended by terms with the form $\left(T_s - S_1/(S_1 + S_2)\right)t$. T_s has a value equal to 1 for s = 1, or 0 for s = 2 (rest of Australia), and S_k is the share of the relevant commodity sourced from region k in the total usage of the commodity by the user in question. With $T_s = 1$ this expression corresponds to (E2.18.18), and with $T_s = 0$ the expression corresponds to (E2.18.19).

The twist terms on domestic demands are determined by Equations *E_ftwist_is1* (twists on intermediate input demands), *E_ftwist_is2* (twists on demands for inputs to capital formation), and *E_ftwist_is3* (twists on household demands). Under the standard short run comparative static closure, the domestic twist variables $twist\_is1_{i,j,r}$, $twist\_is2_{i,j,r}$ and $twist\_is3_{i,r}$ are exogenous, and these three sets of equations determine the shift variables $ftwist\_is1_{i,j,r}$, $ftwist\_is2_{i,j,r}$ and $ftwist\_is3_{i,r}$. Under the historical closure, the endogenous / exogenous status of these variables is swapped. The variable $twist\_isbot_i$ is exogenous under the standard short run comparative static closure, and Equation *E_fi_twist_isbot* determines the shift variable $fi\_twist\_isbot_i$, which appears in no other equation in the model. Under the historical closure, the inter-regional twists are brought into operation by setting $twist\_isbot_i$ endogenous. This is achieved by either setting exogenous the corresponding elements of fx_tot_i, or by bringing Equation *E_twist_isbot* into operation by setting the corresponding elements of *fi_twist_isbot* exogenous. Hence, under the former closure, Equation *E_fi_twist_isbot* remains inoperative, due to the endogenous status of $fi\_twist\_isbot_i$. However under the latter closure it operates to impart cost-neutral inter-regional sourcing twists to each commodity classified within those commodity sectors the output of which has been determined exogenously. The equation can be instated to ensure that the twist to each commodity (within a given commodity sector) is either identical to all other commodities within that commodity sector (XIS_DAMP1 = XIS_DAMP2 = 0) or deviates by some proportion of the difference between the rate of growth in the commodity and either real GRP at factor cost (XIS_DAMP1 $\neq$ 0) or the rate of growth of the output of the commodity sector (XIS_DAMP2 $\neq 0$). In the historical simulations undertaken in Chapter 4, XIS_DAMP2 has been set equal to 1 (with XIS_DAMP1 = 0). Equation

E_fi_twist_isbot can also be used in simulations in which region-specific commodity outputs are determined endogenously, and instead the inter-regional sourcing twists are used to determine exogenously some element of the regional macroeconomic accounts (such as the inter-regional balance of trade surplus). In such cases, the relevant element of the regional macro accounts is determined exogenously, and *ftwist_isbot* is determined endogenously. The endogenous / exogenous status of $twist\_isbot_i$ and $fi\_twist\_isbot_i$ would also be swapped, thereby bringing Equation *E_fi_twist_isbot* into operation. The term $\text{XIS\_DAMP1} \times \left(x\_total_{i,1} - r\_grpfc_1\right)$ imposes an extra cost-neutral twist in favour of the output of region 2 for those commodities produced in region 1 that are experiencing high rates of growth relative to the rate of growth in the region's real gross regional product at factor cost. This term is the analogue of the dampening term in Equation *E_ftwist_srcr*. Again, the dampening term expresses the idea that, for given relative prices, rising output of *i* from region 1 will be associated with shortages and queues for the commodity, and hence rising imports of *i* from region 2.

3 SPECIFICATION OF DATA SET AND PARAMETER VALUES FOR FEDERAL-F

3.1 OVERVIEW

3.1.1 Overview of the structure of the FEDERAL-F database

Figures 3.1 through to 3.7 provide a summary of the basic structure of the FEDERAL-F database. Broadly, the database can be divided into a multi-regional input-output database (Figure 3.1), and a number of ancillary parameter and data sets (Figures 3.2 - 3.7). The structure of the input-output database has changed little from the original FEDERAL model. The key difference is the inclusion of the phantom tax matrices, $TAX1F_{i,s,j,r}$ - $TAX6F_{i,s}$. These matrices record the phantom tax paid on the corresponding basic value flows, which are recorded in the matrices $BAS1_{i,s,j,r}$ - $BAS6_{i,s}$.

Every coefficient represented in Figure 3.1, other than MZ_i[65], is described in Appendix C. A detailed description of the structure of the multi-regional input-output database is also provided in Madden (1990). Hence, only an overview of the structure of the input-output database is provided here. The first feature to note is that six broad categories of user are identified: firms producing current output; capital creators; households; foreigners; regional governments; and the Commonwealth Government. All users, other than the Commonwealth Government and foreigners, are distinguished by the region in which they are located, *r*[66]. Current producers and capital creators are further distinguished by industry type, *j*. These users purchase *i* commodity types, which they can source from *s* origins. The matrices of the first row in Figure 3.1 then record the basic value of sales of commodity *i* from region *s* to six broad user types, with these user types being further

[65] The coefficient MZ(i) records the aggregate duty payable on imports of commodity *i*. The basic values of imports are recorded in the basic value matrices BAS1 - BAS6 as c.i.f plus duty. Hence, subtracting MZ(i) from the basic value sum across users and regions of imported commodity *i* provides the c.i.f. value of *i*.
[66] Figure 3.1 is drawn for the current implementation of FEDERAL-F, which features two domestic regions.

Figure 3.1: Multi-regional Input-Output Database

		Current Production	Capital Creation	Personal Consumption	Exports	Current Government Consumption	
		Tasmania (r=1) Mainland (r=2)	Tasmania (r=1) Mainland (r=2)	Tasmania (r=1) Mainland (r=2)	Tasmania (r=1) Mainland (r=2)	Tasmania (r=1) Mainland (r=2)	Commonwealth
Region of Sources	Tasmania (s=1)	$BAS1_{i,s,j,r}$	$BAS2_{i,s,j,r}$	$BAS3_{i,s,r}$	$BAS4_{i,r}$	$BAS5_{i,s,r}$	$BAS6_{i,s}$
	Mainland (s=2)						
	Overseas (s=3)						
Use of Tasmanian Margins (t=1)	Tasmania (s=1)	$MAR1_{i,s,j,r,u,t}$	$MAR2_{i,s,j,r,u,t}$	$MAR3_{i,s,r,u,t}$	$MAR4_{i,s,u,t}$	$MAR5_{i,s,r,u,t}$	$MAR6_{i,s,u,t}$
	Mainland (s=2)						
	Overseas (s=3)						
Use of Mainland Margins (t=2)	Tasmania (s=1)						
	Mainland (s=2)						
	Overseas (s=3)						
Tasmanian Sales Tax (g=1)	Tasmania (s=1)	$TAX1_{i,s,j,r,g}$	$TAX2_{i,s,j,r,g}$	$TAX3_{i,s,r,g}$	$TAX4_{i,s,g}$		
	Mainland (s=2)						
	Overseas (s=3)						
Mainland Sales Tax (g=2)	Tasmania (s=1)						
	Mainland (s=2)						
	Overseas (s=3)						
Federal Sales Tax (g=3)	Tasmania (s=1)						
	Mainland (s=2)						
	Overseas (s=3)						
Phantom Taxes	Tasmania (x=1)	$TAX1F_{i,x,j,r.}$	$TAX2F_{i,x,j,r.}$	$TAX3F_{i,x,r}$	$TAX4F_{i,x}$	$TAX5F_{i,x,r}$	$TAX6F_{i,x}$
	Mainland (x=2)						
Primary Factor Costs	Wages	$MU1_{q,j,r}$					
	PAYE	$MU2_{q,j,r}$					
	Payroll	$MU3_{q,j,r}$					
	Net rental - capital	$MV1_{k,j,r}$					
	Capital tax	$MV2_{k,j,r}$					
	Property tax	$MV3_{k,j,r}$					
	Net rental - land	$MW1_{k,j,r}$					
	Land tax	$MW2_{k,j,r)}$					
Other costs	State production tax	$MX1_{j,r}$					
	Federal production tax	$MX2_{j,r}$					
	Working capital	$MX3_{j,r}$					

Trade Taxes
MZ_i

$i \in COM$
$s \in SOU$
$j \in IND$
$r \in REG$
$u \in MAR$
$t \in REG$
$g \in GOV$
$q \in OCC$
$k \in OWNERS$
$x \in REG$

distinguished (as appropriate) by both the region in which they are located and their industry type.

The matrices in the second row ($MAR1_{i,s,j,r,u,t}$ - $MAR6_{i,s,u,t}$) record the value of the margins that are associated with the basic value flows recorded in the first row. There are *u* types of margins identified in the model, and these can be sourced from any of the model's *t* domestic regions. Margins are distinguished not only by the type and source of the margin, but also by the location and type of agent purchasing the source-specific commodity with which the margin service is associated. Hence, the second row of Figure 3.1 records the value of margin service type *u*, sourced from region *t*, on purchases of commodity *i* from source *s*, with these data further distinguished by both the type and location of the purchasing agent.

The matrices in the third row of Figure 3.1 record the government commodity taxes associated with the basic flows recorded in the corresponding matrices of the first row. There are no commodity taxes levied on the current consumption purchases of either regional government or the Commonwealth Government. However, commodity taxes are levied by *g* different governments on purchases by all other categories of user. The first *g*-1 governments are the *r* regional governments. These governments each levy commodity and source specific taxes on purchases by agents operating within their jurisdiction[67]. The g^{th} government is the Commonwealth Government, which also levies source-specific commodity taxes on agents operating in all regions. (or on exports from either region, in the case of $TAX4_{i,s,g}$). Hence the third row of Figure 3.1 records very disaggregated information on commodity taxes, with these data being distinguished by the government levying the tax, the type and origin of the commodity on which the tax is collected, and the type and location of the agent making the purchase on which the tax is levied.

[67] While the indices on TAX4(i,s,g) provides for regional government commodity taxes on exports, the values for these taxes in the database are zero.

Figures 3.2 - 3.7: Ancillary Parameter and Data Files

3.2 ELASTICITIES AND OTHER PARAMETERS

Export elasticities	$GAMA_i$
Economy-wide NTRAD export elasticity	GAMX
Frisch parameter	$FRIS_r$
Armington elasticity - inter. inputs	$SIG1_{i,r}$
Armington elasticity - cap. inputs	$SIG2_{i,r}$
Armington elasticity - household cons.	$SIG3_{i,r}$
Setting of intra-regional Arm. elas.	INTA
Marginal budget shares	$MBUD_{i,r}$
FED-F/nat.acc's X-class. Cons.	$FMM_{i,na,r}$

3.3 GOVERNMENT ACCOUNTS

Commonwealth unemployment payments	$CGO3_r$
Commonwealth transfers to regions	$CGO4_r$
Commonwealth other transfers	$CGO5_r$
Commonwealth other outlays	CGO_r
Commonwealth other receipts	$CGR7_r$
Commonwealth GFCF	$BCIN_r$
Commonwealth govt. net debt	FDDT
Commonwealth net interest payments	OSIF
Regional govt. income reducing taxes	$SGR4_r$
Regional govt. receipts of CG transfers	$SGR5_r$
Regional govt. other receipts	$SGR8_r$
Regional govt exog. foreign receipts	$SGR9_r$
Regional govt. transfers to persons	$SGO3_r$
Regional govt exog. foreign outlays	$SGO4_r$
Regional govt. GFCF	$BSIN_r$
Regional govt. net debt	$STDT_r$
Regional govt. net interest payments	$OSIR_r$

3.4 INVESTMENT AND CAPITAL ACCUMULATION

Recip of slope of capital supply curve	MURF
Trend capital growth rate	$GRSE_{j,r}$
Difference between trend and max. capital growth	$DIFF_{j,r}$
Adjustment coefficient - rates of return	$ADJC_{j,r}$
Real interest rate	RINT
Level of the CPI - lagged	LCPL
Level of the CPI	LCPI
Capital supply shift - general	FSEU
Capital supply shift - r	$FSER_r$
Capital supply shift - j,r	$FSEI_{j,r}$
Capital supply shift - j	$FSEJ_j$
Value of capital stocks - start of year	$VCAP_{j,r}$
Normal rates of return	$RORN_{j,r}$
Depreciation rates	$DEP_{j,r}$
Asset price of capital - start of year	$PCAP_{j,r}$
Asset price of capital - end of year	$PCP1_{j,r}$
Asset price of capital - average of year	$PCPM_{j,r}$

3.5 REGIONAL POPULATION AND LABOUR FORCE

Base income gap	BYGP
Base pop 15+	$POP0_r$
Migrant popn	MIGR
Location preference	LOPR
Adjustment coeff	ADCM
Initial popn - home region	INHM
Initial migrants	INMG
Participation rate	$PPRT_r$
Natural growth rate	$NATG_r$
Unemployment rate	$URAT_r$
Regional CPI	$CPIR_r$

3.6 HOUSEHOLD ACCOUNTS

Net interest receipts	$FNIR_r$
Net (non physical capital) assets	$FNAT_r$
Ownership of working capital	$OXX3_k$
Other household net income	$OHNI_r$
Exchange rate	PHI

3.7 LABOUR MARKET ADJUSTMENT

Index of CPI deflated wages	RWAG
Slope of labour supply curve	ALPH
Index of aggregate employment	EMPT

The matrices in the fourth row of Figure 3.1 record the value of the phantom taxes associated with source-specific commodities purchased by each type of user. Unlike their treatment in the MONASH model, phantom taxes in FEDERAL-F are allowed to carry forward and fluctuate from year to year. Hence, they are given a permanent place in the diagrammatic representation of the multi-regional input-output database.

Value added by regional industry is distinguished by four basic types of factor income: wages, capital rentals, land rentals, and working capital rentals. Wages are divided into post-tax wages ($MU1_{q,j,r}$), PAYE tax payments ($MU2_{q,j,r}$), and payroll tax payments ($MU3_{q,j,r}$). The values in these matrices are recorded not only by regional industry, but also by q occupational types. Gross capital rentals are similarly divided into post-tax and tax components. $MV1_{k,j,r}$ records the net rental receipts accruing to owner type k from capital in regional industry j,r. $MV2_{k,j,r}$ records the Commonwealth income tax paid on these rentals, and $MV3_{k,j,r}$ records any property taxes paid. Gross land rentals are divided into after-tax returns ($MW1_{k,j,r}$) and Commonwealth income taxes ($MW2_{k,j,r}$). Returns on working capital by regional industry are recorded in $MX3_{j,r}$. This matrix does not have an ownership dimension, with aggregate ownership of working capital instead being recorded in the matrix $OXX3_k$ (See Figure 3.6).

Figures 3.2 through to 3.7 summarise the remaining FEDERAL-F data sets. These record various parameters and elasticities, and other data relating to base year activity that are not included in the multi-regional input-output database.

All the parameters and coefficients other than GAMX, INTA, and FMM, listed in Figure 3.2 have their counterparts in the elasticities and parameters file of the original FEDERAL model. $GAMA_i$ is a vector of the negative of the inverse of the export demand elasticities by commodity. These elasticities provide the values for the coefficient $GAMMA_i$, described in Appendix C. GAMX records the negative of the reciprocal of the economy-wide non-traditional export elasticity, which provides the value for the coefficient GAMMAN described in Appendix C. FRIS records the value of the Frisch parameter, used in evaluating household own- and cross-price elasticities of demand and in calculating the change in the subsistence component of household consumption. The next four matrices are used to evaluate the Armington elasticities governing substitution possibilities faced by each non-government user between the various sources of each commodity type.

The elasticities that are recorded in the matrices $SIG1_{i,r}$ to $SIG3_{i,r}$ are those relating to domestic/foreign substitution possibilities. The coefficient INTA is a multiplicative factor that is used in evaluating $ZIG1_{i,s,j,r}$ - $ZIG3_{i,s,r}$. It allows a different Armington elasticity to exist on domestically sourced goods relative to foreign sourced goods (See Section 3.1.6.1). The matrix $MBUD_{i,r}$ contains values for marginal budget shares by commodity for each regional household. The matrices $FMM_{i,na,r}$ record consumption by household *r* of FEDERAL-F commodity *i* cross-classified with consumption of national accounts commodity *na*. These data facilitate the exogenous determination of household consumption by commodity in the historical simulations.

Most of the matrices described in Figure 3.3 data file also have their counterparts in the FEDERAL model. Many of these matrices are described in Section 2.7.1 and Section 2.8.1 (Regional and Government accounts) and so are not described again here. Data on Commonwealth and regional government gross fixed capital formation by region are contained in matrices $BCIN_r$ and $BSIN_r$ respectively. Commonwealth and regional government net foreign debt are recorded in the matrices FDDT and $STDT_r$ respectively. The net interest payments associated with this net debt are recorded in the matrices OSIF and $OSIR_r$ respectively.

The matrices listed in Figure 3.4 contain the parameters and data required to operationalise the rate of return and capital accumulation theory described in Section 2.6. The coefficient MURF is the reciprocal of the slope of the economy-wide capital supply function in the vicinity of $G_j^r = G_j^{(Trend)r}$ (1/M in Section 2.6.12). Trend capital growth rates by regional industry (given by $G_j^{(Trend)r}$ in Section 2.6.12) are stored in the matrix $GRSE_{j,r}$. The difference between trend capital growth rates and maximum capital growth rates is stored in DIFF. The regional industry specific coefficients governing the speed with which the adjustment mechanism given by Equation *E_d_diseq* returns actual rates of return to equilibrium rates of return are stored in $ADJC_{j,r}$. The real rate of interest is stored in RINT. The levels of the national CPI at the beginning and end of the database year are stored in LCPL and LCPI respectively. The vertical shifts in regional industry supply curves are stored in the matrices FSEU, $FSER_r$, $FSEI_{j,r}$ and $FSEJ_j$. The asset values of regional industry capital stocks at the start of the database year are stored in $VCAP_{j,r}$. The normal rates of return on these capital stocks are stored in $RORN_{j,r}$. Depreciation rates on capital by regional industry are stored in the matrix $DEP_{j,r}$. Capital asset prices by regional industry relating to the start of the database year, the end of the database year, and the average of the database year, are stored in matrices $PCAP_{j,r}$, $PCP1_{j,r}$ and $PCPM_{j,r}$ respectively.

The matrices described in Figure 3.5 represent the parameters and base year data required to operationalise the FEDERAL-F inter-regional migration theory. The value stored in BYGP is the base difference between regions in the measure of per-capita income to which inter-regional migration responds. This is set so as to generate some given level (in the present application, zero) of desired inter-regional migrants in the initial year (See Section 2.16.4). The matrix $POP0_r$ stores the populations aged 15-plus in each region in the benchmark year (this is the coefficient $BASE\_15\_PLUS_r$ in the equations in Section 14 of Appendix A). The net migrant population aged 15-plus in the database year is stored in the matrix MIGR. The location preference parameter is given by LOPR, and the adjustment coefficient governing the speed with which actual migrant numbers converge to desired migrant numbers is given by ADCM. The initial home region population and initial migrant numbers are stored as permanent values in INHM and INMG respectively. These coefficients are used to calculate the Y-intercept of the inter-regional migration function (the coefficient "A" in Equation (E2.16.1) of Section 2.16.3.4) as $A = LOPR \times (INHM + INMG)$. Regional participation rates are stored in $PPRT_r$, and regional unemployment rates are stored in $URAT_r$. Regional natural population growth rates are stored in the matrix $NATG_r$.

The matrices listed in Figure 3.6 contain data related to the net foreign assets held by regional households, ownership of working capital across the various owner classes, the foreign currency value of other net income, and the nominal exchange rate. The matrices $FNAT_r$ and $FNIR_r$ record (in foreign currency terms) regional household foreign net assets and the net returns on those assets respectively. The level of the exchange rate is recorded to allow for the conversion of household and government net foreign asset and net return accounts to domestic currency values. Data on the ownership of working capital, distinguished by regional households and the remaining classes of owner (regional and Commonwealth governments, and foreigners), are stored in $OXX3_k$. The foreign currency value of other household net income ($OHHNI_r$) is stored in $OHNI_r$. This is converted to Australian dollars using the index of the exchange rate stored in PHI.

The matrices listed in Figure 3.7 contain data related to the operation of the labour market adjustment mechanism (See Section 2.12.14). These data provide input to the model only during deviation simulations, although they are generated during the historical and forecast simulations. As described in Figure 3.7, the data stored in these files are: the index value for the real national consumer pre-tax wage (RWAG); the index value for national aggregate employment (EMPT); and the value of the parameter governing the speed with which aggregate employment in the deviation run returns to its forecast value (ALPH). In the deviation simulations, four logical file names containing the data listed in Figure 3.7 are used, in order to facilitate file management in GEMPACK. These logical names are listed in the first column of Figure 3.8. Figure 3.8 contains the actual physical files represented by the four logical file names over a hypothetical deviation simulation commencing with a policy shock to the model in the year 2000. It is clear from Figure 3.8 that there are two sequences of physical files. These files contain the values for the coefficients in Equation (E2.12.6) in Section 2.12.14. The first sequence (LM98 - LM03) contain (in addition to the value for α) the values for the coefficients $W_{1998}^{[Base]} - W_{2003}^{[Base]}$ and $E_{1999}^{[Base]} - E_{2003}^{[Base]}$ used in the evaluation of Equation (E2.12.6). The values in LM98 - LM03 are generated during the base historical / forecasting simulation, and are not updated during the deviation / policy simulation. The second sequence of files (LM98 - LM03*) is a mixture of files generated during the historical / forecasting simulations (for *t*-1 and *t*-2) and files generated during the deviation / policy simulation (for *t* to $t - n$). This sequence of files contains the values for $W_{1998}^{[Dev]} - W_{2003}^{[Dev]}$ and $E_{1999}^{[Dev]} - E_{2003}^{[Dev]}$ used in the evaluation of Equation (E2.12.6). The final column in Figure 3.8 lists the coefficients (see Equation E2.12.6) that are read in from each file at each step of the deviation / policy simulation.

Figure 3.8

File naming and management for the labour market adjustment mechanism

Logical file name:	Year					Coefficients read in (See Equation (E2.12.6) in Section 2.12.14)
	2000	2001	2002	2003	2004	
	Physical file name for input files.					
LAB	LM99	LM00*	LM01*	LM02*	LM03*	$W_t^{[Dev]}$ $W_{t-1}^{[Dev]}$ $E_t^{[Dev]}$
LAB3	LM99	LM00	LM01	LM02	LM03	$W_t^{[Base]}$ $W_{t-1}^{[Base]}$ $E_t^{[Base]}$
LAB4	LM98	LM99	LM00*	LM01*	LM02*	$W_{t-2}^{[Dev]}$
LAB5	LM98	LM99	LM00	LM01	LM02	$W_{t-2}^{[Base]}$
	updated files generated at end of each deviation run.					
	LM00*	LM01*	LM02*	LM03*	LM04*	

3.1.2 Overview of the compilation of the Tasmanian / Mainland FEDERAL-F database

A 1992/93 database for a Tasmanian / Mainland version of the FEDERAL model (hereafter the "initial database") formed the starting point for the compilation of the database used to operationalise the Tasmanian / Mainland version of FEDERAL-F. The methodology used to construct the initial database is described in detail in Madden (1990). Referring to Figures 3.1-3.7, this initial database consisted of a two region input-output database (absent the phantom tax row) (Figure 3.1), the file containing elasticities and other parameters (Figure 3.2), and the government accounts data file (Figure 3.3). In constructing the FEDERAL-F database, the data in these files were subject to a number of changes. These changes are described in the remainder of this chapter. Furthermore, files containing data relating to investment and capital (Figure 3.4), regional populations and labour forces (Figure 3.5), the household accounts (Figure 3.6) and the labour market adjustment mechanism (Figure 3.7), were added to the database. The construction of these databases is also described in the remainder of this chapter.

3.1.3 The multi-regional input-output database for FEDERAL-F

3.1.3.1 Overview

The starting point for the development of the FEDERAL-F input-output table was an existing 1992/93 input output database for a Tasmanian/Mainland implementation of the FEDERAL model. A number of changes and additions were made to this database, and these are outlined below. The first of these involved relatively minor changes to the existing data to remove apparent anomalies in some basic value and sales tax matrices. The second set of changes involved more fundamental adjustments to both labour / capital ratios (both within industries and regions), and the allocation of regional investment across industries. Finally, phantom tax matrices did not exist in the original FEDERAL database, and so these were added to the new FEDERAL-F database. The values in these phantom tax matrices were set equal to positive numbers that were sufficiently small that they left the balance of the database effectively unchanged.

3.1.3.2 Removal of negative flows in the FEDERAL database

A handful of cell entries in the basic value and margin matrices of the initial database have small negative entries. Such negative flows do not make sense from the perspective of either model's theory, and so should not be present in the initial database. However, they present no problems in comparative-static simulations of the model, unless the model user is interested in the deviation results from these user and commodity-specific base flows. However, in year-on-year historical simulations of the model, in which inter-regional sourcing twist variables are determined endogenously, they do present a major problem. Hence, one of the first steps in constructing the FEDERAL-F database was to eliminate these small negative entries. This was done by first resetting any negative basic value flows equal to 0.001, and then re-setting any negative margins equal to 0.0001. The original values for the negative flows were sufficiently small that this simple resetting of the values had no material consequences for balance of the input-output database.

3.1.3.3 Removal of inter-regional purchases of Dwellings

The initial database has a purchase of "Dwellings" services by the Tasmanian household from the Mainland region. While one might possibly rationalise this as a purchase by Tasmanian visitors and tourists to the Mainland, this seems unlikely given that a corresponding purchase of Tasmanian Dwellings by Mainland households does not also exist in the database. The purchase is small relative to total Tasmanian consumption, and small relative to Mainland consumption of Dwellings. This purchase was eliminated from the database, and the value of the sales transferred to the Mainland household's purchases of Mainland Dwellings. The tax matrices (TAX3) were adjusted accordingly. While this transfer reduced Tasmanian consumption marginally, and increased Mainland consumption marginally, it had no consequences for database balance. After the transfer, the share of Dwellings in total household consumption remained approximately equal in both regions.

3.1.3.4 Re-estimation of sales tax matrices.

The sales tax matrices in the initial database contain some suspicious entries: in particular, in a number of cases the Commonwealth taxes on some flows are the negative of the Tasmanian taxes on the same flows. This suggests that in deriving the initial database, the Tasmanian data had been subtracted from a national figure, and the residual negative balance left as a negative Commonwealth sales tax. This has been rectified by applying MONASH model commodity tax rates to the basic value flows in the initial database. This procedure is described below.

The MONASH database contains data on commodity taxes paid on 115 commodities from two sources: Australia and overseas. The level of government levying the tax is not distinguished. The first task was to aggregate each of the MONASH commodity tax matrices and basic value flow matrices to the 37 commodity / industry classification used in FEDERAL-F. This was done using the concordance in Appendix E. MONASH model commodity tax rates on user and source specific commodity flows ($MRATE1_{i,s,j}$ - $MRATE4_{i,r}$, i=1,...,37, s=1,...3, r=1,2)[68] were then calculated by dividing these aggregated MONASH tax matrices ($MTAX1_{i,k,j}$ - $MTAX4_{i}$, i=1,...,115, k=1,2, j=1,...,113) by the corresponding aggregated MONASH basic value matrices ($MBAS1_{i,k,j}$ - $MBAS4_{i}$, i=1,...,115, k=1,2, j=1,...,113). However a condition that had to be met before this rule was applied was that the basic value flow in the aggregated MONASH data had to be greater than \$2m. The reason for applying this rule was that some very small basic value flows in MONASH were found to nevertheless be associated with relatively high commodity tax payments. This implied very high rates of taxation - so high that they were clearly incorrect. An extreme example of this was the tax paid on usage of Tobacco by the Air transport industry. The basic flow here was only \$0.0085. However on this were levied sales taxes of \$40.8 m. Applying this sales tax : basic flow ratio to the FEDERAL-F basic flow data would have produced an untenable estimate of the associated commodity tax

[68] Rates for FEDERAL-F sources s = 1,2 were set equal to rates for MONASH source k = 1. Rates for FEDERAL-F source s = 3 were set equal to rates for MONASH source k = 2.

payable. From visual inspection of the MONASH data it was clear that these high ratios only occurred where the basic value flow was small (generally less than 1). The rule that was adopted was that where a basic value flow in the MONASH database was found to be less than $2m, the tax rate on that flow was set at the average tax rate for all users of the type in question. For example, the tax rates on intermediate input purchases were calculated as:

$$MRATE1_{i,t,j} = MTAX1_{i,Dom,j}/MBAS1_{i,Dom,j} \quad (MBAS1_{i,Dom,j} \geq 2)$$

$$MRATE1_{i,t,j} = \frac{\left[\sum_j \sum_s MTAX1_{i,s,j}\right]}{\left[\sum_j \sum_s MBAS1_{i,s,j}\right]} \quad (MBAS1_{i,Dom,j} < 2) \qquad i \in COM,\ t \in REG,\ j \in IND.$$

$$MRATE1_{i,RoW,j} = MTAX1_{i,RoW,j}/MBAS1_{i,RoW,j} \quad (MBAS1_{i,RoW,j} \geq 2)$$

$$MRATE1_{i,RoW,j} = \frac{\left[\sum_j \sum_s MTAX1_{i,s,j}\right]}{\left[\sum_j \sum_s MBAS1_{i,s,j}\right]} \quad (MBAS1_{i,RoW,j} < 2) \qquad i \in COM,\ j \in IND.$$

At this stage the MRATE matrices do not distinguish which level of government is levying the tax. The first step in rectifying this was to distinguish those FEDERAL-F commodities that are taxed largely by regional governments only. These commodities are: 11. *Beverages and malts*, 25. *Electricity*, 26. *Other utilities*, 33. *Finance*, 36. *Community services*, and 37. *Entertainment and recreation*. Both the Commonwealth and regional governments tax sales of Petroleum. A 20/80 split was imposed in dividing this tax between the two government levels. The remaining commodities are taxed largely by the Commonwealth Government alone. Having divided commodities in this fashion, it was then possible to estimate the FEDERAL-F tax matrices. By way of example, the initial estimates of the FEDERAL-F commodity tax matrices on intermediate purchases were then calculated as follows:

$$TAX1_{i,s,j,r,Fed} = BAS1_{i,s,j,r} \times MRATE1_{i,s,j} \qquad i \in CTAX,\ s \in SOU,\ j \in IND,\ r \in REG.$$

$TAX1_{i,s,j,r,r} = BAS1_{i,s,j,r} \times MRATE1_{i,s,j}$ $\quad i \in STAX,\ s \in SOU,\ j \in IND,\ r \in REG$

$TAX1_{Petroleum,s,j,r,Fed} =$
$0.8 \times BAS1_{Petroleum,s,j,r} \times MRATE1_{i,s,j}$ $\quad s \in SOU,\ j \in IND,\ r \in REG.$

$TAX1_{Petroleum,s,j,r,r} =$
$0.2 \times BAS1_{Petroleum,s,j,r} \times MRATE1_{i,s,j}$ $\quad s \in SOU,\ j \in IND,\ r \in REG.$

Where CTAX is the set of commodities that are only taxed by the Commonwealth; and STAX is the set of commodities that are only taxed by the regional governments.

After this procedure, the column sums for the TAX1 matrix no longer equalled their original values. Hence the database was out of balance. This was rectified by re-scaling the column values of new TAX1 matrices by the ratio of the column sums of the old TAX1 matrices to the column sums of the new TAX1 matrices.

This approach was used to re-estimate each of the FEDERAL-F commodity tax matrices. The only complication was in the estimation of the $TAX4_{i,r,g}$ matrix, where only the Commonwealth Government is allowed to levy export taxes. In terms of applying to this case the basic routine used to estimate $TAX1_{i,s,j,r,g}$ as outlined above, this was a simple matter of setting CTAX = COM and STAX = $\varnothing$ for this calculation.

3.1.3.5 Adjustment to capital / labour ratios, both at the industry level and economy-wide.

A comparison between the initial FEDERAL database and the MONASH database of industry capital / labour ratios revealed some large differences for a number of industries. Only a single year separates the years to which these two databases pertain - insufficient time to account for the large differences in their industry-level capital / labour ratios. At the economy-wide level, the two databases also differed in the shares of returns to capital and land in total returns to capital and land. Referring to ABS state accounts data (ABS 1998b), the shares of returns to labour and capital in total returns to labour and capital were constant, at the national level, between 1992/93 and 1993/94. It seems fair to expect then that at both the economy-wide level, and at the national industry level, labour / capital ratios in FEDERAL-F should correspond with those in the MONASH model. However, one might expect to find differences in Tasmanian labour / capital ratios, both in aggregate and at the industry level, from their national counterparts. Hence, a number of steps were undertaken to adjust aggregate FEDERAL-F labour / capital ratios towards the values of MONASH labour / capital ratios, while still retaining the existing information in the initial database on Tasmanian labour / capital ratios by industry. These steps are described below.

The first step was to calculate the MONASH shares of economy-wide returns to capital and labour in total returns to capital and labour. These ratios were then applied to the total of existing returns to capital and labour in each region of the initial FEDERAL-F database. This provided starting target aggregate returns to capital and labour for each region. However, at this stage in the procedure, both Tasmania and the Mainland have identical target capital / labour ratios. This contradicts ABS data on this point, which indicate that the Tasmanian labour / capital ratio in 1992/93 was approximately 16% higher than the Mainland ratio. Hence, the next step in the procedure was to impose a cost-neutral twist towards labour in the aggregate target Tasmanian labour / capital ratio. Hence, the final targets for aggregate returns to labour and capital left the Mainland with a labour / capital ratio equal to that of the MONASH model, while leaving Tasmania with a labour / capital ratio approximately 16% higher than that of the Mainland.

The next step in the routine was to move the capital / labour ratio for two industries (residential building and other construction) in both regions towards the MONASH values for these industries. Activity in both these industries is sensitive to changes in economy-wide expected rates of return, because of their role in capital creation. Hence I was keen to have their capital / labour ratios reflect those of the corresponding industries in MONASH. For these industries, the relevant entries in the six matrices distinguishing post-tax returns and tax payments on labour and capital (MU1 - MV3) were adjusted so as to impose upon them the labour / capital ratio from the corresponding industry in the MONASH model, while leaving unchanged the value of payments to capital and labour in total for each industry. For example, post-tax returns to labour in residential building were set equal to:

$$MU1^{(New)q}_{ResBuild,r} = MU1^{(Old)q}_{ResBuild,r} \times \left[\frac{LAB^{(Monash)}_{ResBuild}}{LAB^{(Federal)}_{ResBuild,r}}\right] \times \left[\frac{KL^{(Federal)}_{ResBuild,r}}{KL^{(Monash)}_{ResBuild}}\right] \qquad \begin{array}{l} q \in OCC \\ r \in REG \end{array}$$

Where $MU1^{(New)q}_{ResBuild,r}$ is the new value for post-tax returns to labour in residential building and $MU1^{(Old)q}_{ResBuild,r}$ is its original value, $LAB^{(Monash)}_{ResBuild}$ is the value of total returns to labour in residential building in MONASH, $LAB^{(Federal)}_{ResBuild,r}$ is the original value of total returns to labour in residential building in region *r* in FEDERAL-F, $KL^{(Federal)}_{ResBuild,r}$ is the original value of total payments to labour and capital in residential building in FEDERAL, and $KL^{(Monash)}_{ResBuild}$ is the MONASH value for the same. This procedure was then applied to the relevant columns of the remaining matrices from MU2 through to MV3. For example, the MV3 matrix for residential building was adjusted as follows:

$$MV3^{(New)t}_{ResBuild,r} = MV3^{(Old)t}_{ResBuild,r} \times \left[\frac{KAP^{(Monash)}_{ResBuild}}{KAP^{(Federal)}_{ResBuild,r}}\right] \times \left[\frac{KL^{(Federal)}_{ResBuild,r}}{KL^{(Monash)}_{ResBuild}}\right] \qquad \begin{array}{l} t \in OWNERS \\ r \in REG \end{array}$$

Where $KAP^{(Monash)}_{ResBuild}$ is the value of total returns to capital in residential building in MONASH, and $KAP^{(Federal)}_{ResBuild,r}$ is the original value of total returns to capital in residential building in region *r* of FEDERAL-F.

Finally, an iterative bi-proportional re-scaling of the six matrices MU1 - MV3 was undertaken. Within each iteration, the first step was to re-scale the three labour matrices and three capital matrices, within each region, so that their sum over industries equalled the target aggregate regional returns to labour and capital, as discussed above. However, this leaves total returns to labour and capital, for each regional industry, different from its starting value, making the database imbalanced. Hence, the second step within each iteration was to re-scale the elements of each regional industry column (over the six matrices) so that the resulting new (re-scaled) column sum was returned to its original value. The final step in each iteration was to reset returns to labour and capital in residential building and other construction equal to their new values as described in the previous paragraph. Hence, at the end of each iteration, the database is re-balanced, and labour / capital ratios in residential building and other construction are reset to their imposed values. However, within each region, the distribution of aggregate returns to labour and capital between labour and capital individually might diverge from their target values. However, repeating these steps a sufficient number of times (ten times was found to be adequate) left the database balanced, with aggregate returns to labour and capital in each region equal to their target values.

The next set of adjustments were made to Mainland labour / capital ratios by industry. The objective of these adjustments was to move the values of these ratios towards those of the corresponding MONASH industries. Again, an iterative bi-proportional re-scaling method was used. During these iterations, value-added by Mainland industry, and the sum across industries of each of the seven value added matrices individually (MU1-MV3 and MX3), were constrained to equal their original values. The first step in this procedure was to re-scale the individual factor shares (labour, land, capital and other costs) in total value added by Mainland industry to equal the factor shares of their MONASH counterparts. This step left value added by Mainland industry unchanged, but caused the sum across industries of each of the seven value added matrices to diverge from their original values. It was at this stage that the iterative rescaling procedure was applied. The first step in each of these iterations was to re-scale (across the rows) the elements of each of the seven value added matrices, returning their sum across industries to their original values. This step left value added by industry different from their original values. Hence the second step in each iteration was to re-scale, for each industry (i.e. up the columns) the values of the seven value added matrices, thereby returning these column sums to their original values. Again, ten iterations were sufficient to ensure that both the row sums and column sums reconciled with their target values.

3.1.3.6 Adjustment to regional industry investments.

As is clear from Figure 3.1, the initial multi-regional input output table contained sufficient data to calculate gross fixed capital formation by both industry and region. However, the values of the $BAS2_{i,s,j,r}$, $TAX2_{i,s,j,r}$ and $MAR2_{i,s,j,r,u,t}$ matrices were subject to some manipulation before being input to the new FEDERAL-F database. The objective of these manipulations was to bring the FEDERAL-F values for certain key ratios relating to the investment and capital theory as close to their MONASH counterparts as possible, while retaining as much regional information as possible from the original database.

Data on investment by region are available from the ABS state accounts. However such data are not available by industry and region, allowing some flexibility in the allocation of regional investment across industries in the process of compiling the database. Hence, in the process of incorporating the original BAS2, TAX2, and MAR2 matrices into the FEDERAL-F database, while the aggregate value of regional investment was retained, the allocation of this investment across industries was modified. A key constraint on all the modifications undertaken to the initial database was to ensure that the structure of the FEDERAL-F database at the national level departed as little as possible from the structure of the MONASH database. Since the Mainland accounts for around 98% of national economic activity, this constraint was typically implemented by reserving most modifications to the Mainland section of the database. With respect to total Mainland investment then, this was redistributed across Mainland industries so that each received a share of the total that was equal to the share of national investment received by the corresponding industry in MONASH. Recall that by this stage of the database construction routine, both: (i) the share in FEDERAL-F of capital payments in total gross domestic product at factor cost; and (ii) mainland industry capital / labour ratios; had already been brought in line with their MONASH counterparts. Hence, setting Mainland industry investment in FEDERAL-F in accordance with the MONASH shares of industry investment in total investment, left the investment : capital returns ratios by industry in the two models quite similar. In determining investment by industry for Tasmania, this ratio was imposed directly. A calculation was made of the level of investment that would prevail in Tasmania if the MONASH ratio of investment to gross returns to capital also prevailed in the FEDERAL-F model. These individual industry investments were then adjusted proportionally to ensure that their sum was equal to the original value for total Tasmanian investment. Hence by this stage of the database construction procedure, a preliminary set of target levels for investment by regional industry have been calculated.

The target levels of investment for those regional industries in the set of government business enterprises is then checked against total state and Commonwealth government investment in each region. The sum across GBE industries of industry investment in each region must be at least equal to the value of state and Commonwealth investment grants to industries in the region (i.e. $BSIN_r + BCIN_r$). If this is not the case then the share of private investment in total investment in GBE's in the region (Coefficient $PRINSH_{j,r}$ in Equation *E_y_kap*) will be negative: a meaningless number. Hence, at this stage of the investment adjustment procedure, where the sum of GBE investments in a region is less than the sum of state and Commonwealth investment grants to industries in that region, it is necessary to scale the target investments for GBE's in the region upwards until they sum to at least the exogenously given sum of state and Commonwealth investment in the region. In scaling the investment in individual GBE industries upwards, an assumption must be made about what will be the final share of private investments in GBE's. This has been set at 5 per cent.

Having established the target levels of investment for each regional industry, the final step is to ensure that the elements of the database matrices which comprise aggregate investment (BAS2, MAR2, and TAX2) do indeed sum to the desired level of investment for each regional industry. An iterative scaling procedure is used to achieve this. Summing down the column for BAS2, MAR2, and TAX2 for any individual regional industry provides the value of investment in that industry. This value will not initially accord with the target level of investment for that regional industry. In the first calculation of the first iteration, each element of a given column is scaled by the ratio of its target sum to its actual sum. After this first scaling the column sums will equal their target sums, however the rows sums will no longer equal their original values. The original values of the row sums[69] must be maintained to ensure that the database remains balanced. Hence in the second calculation of the first iteration the values of each element of a given row is scaled by the ratio of the value of its initial sum to the value of its current sum. After this calculation, the row sums will again equal their target (that is, there initial) values, however the column sums will now differ from their target values. The second iteration involves the application of the same procedure as that applied in the first iteration, and so on through successive iterations until the row and column sums converge to their target values. Ten such iterations of these manipulations of the investment matrices were sufficient to ensure that the actual row and column sums converged to their desired level.

[69] For any given row, two row sums are calculated - one within each region. The rescaling across rows is then undertaken within each region, not across regions.

3.1.3.7 Adjustments to the basic values for Tasmanian exogenous export commodities

Together, FEDERAL-F Equations *E_p_rexp* and *E_g_extax* require that the basic value flows of exports in $BAS4_{i,r}$ exceed the values for Commonwealth export taxes in matrices $TAX4_{i,r,g}$. Under certain circumstances the failure to meet this condition will result in a numerically singular left-hand-side matrix, and the model cannot be solved. The condition was not met for some elements of the Tasmanian components of these matrices in the original FEDERAL. However, only very small values of exports and tax collections were recorded for the offending commodities. Increasing the basic value of exports for the offending commodities to $0.01 million was sufficient to remedy the problem, with this adjustment being sufficiently small that no other changes to maintain overall balance were necessary.

3.1.3.8 Import duties

The values in the duty matrix MZ(i) were rescaled so that their sum equated with the ABS data on the value of total Commonwealth receipts from import duties.

3.1.3.9 Payroll taxes

The earlier manipulations to the wage matrices left the value of aggregate payroll tax receipts in each region slightly different from their values as given by ABS data. To correct this, the values of the MU3 matrices in each region were rescaled to ensure that their sums across industries and occupations accorded with ABS government finance statistics data on state government payroll tax receipts. Balancing adjustments were then made to each region's post-tax wage matrix, MU1.

3.1.3.10 Property taxes

The regional government property tax matrices (MV3) were rescaled to ensure that total regional government property tax receipts coincided with the ABS data on such. Balancing adjustments were then made to the net rental matrix (MV1).

3.1.3.11 Regional government production tax receipts

The production tax matrix MX1 was rescaled to ensure that aggregate regional government production tax revenues were equal to regional government production tax revenues as given by ABS government finance data. Balancing adjustments were then made to the working capital matrix, MX3. The matrix recording aggregate ownership of working capital (OXX3) was then rescaled so that its aggregate value was equal to that of MX3. No adjustment was made to MX2, since the aggregate value of Commonwealth production taxes in the initial database was broadly in line with the ABS data.

3.1.3.12 Installation of phantom tax matrices

The phantom tax matrices TAX1F through to TAX6F were created by entering them in the multi-regional input output table with sufficiently small values in the initial database year that they did not materially affect the overall balance of the database. In some simulations of the model, uniform shifters may be applied to the rates of phantom taxation, hence it is important that the starting values for the taxes are a uniform proportion of the purchasers' values of the corresponding flows. Hence the values for these taxes were set equal to 0.00001 of the purchaser's values of the flows upon which they attached.

3.1.4 Parameters and values relating to rates of return, investment, and capital accumulation

3.1.4.1 Overview

Estimates had to be made of all the values and parameters summarised in Figure 3.4. It is clear that a number of these do not have a regional subscript, indicating that their values are set independently of conditions in either region individually. These parameters have been set equal to their values in the MONASH model. In particular, MURF (M) and RINT $\left(R_{(t)}^{[Real]}\right)$ are set equal to the values of the equivalent parameters in MONASH. The FEDERAL-F parameters DIFF $\left(N_j^{(Diff)r}\right)$ and ADJ_COEFF$_{j,r}$ $\left(\Phi_j^r\right)$ have a regional dimension. However they are also currently set equal to their corresponding (industry level) values in MONASH.

3.1.4.2 *The real rate of interest*

The value for the real rate of interest, $R_{(t)}^{(Real)}$ or RINT, is read in from the MONASH database, and set equal to this value (which is 0.04).

3.1.4.3 The CPI and lagged CPI

The levels of the national consumer price index at the start and end of the database year respectively: LCPL and LCPI; can be established from Australian Bureau of Statistics data. The coefficient LCPI is set equal to 109.3, being the level of the consumer price index for the June quarter of 1993. The coefficient LCPL is set equal to 107.3, being the level of the consumer price index for the June quarter of 1992 (ABS 1997).

3.1.4.4 The slope of the capital supply function in the vicinity of the trend growth rate

The parameter measuring the slope of the capital supply function in the vicinity of $G_j^r = G_j^{(Trend)r}$, M (or MURF in Figure 3.4), is set equal to 1.00, being its value in the MONASH database. This parameter does not have a regional dimension, reflecting the absence of information at the regional level on the sensitivity of regional investment to changes in expected rates of return.

3.1.4.5 The difference between the maximum growth rate and the trend growth rate in capital

The maximum allowable rate of growth in capital in regional industry *j,r*, $G_j^{(Max)r}$ (See Section 2.6.12), is set equal to a fixed amount above the historically normal rate of growth, $G_j^{(Trend)r}$. Trend growth rates by regional industry are stored in the matrix $GRSE_{j,r}$. The difference between maximum and trend growth rates is assumed to be uniform across regional industries. The difference between these two values is stored is stored as DIFF in Figure 3.4. The value for DIFF is set equal to its MONASH value of 0.10.

The calculation of $TREND_{j,r}$ (stored under GRSEjr in Figure 3.4) proceeds through a number of steps. First, the quantity of capital corresponding to a year's trend growth in capital is calculated for each MONASH industry. These are then aggregated to the FEDERAL-F industry classification in accordance with the concordance in Appendix E. Base-year quantities of capital by industry from the MONASH model are then similarly aggregated to the FEDERAL-F classification. An initial estimate of $TREND_{j,r}$ is then calculated by dividing the aggregated quantity of capital represented by a year's trend growth, by the aggregated base quantity of capital. While these then provide the trend values for the mainland, trend growth rates across all Tasmanian industries are reduced by 0.003 points[70] on these values (that is, trend growth rates are set 0.3 percentage points lower in Tasmania). The value for the trend rate of growth in the Tasmanian Dwellings industry was set in a different manner. Tasmania's annual average population growth rate over the period 1985/86 to 1996/7 was only 40% of the national average. To reflect the likely implications of this for the trend growth rate in Tasmania's stock of housing, a lower trend growth rate, equal to 40% of the MONASH value for trend growth in Ownership of Dwellings, has been set for the Tasmanian Dwellings industry.

3.1.4.6 Closing the difference between expected and equilibrium rates of return

The parameter governing the proportion of the gap between expected rates of return and the capital supply function that is closed in each period $\left(\Phi_j^r\right)$ is set equal to its MONASH value of 0.50 for each regional industry. This is stored as $ADJC_{j,r}$ in Figure 3.4.

3.1.4.7 Vertical shifts in the capital supply functions

The values of the parameters governing the vertical positions of the regional industry capital supply functions, $F_{(1)j}^{(Eqm)r}$, $F_{(4)j}^{(Eqm)}$, $F_{(2)}^{(Eqm)r}$, and $F_{(3)}^{(Eqm)}$ are stored in the matrices FSEI, FSEJ, FSER, and FSEU respectively. These parameters are assigned initial values of zero in the database year.

[70] Assuming identical rates of growth in labour and capital productivity over the period 1984/85 to 1997/98, the average annual rate of capital growth in Tasmania appears to have been around 0.003 points lower than the Mainland.

3.1.4.8 The value of capital stocks by regional industry

The value of capital stocks by regional industry are stored in the matrix $VCAP_{j,r}$, and are estimated from the MONASH model database. The first step in estimating these data was to aggregate industry level values for capital and investment from the MONASH database to the FEDERAL-F industrial classification scheme. These data were then used to calculate ratios of the value of capital to investment by industry. The estimates of the value of capital by regional industry were then made by multiplying these ratios by the values for investment by regional industry, as calculated from the FEDERAL-F input-output table.

3.1.4.9 Normal rates of return by regional industry

Normal rates of return are read in as parameters in the MONASH model. To calculate normal rates of return for the 37 FEDERAL-F industry categories, it was first necessary to calculate a value for returns to capital ($CAPITAL_j$) for each of the 113 MONASH industries that generates the normal rate of return, $RORN_j$. The MONASH static expectations rate of return formula is given by:

$$\begin{aligned} ROR\_SE_j &= (1/[1+RINT\_PT\_SE]) \times \\ &\{[CAPITAL_j \times (1-TAX\_K\_RATE)]/VCAP\_AT\_T_j + \\ &(1-DEP_j) + TAX\_K\_RATE \times DEP_j\} - 1; \end{aligned} \qquad \text{(E3.1.1)} \quad j=1,\ldots,113$$

Where:

ROR_SE_j	are static expectations rates of return in year t;
$RINT\_PT\_SE$	is the static expectations post-tax real interest rate;
$CAPITAL_j$	are the returns to capital by industry;
TAX_K_RATE	is the rate of tax on capital and land income;
$VCAP\_AT\_T_j$	are the values of capital stocks at the start of the forecast year; and
DEP_j	are the rates of depreciation of physical capital;

Substituting $RORN_j$ for ROR_SE_j, and then manipulating the above expression to solve for the value of capital returns ($CAPITAL\_N_j$) that generates a normal rate of return:

$$\text{CAPITAL\_N}_j = [\text{VCAP\_AT\_T}_j / (1 - \text{TAX\_K\_RATE})] \times \qquad \text{(E3.1.2)}$$
$$\{(\text{RORN}_j + 1) \times (1 + \text{RINT\_PT\_SE}) - (1 - \text{DEP}_j - \text{TAX\_K\_RATE} \times \text{DEP}_j)\} \quad j = 1, \ldots, 113$$

Having calculated these values for $CAPITAL\_N_j$, they were then aggregated into the relevant FEDERAL-F 37 industry categories according to the concordance provided in Appendix E. Next, by returning to Equation (E3.1.1) above, and evaluating it using MONASH data classified to the FEDERAL-F 37 industry classification, it was possible to evaluate normal rates of return by FEDERAL-F industry. Hence, the first step was to set $CAPITAL_j$ equal to $CAPITAL\_N_j$ in this equation. Also, neither the capital tax rate, nor the discount rate faced by each industry in MONASH differs across industries. Hence these could be input directly to Equation (E3.1.1).

Next, depreciation rates (DEP_j) for each of the 37 FEDERAL-F industries, were calculated as a capital quantity weighted average of the MONASH industries of which the FEDERAL-F industry is comprised. These were then input to Equation (E3.1.1).

The value of capital by industry from the MONASH database ($VCAP\_AT\_T_j$) aggregated to the 37 industry FEDERAL-F classification, had already calculated been calculated in a prior step (See Section 3.1.4.8 above). These data were also input to Equation (E3.1.1).

These calculations provided sufficient data to calculate normal rates of return for the 37 FEDERAL-F industries using appropriately aggregated MONASH data. The final step was to simply set the normal rate of return for each industry in each region ($RORN_{j,r}$ in Figure 3.4) equal to these national MONASH normal rates of return by FEDERAL-F industry.

3.1.4.10 Capital asset prices by regional industry

Capital asset prices for the beginning, end, and average, of the database year are required. These are stored as $PCAP_{j,r}$, $PCP1_{j,r}$ and $PCPM_{j,r}$ respectively in Figure 3.4. The database for the 1997 MONASH model contains capital asset prices for the year t-2; that is, the beginning of the year 1992/93. These are used to estimate the FEDERAL-F start of year capital asset prices. For each regional industry, its start of year capital asset price is set equal to a weighted average of the lagged asset prices of capital for those MONASH industry categories subsumed within in it (See the MONASH / FEDERAL-F industry concordance

Appendix E). The weights used are calculated from the MONASH data on capital quantities by industry. The weight on each MONASH lagged capital asset price is set equal to the share of the quantity of capital in that industry in the total quantity of capital in the broader FEDERAL-F industry category under which it is subsumed.

Capital asset prices at the end of the database year (PCP1) are also calculated directly from the MONASH database. FEDERAL-F end of year capital asset prices are equal to the MONASH start of year capital asset prices. First, both the quantity and value of capital by industry from the MONASH database were aggregated to the FEDERAL-F industry classification. End of year capital asset prices by FEDERAL-F industry were then calculated by dividing the reclassified MONASH value of capital by the reclassified MONASH capital quantities. End of year capital asset prices in each region were then set equal to these values.

Average year capital asset prices ($PCPM_{j,r}$) are set equal to beginning of year capital asset prices multiplied by six month's worth of the growth in such prices established by the values of $PCP1_{j,r}$ and $PCAP_{j,r}$.

3.1.5 Regional population and labour force

3.1.5.1 Base year income gap.

As discussed in Section 2.16, inter-regional migration in FEDERAL-F is driven by deviations in the difference between regional expected per-capita income away from its base difference. This base difference is calculated from the 1992/93 data by first evaluating Equation (E2.16.13) in Section 2.16.3.8 for both regions. The difference between this income measure for the Mainland and Tasmania is then calculated. This difference is stored as a permanent (non-updated) parameter as BYGP in Figure 3.5.

3.1.5.2 Base year populations

The base year population aged 15 and over in each region is stored as $POP0_r$ in Figure 3.5. These data are calculated from ABS (1999a), which contains monthly data on both the labour force and participation rate by state - sufficient information to calculate the population aged over fifteen in each state. The data in $POP0_r$ relate to the start of the database year, hence these values were calculated from labour force data for July 1992. The value for $POP0_{Tas}$ in the base year also provides the value for the initial population of the home region (INHM) which is a non-updateable parameter.

ABS labour force data are also used to set the initial values for the participation rates in each region. These are stored as the updateable coefficients $PPRT_r$ in Figure 3.5.

3.1.5.3 Migrant population

The number of net inter-regional migrants, which is stored as the updateable coefficient MIGR in Figure 3.5, is initially set equal to zero. The value for the initial number of migrants, which is a non-updateable parameter stored as INMG in the regional population and labour force file, is initially set equal to the value assigned to MIGR.

3.1.5.4 Location preference and adjustment parameter

The parameter governing the proportion of the gap between the actual and desired inter-regional migration population that is closed in each period is set at 0.5[71], and is stored as the (non updateable) parameter ADCM in Figure 3.5. Given a value of 0.5 for this parameter, a value for the location preference parameter LOPR was chosen that minimised the sum of the squared deviations of actual yearly Tasmanian net inter-regional migration numbers from those produced by the model over the historical simulation period. This value was found to be 2.75. It is represented in Figure 3.5 as the (non updateable) parameter LOPR.

3.1.5.5 Base year population growth rates

Population growth rates (exclusive of that due to inter-regional migration) were calculated from ABS labour force statistics and ABS migration statistics (ABS 1999c). The growth in the population aged 15 and over in each region was calculated by first adding back the ABS's 1992/93 estimate of net inter-regional migrant numbers to the ABS's estimates of year-end regional populations for 1992/93. Population growth rates were then calculated

[71] This value closes about ninety percent of the gap between actual and desired inter-regional migration numbers after five years.

by dividing these values by the ABS's estimates for regional populations at the commencement of 1992/93. These are stored as the coefficient NATG in Figure 3.5.

3.1.5.6 Base year regional unemployment rates

Base year regional unemployment rates are stored as the coefficient URAT in Figure 3.5. The 1992/93 values for this coefficient were sourced from ABS (1999b).

3.1.5.7 Household accounts data file

The household accounts data file contains information on the starting values of household net foreign asset holdings ($FNAT_r$) and net returns on those assets ($FNIR_r$), the aggregate ownership of working capital by each owner type ($OXX3_k$), other household net income ($OHNI_r$), and the base year value for the nominal exchange rate (PHI). The initial value of net foreign assets ($FNAT_r$) was set at a negligible value (0.10) in each region. The choice of the net interest received on this also determined the initial rate of return on these assets. An initial rate of return of five percent per annum was chosen, hence the starting value for $FNIR_r$ was set at 0.005. Since the initial values for foreign net assets held by both households and the government were set at negligible values, the choice of the value for the initial nominal exchange rate is arbitrary (within obvious limits). Hence the starting value of PHI was simply set equal to 1. The values for $OXX3_k$ were read in directly from their corresponding values in the initial database, and then adjusted as outlined in Section 3.1.3.11. The values for $OHNI_r$ were set such that the values of household gross savings in the base-year database are equal to the values of household savings as given by the ABS (1999i).

3.1.5.8 Government accounts data file

A number of changes and additions had to be made to the government accounts data recorded in the initial database before being input to the FEDERAL-F database. These were made for two reasons. First, the ABS has made some amendments to the government finance data for the 1992/93 financial year since the compilation of the initial database. An effort is made to update these data in those instances. Second, the aggregate revenues and receipts for each government as recorded in the initial database do not coincide exactly with those recorded in ABS government finance statistics. This discrepancy could only be reduced in part by the aforementioned updating of the values of individual revenue and receipt categories. The new government finance theory in FEDERAL-F links the net financing requirement of each government to its level of net assets. For the model to track the actual changes in each government's net asset position it is necessary that the initial database accurately reflect each government's net financing requirement as given by ABS data. Hence, in establishing the FEDERAL-F government accounts data, new categories of other receipts and outlays are introduced to the government accounts. These provide values for aggregate receipts and outlays by each government which accord with ABS data, and thus generate an accurate base-year net financing requirement. Note that all ABS data were sourced from two publications: Government Finance Statistics (ABS 1999k) and Taxation Revenue (ABS 1998a).

In establishing the new government accounts database, only two matrices from the initial database are transferred unchanged: CGO3 (unemployment benefit payments) and SGO3 (regional government transfer payments). The values for Commonwealth outlays on transfers to regional governments (CGO4) and transfers to persons (CGO5) are set equal to the ABS values for the same. In thus setting CGO4, the values in SGR5 were also reset. Commonwealth revenues from other receipts (CGR7) were reset so that the share of the total of CGR7 and Commonwealth receipts from GBE's in total Commonwealth receipts was equal to the same share as evident in the ABS government finance data. A new category of Commonwealth outlays, CGO6, was introduced. The value of these outlays was set such that the net financing requirement of the Commonwealth in the FEDERAL-F database was equal to that in the ABS statistics. The values of regional government receipts from fees and fines (SGR4) and other receipts (SGR8) were set equal to the ABS data on the same. A new category of receipt (SGR9) and a new category of outlay (SGO4) were then introduced to the regional government accounts. The values of these are set so that the total revenues and outlays of each regional government coincide with the ABS data on the same. This also ensures that the ABS values for regional government financing requirements are reflected in the model's base-year data.

Finally, initial base year values for government foreign net asset holdings and net interest payments had to be established. These were set at negligible positive values. Both FDDT and $STDT_r$, recording Commonwealth and regional government net foreign debt respectively, were initially set equal to 0.10. To establish an initial rate of interest of five percent per annum on this debt, foreign net interest payments by each level of government, OSIF and $OSIR_r$, were each set equal to 0.005.

3.1.6 Elasticities and Other Parameters

3.1.6.1 Export elasticities

The export elasticities used in FEDERAL-F are derived from those in the 1997 MONASH model. Individual commodity export elasticities are calculated by assuming that the export elasticity for FEDERAL-F commodity *c*, is an export value weighted sum of the export elasticities of the *k* MONASH commodities of which it is composed. The negative of the reciprocal of these aggregated export elasticities is then calculated, and the results stored as $GAMA_i$ in Figure 3.2. The economy-wide non-traditional export demand elasticity is stored as GAMX in the Figure 3.2. The value of this parameter is set equal to its MONASH-equivalent value of 0.10.

3.1.6.2 Armington elasticities

Armington elasticities are required for three broad types of user: firms, capital creators, and households. The original 1992/93 FEDERAL database set these elasticities equal to two, across all users and commodities. However substitution possibilities should, as a minimum, differ between commodities. For some commodities substitution possibilities will be either non-evident or negligible (for example, household substitution between sources for ownership of dwellings, or many personal services). For industrial users we may wish to limit substitution possibilities between sources for certain commodities which by their nature, cannot be readily traded (for example, concrete, construction, the output of certain utilities). These commodities should have an Armington elasticity close to, or equal to, zero. For other commodities, we will want to reflect the greater substitution possibilities between sources for that commodity through higher Armington elasticities. In a multi-regional model, we may also wish to introduce different Armington elasticities between domestic and foreign sources for the same commodity, in recognition of greater substitution possibilities existing between intra-national sources relative to international sources.

Armington elasticities for intermediate input use for the 37 commodities in the FEDERAL-F database are derived from the MONASH database by assuming that the Armington elasticity for FEDERAL commodity c is the purchaser's value weighted sum of the Armington elasticities of the k MONASH commodities of which it is composed. Armington elasticities for capital creators and households were derived from the MONASH database in the same manner. Since MONASH is a single region model, the Armington elasticities thus derived have neither a regional nor a sourcing dimension. A regional dimension is added to these values by assuming that the Armington elasticity for each commodity for each type of user is the same across regions. These values are then stored in the matrices $SIG1_{i,r}$ - $SIG3_{i,r}$ in Figure 3.2. The option of adding a sourcing dimension to these elasticities is added within the coding of the FEDERAL-F model through the parameter INTA. The Armington elasticities in $SIG1_{i,r}$ - $SIG3_{i,r}$ have been used for the elasticities relating to domestic / foreign substitution possibilities faced by agents in each region. It assumed that inter-regional elasticities for the same commodities are a uniform multiple of the corresponding international elasticity. A similar assumption is used to derive the Armington elasticities in the MMRF model, with this multiple being set at five. Notwithstanding that most implementations of the MMRF model feature around half a dozen commodity types, for such broad commodity types as are identified even in the 37 sector FEDERAL-F model, an elasticity of demand for locally sourced commodities that is five times that of the foreign substitute seems far too high. Hence currently the value this multiple has been set at 1. This parameter is stored under INTA in Figure 3.2. When FEDERAL-F is run, this parameter is read in as data, and the domestic elasticities are then computed from the domestic / international elasticities.

3.1.6.3 Marginal budget shares

The expenditure elasticity for good i in region r, $\varepsilon_{(ir)}$ is:

$$\varepsilon_{(ir)} = \frac{dx_{(ir)}}{dy_r}\frac{y_r}{x_{(ir)}}$$

that is, the marginal budget share for good i divided by the average budget share for good i. When the FEDERAL-F model is run, the expenditure elasticities are calculated from the average budget shares (evaluated from the relevant matrices of the multi-regional input output database) with marginal budget shares read in from $MBUD_{i,r}$ in Figure 3.2. In the initial year, these marginal budget shares are evaluated so as to generate expenditure elasticities that accord with the MONASH elasticities for the corresponding commodities.

The calculation of the marginal budget shares stored in $MBUD_{j,r}$ follows two steps. First, the MONASH expenditure elasticities are converted to the FEDERAL-F commodity classification by assuming that the expenditure elasticity for FEDERAL-F commodity *i* is a budget-share weighted sum of the expenditure elasticities of the *k* MONASH commodities of which it is composed. This generates an expenditure elasticity for each of the 37 FEDERAL-F commodities from the original 115 expenditure elasticities in the MONASH model. These expenditure elasticities satisfy the Engel aggregation property given the MONASH household consumption shares, however they need not satisfy this property given the household consumption shares in each region of the FEDERAL-F database. Hence, the second step is to use these expenditure elasticities, appropriately scaled, to generate a set of region-specific marginal budget shares that sum to one, as follows:

$$m_{i,r} = \frac{\varepsilon_i A_{i,r}}{\sum_t \varepsilon_t A_{t,r}}$$

Where $m_{i,r}$ are the marginal budget shares stored in $MBUD_{i,r}$, ε_i is the expenditure elasticity for FEDERAL-F commodity *i* calculated from the MONASH model, and $A_{i,r}$ is the average budget share for commodity *i* in region *r*, evaluated from the multi-regional input output table.

3.1.6.4 Cross-classified consumption

As discussed in Section 2.5.2, the commodity classification system for household consumption used by the ABS differs from those used within MONASH and FEDERAL-F. To make use of the ABS data on household consumption by (national accounts) commodity, a matrix is required which provides a mapping between the two classifications. In the MONASH model, this is provided by $MM_{x,112}$. This records the purchaser's value of household consumption of MONASH commodity x classified within ABS national accounts category na. A similar mapping matrix was calculated for FEDERAL-F by first aggregating (in the dimension x) the MONASH coefficient $MM_{x,na}$ to the FEDERAL-F commodity classification system, as follows:

$$AGGM_{i,na} = \sum_{x \in AGGNOC_i} MM_{x,na} \qquad i = 1,\ldots,37 \qquad na = 1,\ldots,38$$

And then providing a regional dimension to $AGGM_{i,na}$ as follows:

$$FMM_{i,na,r} = \frac{AGGM_{i,na}}{\sum_j AGGM_{i,j}} \times PV3_{i,r} \qquad i = 1,\ldots,37 \quad na = 1,\ldots,38 \quad r = 1,2$$

Where $PV3_{i,r}$ is the purchaser's value of commodity i consumed by household r. The values for $FMM_{i,na,r}$ are then stored as FMM in the data file represented by Figure 3.2.

4 ILLUSTRATIVE APPLICATION I: HISTORICAL AND DECOMPOSITION SIMULATIONS

4.1 OVERVIEW

The simulations reported in this chapter have two purposes, and two sets of simulations are required to achieve these purposes. The first purpose is to uncover the values of the changes in the model's structural variables (such as factor and material input productivities, taste changes, positions of export demand schedules, and such like) and policy variables (such as various income, commodity, and production tax rates, rates of personal benefit payment, real regional and Commonwealth outlays on current consumption expenditure, and the like), which together account for the observed regional and national economic outcomes over the six year period 1992/93 to 1998/99. The values of many of these structural and policy variables are largely unobservable without the aid of some analytical framework, which in this case is provided by FEDERAL-F. To uncover these values, the model is shocked with the observed values for certain macroeconomic, commodity, industry, and government variables relating to both the national and regional economies over the period 1992/93 to 1998/99. Following the parlance established by the developers of the MONASH model, this will be referred to as the "historical simulation" hereafter. The second purpose of the simulations is to determine the contribution that each of the structural and policy shifts made to the observed regional economic outcomes over the period 1992/93 to 1998/99. This requires that a second simulation be undertaken in which the structural and policy variables are shocked equal to the values that they were calculated to have attained under the historical simulation. Again, following the parlance established by the developers of the MONASH model, this will be referred to as the "decomposition simulation" hereafter. In undertaking both the historical and decomposition simulations, the model is solved one period at a time, commencing with an initial database for the year 1992/93, and terminating with the creation of a database for 1998/99. These ideas are elaborated upon further below.

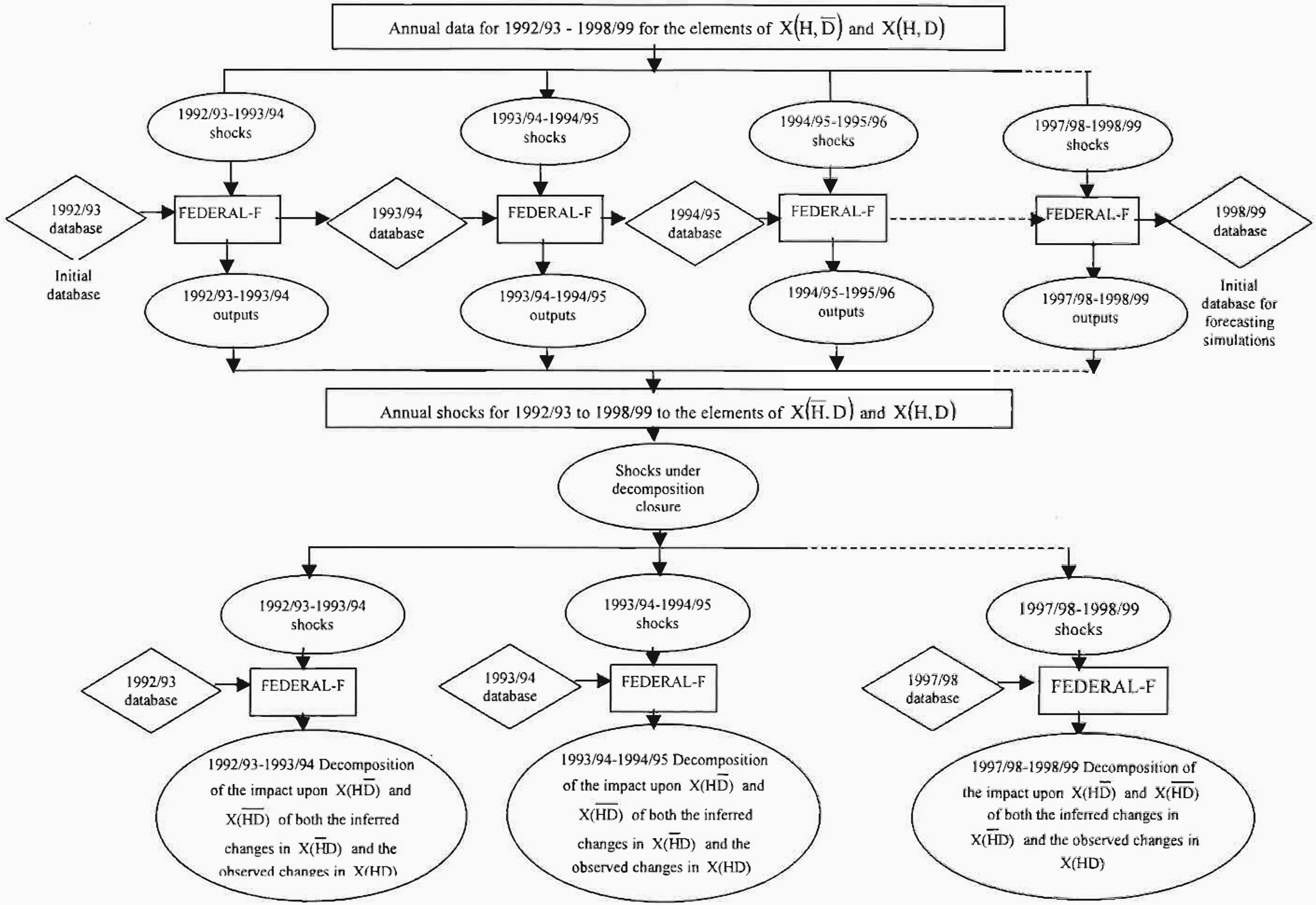
Dixon et al. (2000) note that, on the basis of the two closures, it is possible to partition the variables of the model into four sets:

$$X(HD),\ X(\overline{H}D),\ X(H\overline{D}),\ X(\overline{HD})$$

Where H and $\overline{H}$ denote respectively exogenous and endogenous under the historical closure, and D and $\overline{D}$ denote respectively exogenous and endogenous under the decomposition closure. Hence, X(HD) represents those variables that are exogenous under both the historical and decomposition closures. In FEDERAL-F these include foreign currency import prices, homotopy variables, and real government consumption. $X(\overline{HD})$ is comprised of those variables that are endogenous under both historical and decomposition closures. Many variables are in this category, and examples include regional industry demands for source specific commodities, and the nominal values of national and regional macroeconomic variables. For these variables, either observable values from official statistics were not available (preventing their inclusion in $X(H\overline{D})$), or their values are already effectively determined by the variables in $X(H\overline{D})$ and X(HD). $X(H\overline{D})$ is composed of those variables that are exogenous under the historical closure, but endogenous under the decomposition closure. Variables in this category include certain national and regional macroeconomic variables, and sectoral investments, employments, and outputs at the national and regional levels. $X(\overline{H}D)$ is comprised of those variables that are endogenous under the historical closure, but exogenous under the decomposition closure. $X(\overline{H}D)$ has the same number of variables as $X(H\overline{D})$, and a readily apparent economic relationship exists between the individual elements of each. These relationships are exploited to allow the elements of $X(H\overline{D})$ to be determined exogenously under the historical closure, and endogenously under the decomposition closure. Examples of variables in $X(\overline{H}D)$ include regional average propensities to consume, the positions of foreign export demand schedules, and variables measuring household preferences. The relationship between $X(\overline{H}D)$ and $X(H\overline{D})$ will be made more clear in the discussion of the elements of each in Section 4.2.

Figure 4.1 provides a diagrammatic representation of the steps involved in the historical and decomposition simulations. First, the elements of $X(H\overline{D})$ (and hence $X(\overline{H}D)$) are

Figure 4.1: Steps in undertaking the historical and decomposition simulations



chosen on the basis of the availability of data for the period 1992/93 to 1998/99. Annual shocks to the relevant elements of $X(H\bar{D})$ and $X(HD)$ are then calculated from available statistics[72]. These shocks are administered to the model on a year-by-year basis. The initial database relates to 1992/93. Hence the first set of shocks to $X(H\bar{D})$ and $X(HD)$ consist of the percentage rates of change in these variables (and unitary shocks to homotopy variables) over the period 1992/93 to 1993/94. The 1992/93 database is updated on the basis of the results from these shocks, generating a database relating to the 1993/94 year. This database then forms the starting point for the shocks to $X(H\bar{D})$ and $X(HD)$ relating to the changes in the economy between the 1993/94 and 1994/95 financial years, and so on.

An output of each year's simulation are values for the elements of $X(\bar{H}D)$. Combined with the shocks to $X(HD)$ that were administered under the historical closure, these comprise the annual shocks to the model under the decomposition closure. The decomposition shocks are also administered on a year-by-year basis, generating values for $X(H\bar{D})$ and $X(\overline{HD})$ for each of the years between 1993/94 and 1998/99 inclusive. A key feature of the shocks to $X(\bar{H}D)$ and $X(HD)$ is that they reproduce exactly the values that $X(H\bar{D})$ and $X(\overline{HD})$ possessed under the historical closure. Furthermore, the total impact on any element of $X(H\bar{D})$ and $X(\overline{HD})$ can be decomposed into the individual contributions of each of the individual shocks to the elements of $X(\bar{H}D)$ and $X(HD)$. These two features will be exploited in Section 4.5, where an explanation is sought for the divergent growth experiences of the Tasmanian and Mainland economies over the period 1992/93 - 1998/99.

4.2 DESCRIPTION OF THE HISTORICAL AND DECOMPOSITION CLOSURES

A complete description of the historical closure (as it differs from the standard short run closure presented in Appendix B) is provided in this section. This section presents an overview of the steps required to derive the historical closure from the standard short run

72 The exception is the homotopy variables, which are also part of $X(HD)$, but are only ever shocked equal to 1.

closure. Except as part of providing this overview, this section does not describe how the underlying equations of the model function under the historical closure. Furthermore, except where it is clearly necessary to describe the historical closure, a complete discussion of which elements of certain variables (particularly those with industry and commodity sub-scripts) are endogenously or exogenously determined is avoided in this section. Detailed discussions of how the equations operate under the historical closure can be found in those parts of Chapter 2 that describe the theoretical structure of the model. The availability of historical data is the chief factor determining the choice of which elements of multi-dimensional variables are determined endogenously and which elements are determined exogenously under the historical closure. Hence the discussion of this is deferred to Section 4.4 below.

4.2.1 The historical closure

Table 4.1 summarises those variables, the changes in the endogenous / exogenous status of which, distinguish the historical and decomposition closures. That is, it describes the elements of $X(H,\overline{D})$ and $X(\overline{H},D)$. For expository purposes it is useful to view the historical closure as being developed in two steps. The starting point is the standard comparative static short-run closure (Column 1). A number of swaps in the endogenous / exogenous status of certain variables are then undertake to produce a closure characteristic of the MONASH model structural macroeconomic closure (Column 2). The final set of swaps provides the historical closure (Column 3-4).

The short run comparative static closure (Column 1) is characterised by an exogenous pre-tax real wage (*fpre*), and endogenous economy-wide labour supply (*l_emp*). Regional industry capital stocks (*cap_at_t*) are exogenous, and rates of return on capital (*crates*) are endogenous. Real household consumption (*cR*) is endogenous, and linked to real household disposable income. Both the economy-wide average propensity to consume (*f_eq19*), and the average propensities to consume of the individual regional households (*f_apc*) are exogenous. The ratio (*finv_com*) of real economy-wide private investment (*i_real*) to real economy-wide private consumption (*cR*) is exogenous, thus establishing an indexing relationship between *i_real* and *cR*. The economy-wide expected rate of return

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure

Row	Variable description	Variable name	Short run comparative static (1)	Stylised MONASH closure (2)	Historical Closure: Macro (3)	Historical Closure: Remainder (4)	Structural Closure (5)
1	Real national consumption - budget constraint side	*cR*	N	N	X	X	N
2	Real national investment - commodity accounts side	*x2nat*	N	N	X	X	N
3	Real national exports	*x4nat*	N	N	X	X	N
4	Real national imports	*xMnat*	N	N	X	X	N
5	Economy-wide real government outlays	*f_govcon_gen*	X	N	X	X	X
6	Real regional consumption - selected elements	$x3reg_1$	N	N	N	X	N
7	Real regional exports - selected elements	$x4reg_1$	N	N	N	X	N
8	Real gross regional product - selected elements	r_grpe_1	N	N	N	X	N
9	Change in the Australian dollar BOT / nominal GDP ratio	*del_bt_gdp*	N	X	N	N	N
10	Shift on year-to-year capital accumulation equation	*del_f_ac_p_y*	N	X	X	X	X
11	Capital stocks at commencement of year	*cap_at_t*	X	N	N	N	N
12	Positions of regional industry capital supply functions	*d_f_eeqror_jr*	N	X	X	N	X
13	Shift on comp. stat. relationship between ROR and K growth	*f_Eqn54*	X	N	N	N	N
14	Economy-wide expected ROR (comp. stat. Definition)	*omega*	N	X	X	X	X
15	Economy-wide shift on regional industry K supply functions	*d_f_eeqror*	X	N	N	X	X
16	Shift on Equation *E_xr_expn1*: individual treatment of NTRAD exports	*f_eq24N_ir*	X	N	N	N	N
17	Shift on Equation *E_xr_expn2*: block treatment of NTRAD exports	*f_ntrad*	N	X	X	X	X
18	Economy-wide APC	*f_eq19*	X	N	N	X	X
19	Regional APC	*f_apc*	X	X	X	N	X
20	Ratio of real consumption to real GNE	*r_cr_rgne*	N	X	N	N	N
21	Nominal exchange rate	*x_rate*	X	N	X	X	N
22	Economy wide household consumption price index	*p3nat*	N	X	X	X	X
23	Ratio of real private investment to real consumption	*finv_com*	X	N	N	N	N
24	Ratio of real economy-wide investment to real GNE	*r_ir_rgne*	N	X	N	N	N

Note: "X" denotes exogenous and "N" denotes endogenous.

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure (continued)

Row	Variable description	Variable name	Short run comparative static	Stylised MONASH closure	Historical Closure		Structural Closure
					Macro	Remainder	
			(1)	(2)	(3)	(4)	(5)
25	Shift on national / foreign sourcing twists	*twist_src_bar*	X	X	N	N	X
26	Ratio of real consumption to real GNE	*r_cr_rgne*	N	X	N	N	N
27	General export demand shift variable	*feq_general*	X	X	N	X	X
28	Region-specific export demand shift variables	*ffeq_generalr*	X	X	X	N	X
29	Economy-wide shift variable on primary factor productivity	*f_a_fac*	X	X	N	X	X
30	General shifter on export prices (other than TRAD exports)	*fpentrad*	X	X	N	N	X
31	Terms of trade	*toft*	N	N	X	X	N
32	Shift on Equation *E_p_rexp_exog*	*p_rexp_exog*	N	N	X	X	N
33	Non-spreading phantom tax rate - selected elements	$tax\_nsph_{NTRAD,REG}$	X	X	N	N	N
34	Shift on Equation *E_p_rexp_imp*	*p_rexp_imp*	N	N	X	X	N
35	Non-spreading phantom tax rate - selected elements	$tax\_nsph_{EXOG,REG}$	X	X	N	N	N
37	Economy-wide employment	*l_emp*	N	N	X	N	N
38	Economy-wide cost-neutral shift in labour / capital ratio	*f_twistlk*	X	X	N	N	X
40	Regional household APC's	*f_apc*	X	X	X	N	X
43	Exports of commodity *i* from region *r* - selected elements	$xr\_exp_{TRAD,REG}$	N	N	N	X	N
44	Shift on position of demand schedules of traditional exports	*f_eq24T_ir*	X	X	X	N	X
45	Change in the net inter-regional migrant population	*ch_migrants*	N	N	N	X	N
46	Shift on Equation *E_chmigrant*	*f_chmigrants*	X	X	X	N	X
47	Budget share weighted sum of taste changes	*ave_a3*	N	N	N	X	N
48	Exogenous regional household consumption categories	*x3ncom*	N	N	N	X	N
49	Taste change shifts on regional household consumption cats.	*a3ncom*	X	X	X	N	X
50	Shifter on national accounts consumption commodities	*f_x3r*	X	X	X	N	X
51	Household taste change shift variables	*f_a3_kr*	X	X	X	N	X
52	Shift variable on Equation *E_x3_ff_na*	*a3shift*	N	N	N	X	N
53	Australia-wide industry-specific capital supply shift variables	*d_f_eeqror_j*	X	X	X	N	X

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure (continued)

Row	Variable description	Variable name	Short run comparative static (1)	Stylised MONASH closure (2)	Historical Closure: Macro (3)	Historical Closure: Remainder (4)	Structural Closure (5)
54	Shift variable on Equation *E_fy_nat* (Option 1)	*fy_nat*	N	N	N	X	N
	Or:						
55	Shift on Equation *E_fd_f_eeqror_j* (Option 2)	*fd_f_eeqror_j*	N	N	N	X	N
56	Real investment by national investment sector	*y_s*	N	N	N	X	N
57	Shift variable on Equation *E_fy_nat*	*fy_s*	X	X	X	N	X
58	Economy-wide shift on exogenous investment sectors	*yshift*	X	X	X	N	X
59	Real Tasmanian private investment expenditure	*i_rr*$_1$	N	N	N	X	N
60	Tasmania-specific shift on industry capital supply functions	*d_f_eeqror_r*$_1$	X	X	X	N	X
61	Regional investment sectors - selected elements	*y_sr*	N	N	N	X	N
62	Shift variable on Equation *E_fy_p56*	*fy_sr*	X	X	X	N	X
63	Regional industry shifts in capital supply functions - selected elements	*d_f_eeqror_jr*	X	X	X	N	X
64	Shift on Equation *E_fy_p56* - selected elements (Option 1)	*fy_p56*	N	N	N	X	N
	Or:						
65	Shift on Equation *E_fd_f_eeqror_jr* - selected elements (Option 2)	*fd_f_eeqror_jr*	N	N	N	X	N
66	Shift variable on Equation *E_tfd_f_eeqror_jr* (Option 2)	*tfd_f_eeqror_jr*	N	N	N	X	N
	Or:						
67	Shift variable on Equation *E_fyt_p56* (Option 1)		N	N	N	X	N
68	Tasmanian sectoral investments		N	N	N	X	N
69	Shift variable on Equation *E_fempjr* (Option 1)	*femp_s*	X	X	X	N	X
	Or:						
70	Shift on Equation *E_ffafac* (Option 2)	*shift_afac*	X	X	X	N	X
71	Employment by regional employment sector	*emp_s*	N	N	N	X	N
72	Shift variable on regional industry primary factor technical change	*f_a_facjr*	X	X	X	N	X

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure (continued)

Row	Variable description	Variable name	Short run comparative static	Stylised MONASH closure	Historical Closure		Structural Closure
					Macro	Remainder	
			(1)	(2)	(3)	(4)	(5)
73	Shift variable on Equation *E_fempjr* (Option 1) *Or:*	*fempjr*	N	N	N	X	N
74	Shift on Equation *E_ffafac* (Option 2)	*ffafac*	N	N	N	X	N
75	Regional employment	*lr_emp*	N	N	N	X	N
76	Shift on regional sectoral employments	*f_lr_emp*	X	X	X	N	X
77	Real output for national output sectors - selected elements	*x_s*	N	N	N	X	N
78	Shifter on Equation *E_fx_total* - selected elements (Option 1) *Or:*	*fx_s*	X	X	X	N	X
79	Shift on Equation *E_fai* (Option 2)	*shift_ai*	X	X	X	N	X
80	Commodity *i* using technical change - selected elements	*ai*	X	X	X	N	X
81	Shifter on Equation *E_fx_total* - selected elements (Option 1) *Or*	*fx_total*	N	N	N	X	N
82	Shift on Equation *E_fai* (Option 2)	*fai*	N	N	N	X	N
83	All input using technical change - current production	*a_in1*	X	X	X	N	X
84	Shift variable on Equation *E_del_f_a1*	*del_f_a1*	N	N	N	X	N
85	All input using technical change - capital creation	*a_in2*	X	X	X	N	X
86	Shift variable on Equation *E_del_f_a2*	*del_f_a2*	N	N	N	X	N
87	Output sectors by region	*x_sr*	N	N	N	X	N
88	Shifter on Equation *E_fx_tot* - selected elements (Option 1) *Or:*	*fx_sr*	X	X	X	N	X
89	Shift on Equation *E_fi_twist_isbot* (Option 2)	*twist_is_s*	X	X	X	N	X
90	Commodity and source-specific technical change - selected elements	*ais*	X	X	X	N	X
91	Shifter on Equation *E_fx_tot* - selected elements (Option 1) *Or:*	*fx_tot*	N	N	N	X	N
92	Shift on Equation *E_fi_twist_isbot* - selected elements (Option 2)	*fi_twist_isbot*	N	N	N	X	N

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure (continued)

Row	Variable description	Variable name	Short run comparative static (1)	Stylised MONASH closure (2)	Historical Closure: Macro (3)	Historical Closure: Remainder (4)	Structural Closure (5)
93	Inter-regional sourcing twist shifter	*twist_isbot*	X	X	X	N	X
94	Shift on exogenous output sectors - selected elements	$fxsr_1$	X	X	X	N	X
95	Commonwealth PAYE receipts	*b41*	N	N	N	X	N
96	Shift on average rate of PAYE tax	*fswitch_paye*	X	X	X	N	X
97	Other Commonwealth income tax receipts	*b42*	N	N	N	X	N
98	Shift on per-unit taxes on capital and land	*f_o_it*	X	X	X	N	X
99	Commonwealth import duty receipts	*b43*	N	N	N	X	N
100	General shift variable on tariff rates	*f_t3*	X	X	X	N	X
101	Commonwealth production tax revenues	*b44*	N	N	N	X	N
102	General shift variable on industry production tax rates	*ffprod*	X	X	X	N	X
103	Commonwealth commodity tax revenues	*b45*	N	N	N	X	N
104	General shift variable on Commonwealth commodity tax rates	*com_tax*	X	X	X	N	X
105	Commonwealth export tax revenues	*b46*	N	N	N	X	N
106	General shift on export tax rate	*ft4*	X	X	X	N	X
107	Commonwealth other receipts	*b47*	N	N	N	X	N
108	Real value of other Commonwealth receipts	*fswitch_f47*	X	X	X	N	X
109	Commonwealth Government outlays on unemployment benefits	*u_benefit*	N	N	N	X	N
110	Real value of per-person unemployment benefits	*fun_b*	X	X	X	N	X
111	Other Commonwealth transfers to persons	*transfers*	N	N	N	X	N
112	Economy-wide shift on the real value of Commonwealth other transfers	*f65*	X	X	X	N	X
113	Regional government payroll tax receipts	*sgptr*	N	N	N	X	N
114	Change in the average rate of regional payroll tax	*frollr*	X	X	X	N	X
115	Regional government residential land tax receipts	*rltax*	N	N	N	X	N
116	Shift variable on the average rate of residential land tax	*fres_tax*	X	X	X	N	X
117	Regional government commercial land tax receipts	*cltax*	N	N	N	X	N

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure (continued)

Row	Variable description	Variable name	Short run comparative static	Stylised MONASH closure	Historical Closure		Structural Closure
					Macro	Remainder	
			(1)	(2)	(3)	(4)	(5)
118	Shift variable on the average rate of commercial land tax	*fcom_taxr*	X	X	X	N	X
119	Regional government receipts of income reducing taxes	*b34r*	N	N	N	X	N
120	Shift variable on the average rate of regional income reducing taxes	*f_ytax*	X	X	X	N	X
121	Regional government receipts of Commonwealth transfers	*b35r*	N	N	N	X	N
122	Shift on the real value of Commonwealth inter-government transfers	*f64r*	X	X	X	N	X
123	Regional government commodity tax receipts	*b36r*	N	N	N	X	N
124	Shift variable (uniform across user types) on regional commodity taxes	*salestax*	X	X	X	N	X
125	Regional government production tax receipts	*b37r*	N	N	N	X	N
	Or:						
126	Regional government production tax receipts from non-utilities industries	*prod_n_util*	N	N	N	X	N
127	Shift variable on the rate of regional government production tax	*fprodr*	X	X	X	N	X
128	Regional government other receipts	*b38r*	N	N	N	X	N
129	Real value of regional government other receipts	*f_getr*	X	X	X	N	X
130	Regional government transfers to persons	*t51*	N	N	N	X	N
131	Real value of regional government transfers to persons	*f_transr*	X	X	X	N	X
132	Foreign currency export prices for traditional export commodities	$p\_rexp_{TRAD,REG}$	N	N	N	X	N
133	Non-spreading phantom taxes on traditional export commodities	$tax\_nsph_{TRAD,REG}$	X	X	X	N	N
134	Change in the Commonwealth net financing requirement	*cb2*	N	N	N	X	N
135	Ratio of other Commonwealth outlays to nominal GDP	*t64*	X	X	X	N	X
136	Change in regional government net financing requirements	*cb1r*	N	N	N	X	N
137	Shift common to residual regional government outlays and receipts	*fni_shift*	X	X	X	N	X

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure (continued)

Row	Variable description	Variable name	Short run comparative static (1)	Stylised MONASH closure (2)	Historical Closure Macro (3)	Historical Closure Remainder (4)	Structural Closure (5)
138	Regional household savings	*n_sav*	N	N	N	X	N
139	Foreign currency value of household net foreign income	*ex_hhnfi*	X	X	X	N	X
140	Share of sales tax in economy-wide investment	*sh_stax2*	N	N	N	X	N
141	Purpose-specific shift in Commonwealth sales taxes - selected elements	*fk_tc0_ind*	X	X	X	N	X
142	Share of *q*'s ownership of capital in regional industry *j,r*.	$sk\_owners_{q,j,r}$	X	X	X	N	N
143	Shift on Equation *E_fsk_owners*.	$fsk\_owners_{q,j,r}$	N	N	N	X	X
144	Price to consumers in region *r* for national accounts commodity *na*	$p3ncom_{na,r}$	N	N	N	X	N
145	Shift variable on *Equation E_p3_ff_na*.	$fp3ncom_{na,r}$	X	X	X	N	X
146	Shift variable on Equation *E_p3_ff_na*.	$p3shift_{i,r}$	N	N	N	X	N
147	Shift variable on Equation *E_ffp3r*.	$fp3r_{i,r}$	X	X	X	N	X
148	Household phantom tax shift variable.	$fphtax3_{i,r,r}$	X	X	X	N	N
149	Shift variable on Equation *E_ffp3r*.	$ffp3r_{i,r,r}$	N	N	N	X	N
150	Economy-wide collection of phantom taxes on household purchases	*phant3nat*	N	N	N	X	N
151	Shift variable on Equation *E_p3ncom*.	*f_p3gen*	X	X	X	N	X
152	Consumer price index of region of focus	$p3reg_{1}$	N	N	N	X	N
153	Shift variable on Equation *E_p3ncom*.	f_p3r_{1}	X	X	X	N	X
154	Regional gross fixed capital formation deflator	$p2reg_r$	N	N	N	X	N
155	Capital creation phantom tax shift variable.	$fphtax2_r$	X	X	X	N	X
156	Regional government consumption expenditure deflator	$p5reg_r$	N	N	N	X	N
157	Regional government phantom tax shift variable	$fphtax5_r$	X	X	X	N	X
158	Commonwealth Government consumption expenditure deflator.	$p6reg_r$	N	N	N	X	N
159	Commonwealth Government phantom tax shift variable.	$fphtax6_r$	X	X	X	N	X
160	Foreign currency national import price index	*pMnat_fc*	N	N	N	X	N

Table 4.1: Derivation of the historical and decomposition closures from the short-run comparative static closure (continued)

Row	Variable description	Variable name	Short run comparative static	Stylised MONASH closure	Historical Closure		Structural Closure
					Macro	Remainder	
			(1)	(2)	(3)	(4)	(5)
161	Uniform shift on foreign currency commodity import prices	*f_pmp*	X	X	X	N	X
162	Real regional consumer pre-tax wage	*prewage_rr*	N	N	N	X	N
163	Shift variable on regional pre-tax wage	*fprer*	X	X	X	N	X
164	Power of phantom tax on investment inputs	*powtax2ph*	N	N	N	N	X
165	Power of phantom tax on household purchases	*powtax3ph*	N	N	N	N	X
166	Power of phantom tax on exports	*powtax4ph*	N	N	N	N	X
167	Power of phantom tax on regional govt. purchases	*powtax5ph*	N	N	N	N	X
168	Power of phantom tax on Commonwealth purchases	*powtax6ph*	N	N	N	N	X
169	Shift on investment phantom taxes	*fphtax2isr*	X	X	X	X	N
170	Shift on regional government phantom taxes	*fphtax5isr*	X	X	X	X	N
171	Shift on Commonwealth phantom taxes	*fphtax6is*	X	X	X	X	N
172	Shift on Equation *E_fp_utility* (CPI-X formula)	$fp\_utility_{UTILITY,r}$	N	N	N	X	N
173	Production tax rates on utility industries	$fprodrj_{UTILITY,r}$	X	X	X	N	X

on capital (*omega*) is endogenous, thus rationing the national investment budget among regional industry investment demands. Real government consumption expenditure for all levels of government (*f_govcon_gen*) is exogenous. The nominal exchange rate (*x_rate*) is the numeraire.

In moving to a stylised version of the MONASH model macroeconomic structural closure (Column 2), the first step is to determine exogenously the ratio (*r_ir_rgne*) of real economy-wide investment (*x2nat*) to real gross national expenditure (*real_gne*). In so doing, the ratio of real private investment to real consumption expenditure (*finv_com*) is now determined endogenously. The relationship between real economy-wide consumption and the FEDERAL-F definition of real household disposable income is then broken by setting endogenous the economy-wide average propensity to consume (*f_eq19*), and setting exogenous the ratio of real consumption to real gross national expenditure (*r_cr_rgne*). Next, the MONASH treatment of non-traditional export volumes is instituted by setting endogenous the positions of the individual commodity and region specific FEDERAL-F non-traditional export demand schedules (*f_eq24N_ir*), and setting exogenous the corresponding shift variables (*f_ntrad*) on Equation *E_xr_expN2*. Equation *E_xr_expN2* then allows the volume of exports of individual non-traditional export commodities from each region to respond as a block in response to movements in region-specific non-traditional export price indices. The numeraire is switched from the nominal exchange rate to the economy-wide household consumption price index (*p3nat*). Finally, the change in the ratio of the balance of trade to GDP (*del_bt_gdp*) is determined exogenously, and aggregate demand is reconciled with aggregate supply via the endogenous determination of real government-wide consumption expenditure (*f_govcon_gen*).

Three further swaps are dealt with in Column (2). These "switch off" the comparative-static rate of return theory and "switch-on" the year-on-year capital accumulation and rate of return theory. First, the year-on-year capital accumulation equation *E_del_f_ac_p_y* is brought into operation by setting exogenous the shift variable on that equation (*del_f_ac_p_y*), and then allowing that equation to determine regional industry capital stocks by setting endogenous *cap_at_t*. Next the FEDERAL relationship between rates of return and capital growth (Equation *E_cap_at_tplus1*) is rendered inoperative by determining endogenously the shift variable on that equation (*f_eqn54*). In their stead are placed the MONASH inverse-logistic regional-industry specific capital supply functions, given by Equation *E_d_f_eeqror_jr*. This requires that the shift variables on this equation (*d_f_eeqror_jr*) be determined exogenously. The general shift variable on the positions of these functions (*d_f_eeqror*) is then determined endogenously to ration economy-wide investment. With Equation *E_cap_at_tplus1* now inoperative, this function is no longer served by *omega*, which must now be determined exogenously.

The historical closure is described by Columns (3) - (4). For expository purposes, it is convenient to describe the historical closure as being developed from the stylised MONASH macro closure in two steps. First, the major variables describing the national macroeconomy are determined exogenously (Column (3)). Then, a second set of swaps - relating to regional macro variables, industry and commodity variables, and the government accounts - establishes the final historical closure (Column (4)).

Column (3) sets out the swaps between the exogenous / endogenous status of certain variables that are required to determine exogenously the main variables describing the national macroeconomy. Real national consumption spending (*cR*) is set exogenous, and the ratio of national consumption to national GNE (*r_cr_rgne*) is determined endogenously. Under this closure the economy-wide APC adjusts to reconcile the exogenously determined national consumption with economy-wide household disposable income. Economy-wide real investment (*x2nat*) is determined exogenously, requiring that the indexing relationship with real GNE (*r_ir_rgne*) be determined endogenously. Real national export volumes are determined exogenously, and the general shift variable on the position of each regional-commodity export demand schedule (*feq_general*) is determined endogenously. The national volume of imports (*xMnat*) is determined exogenously, and the general shift variable on the ratio of imports to domestically consumed goods by non-government purchasers (*twist_src_bar*) is determined endogenously. Real government expenditure (*f_govcon_gen*) is determined exogenously. With all the major elements of real aggregate demand determined exogenously, aggregate supply is determined endogenously by setting endogenous the general shift variable on economy-wide primary factor productivity (*f_a_fac*).

The terms of trade is transferred to the set of exogenous variables in two steps. First, the shift variables *p_rexp_exog* and *p_rexp_imp* are switched to exogenous, and the corresponding elements (i.e. the elements of the sets NTRAD and EXOG in each region) of the non-spreading phantom tax rates (*tax_nsph*) are determined endogenously. This brings equations *E_p_rexp_exog* and *E_p_rexp_imp* into operation. The general shifter on these two equations (*fpentrad*) is then switched to being determined endogenously, and the terms of trade (*toft*) is determined exogenously.

Economy-wide employment (*l_emp*) is switched to the set of exogenous variables. The real pre-tax wage (*fpre*) is already exogenous. The exogenous status of these two variable is reconciled via the endogenous determination of a uniform cost-neutral change in the ratio of labour and capital usage across all regional industries (*f_twistlk*).

Finally, the nominal exchange rate (*x_rate*) is set exogenous. With aggregate import quantities and export quantities determined exogenously, and foreign currency import prices and export prices (via the terms of trade) also determined exogenously, this effectively determines the nominal Australian dollar value of net exports. Hence the ratio of the Australian dollar balance of trade to nominal GDP (*del_bt_gdp*) must now be determined endogenously.

Column (4) summarises the remaining swaps, relating to regional macro variables, industry and commodity level variables, and the government accounts, required to complete the historical closure. Real foreign exports for one region ($x4reg_1$) are determined exogenously, and the region-specific general shift variable on non-traditional and exogenous export volumes ($ffeq\_generalr_1$) is determined endogenously. The economy-wide general shift variable (*feq_general*) is returned to the set of exogenous variables, and the adjustments in the positions of export demand schedules required to meet the exogenously determined economy-wide export volume is now achieved by movements in $ffeq\_generalr_2$.

The number of households migrating between the two regions is known for each period of the historical simulation. Hence Equation *E_ch_migrants* is over-ridden by determining *ch_migrants* exogenously, and determining the shift variable on *E_ch_migrants* endogenously.

Regional household commodity demands are set exogenously in a number of steps. First, since regional household commodity demands are to be determined exogenously, this will effectively determine real household consumption expenditure. Hence *ave_a3* can no longer operate to ensure that household preference changes are budget neutral, and instead regional household budget constraints must be determined endogenously via the endogenous determination of *f_apc*. Hence *ave_a3* is determined exogenously, and *f_apc* is determined endogenously. Next, the regional household consumption categories (*x3ncom*) are determined exogenously, and the taste change shift variable on these categories (*a3ncom*) are determined endogenously. The link between the exogenous determination of the household consumption categories and the FEDERAL-F consumption theory is then established by setting the shift variable *a3shift* exogenous and setting endogenous the household taste change shift variables (*f_a3_kr*). Household real consumption expenditure in one region ($x3reg_1$) is then determined exogenously by setting endogenous the shift variable (f_x3r_1) on the exogenous household consumption categories. Finally, the corresponding shift variable for region 2 (f_x3r_2) is also determined endogenously, and the economy-wide average propensity to consume (*f_eq19*) is determined exogenously.

Real investment at the regional and industry levels are set exogenously in a number of steps. First, real investment by national investment sector (*y_s*) is determined exogenously and the shift variable on Equation *E_fy_nat* (*fy_s*) is determined endogenously. Next, the link must be established between the exogenous determination of investment by investment sector, and the FEDERAL-F theory determining investment by industry. This requires that the industry-specific capital supply schedule shift variables (*d_f_eeqror_j*) be determined endogenously, and that either Equation *E_fy_nat* (Option 1) be brought into operation by determining *fy_nat* exogenously, or that Equation *E_fd_f_eeqror_j* (Option 2) be brought into operation by determining $fd\_f\_eeqror\_j_j$ exogenously. The exogenous determination of investment by national investment sector effectively determines real national investment. However real national investment (*x2nat*) is also determined exogenously. This is desirable because of the possibility of small differences between official statistics and the FEDERAL-F database in the shares of investment by sector in total investment. Any incompatibility is avoided by setting endogenous the common shift variable (*yshift*) on sectoral investments. The corresponding exogenous variable is *d_f_eeqror*: with the positions of every national industry capital supply schedule now endogenous, this variable must now be exogenous.

Next, investment for selected investment sectors for one region can be set exogenously. Generally, this can be done by determining exogenously the relevant elements of *y_sr*, and determining endogenously the corresponding elements of the shift variable *fy_sr*. The link with the FEDERAL-F investment theory is then established by first setting endogenous the positions of the relevant regional industry capital supply schedules (*d_f_eeqror_jr*), and either setting exogenous the shift variable *fy_p56* (Option 1) or the shift variable *fd_f_eeqror_jr* (Option 2). However, as foreshadowed in Chapter 2, this general approach has not been followed in the simulations reported in Section 4.5. The sectors for which Tasmanian investment data were available differed from the sectoral definitions for which national investment data were available. To allow the Tasmanian data to be used, Equations *E_tfd_f_eeqror_jr* and *E_fyt_p56* are used as an alternative to the general approach outlined above. Selected Tasmanian sectoral investments (*y_tr*) are first determined exogenously by setting endogenous the corresponding elements of the shift variable *fy_tr*. The link between the exogenous determination of Tasmanian sectoral investments and the FEDERAL-F investment theory is then established by setting endogenous the appropriate Tasmanian elements of *d_f_eeqror_jr* and then either setting exogenous the corresponding elements of *fyt_p56* (Option 1) or *tfd_f_eeqror_jr* (Option 2). Finally, Tasmanian real private investment expenditure (*i_rr*) is determined exogenously, and the Tasmania-wide shift variable on the positions of Tasmanian industry capital supply schedules ($d\_f\_eeqror\_r_l$) is determined endogenously. Since real investment for only a selection of Tasmanian investment sectors is determined exogenously, there is no incompatibility to be resolved between the exogenous determination of both Tasmanian sectoral investments and aggregate Tasmanian investment.

Employment by employment sector in each region (*emp_s*) is determined exogenously under the historical closure, and the corresponding sectoral shifters on either Equation *E_fempjr*, *femp_s*, (to implement Option 1) or Equation *E_ffafac*, *shift_afac*, (to implement Option 2) are determined endogenously. Either Equation *E_fempjr* (Option 1) or *E_ffafac* (Option 2) must then be brought into operation by setting exogenous either *fempjr* or *ffafac* respectively. Under either option, the regional industry primary factor productivity shift variables (*f_a_facjr*) must be endogenous. With regional sectoral employments exogenous, this effectively determines both regional and national employment. Hence national employment (*l_emp*) must be returned to the set of endogenous variables, and the economy-wide primary factor productivity shift variable (*f_a_fac*) must be returned to the set of exogenous variables. Nevertheless, small differences in employment shares between the model and official statistics may lead the model results for regional employments to depart from those as given by official statistics. To overcome this, the common shift variable on regional sectoral employments (*f_lr_emp*) is set endogenous, and regional employments (*lr_emp*) are determined exogenously.

Output by commodity sector at the national level (*x_s*) is determined exogenously under the historical closure, and either the shift variable *fx_s* in Equation *E_fx_total* (Option 1) or the shift variable *shift_ai* in Equation *E_fai* (Option 2), is determined endogenously. If Option 1 is implemented then Equation *E_fx_total* is brought into operation by setting the shift variable *fx_total* exogenously, and determining commodity-specific economy-wide technical change in commodity usage (*ai*) endogenously. If Option 2 is implemented, then Equation *E_fai* is brought into operation by setting the shift variable *fai* exogenously, and determining *ai* endogenously. The impacts that commodity using technical change would otherwise have had on the costs of current production and capital formation are then neutralised by bringing equations *E_del_f_a1* and *E_del_f_a2* into operation. This involves setting endogenous the all-input using technical change shift variables relating to current production (*a_in1*) and capital formation (*a_in2*), and setting exogenous the corresponding elements of the shift variables *del_f_a1* and *del_f_a2*.

Real output for a selection of Tasmanian output sectors ($x\_sr_{i,1}$) is determined exogenously under the historical closure. For non-margin commodities, this is facilitated by the endogenous determination of the inter-regional sourcing twist variables (*twist_isbot(i)*). These can be determined by bringing either *Equation E_fx_tot* (Option 1) or *E_fi_twist_isbot* (Option 2) into operation. In the first case, the shift variable *fx_sr* on Equation *E_fx_tot* is determined endogenously, and Equation *E_fx_tot* is then brought into operation by swapping the endogenous / exogenous status of *fx_tot* and *twist_isbot*. However if Option 2 is implemented, then the shift variable *twist_is_s* on Equation *E_fi_twist_isbot* is determined endogenously, and this equation is then brought into operation by swapping the endogenous / exogenous status of *twist_isbot* and *fi_twist_isbot*. For margin commodities, and utilities (for which there is no interstate trade), the appropriate elements of *x_sr* and *fx_sr* are swapped, and Equation *E_fx_tot* is then brought into operation by swapping the exogenous / endogenous status of the appropriate elements of *fx_tot* and *ais*. With the real output of most Tasmanian industries thus determined exogenously, this closure is sufficient to largely determine real Tasmanian gross regional product at factor cost. Aggregate indirect taxes are determined by both the government accounts closure, and the exogenous determination of traditional export commodity prices and the terms of trade. Hence Tasmanian gross regional product at market prices is also largely determined by this closure. With employment and capital stocks by industry determined exogenously, this determines primary factor productivities by industry. Furthermore, with real Tasmanian consumption, investment, regional and Commonwealth government consumption spending, and foreign exports all determined exogenously, this closure effectively determines Tasmania's interstate trade balance. Again, because of small differences between the database shares and the shares from official statistics in value added by regional industry, real gross regional product at factor cost (r_grpfc3_1) is set exogenously, and the common shift variable on the Tasmanian sectoral outputs ($fxsr_1$) is determined endogenously.

All the major categories of Commonwealth Government receipts (other than residual receipts, *r_rcpts*) are determined exogenously under the historical closure. The shift variable on the average rate of PAYE tax (*fswitch_paye*) is determined endogenously so that Commonwealth PAYE receipts (*b41*) can be determined exogenously. Other Commonwealth Government income tax receipts (*b42*) are determined exogenously and the shift variable common to the equations determining both per-unit capital and per unit land taxes (*f_o_it*) is determined endogenously. Commonwealth import duty receipts (*b43*) are determined exogenously, and the general shift variable on tariff rates (*f_t3*) is determined endogenously. Commonwealth production tax receipts (*b44*) are determined exogenously and the general shift variable on rates of Commonwealth production tax (*ffprod*) is determined endogenously. Commonwealth commodity tax revenues (*b45*) are determined exogenously, and the general shift variable on Commonwealth commodity tax rates (*com_tax*) is determined endogenously. Export tax revenues (*b46*) are determined exogenously with the general shift on the export tax rate (*ft4*) set endogenously. Finally, Commonwealth other receipts (*b47*) is determined exogenously, and the shift variable on the real value of Commonwealth other receipts (*fswitch_f47*) is determined endogenously.

Aggregate Commonwealth outlays on unemployment benefits (*u_benefit*) and other transfers to persons (*transfers*) are each determined exogenously under the historical closure. This requires that the real value of unemployment benefit payments per person (*fun_b*), and the shift variable on the real value of other Commonwealth transfer payments (*f65*), each be determined endogenously.

Each of the major categories of regional government receipt is determined exogenously under the historical closure. Payroll tax receipts (*sgptr*) are determined exogenously in each region, with the change in the average rate of regional payroll tax (*frollr*) determined endogenously. Regional government residential land tax receipts (*rltax*) are determined exogenously, with the shift variable on the rate of residential land tax (*fres_tax*) determined endogenously. Commercial land tax receipts collected by each regional government (*cltax*) are determined exogenously, and the shift variable on the average regional rate of commercial land tax (*fcom_taxr*) is determined endogenously. Regional government receipts from income reducing taxes (*b34r*) are determined exogenously with the regional shift variables on the average rate of such taxes (*f_ytax*) set endogenously. Commonwealth transfers to each regional government (*b35r*) are determined exogenously, and the real value of Commonwealth inter-governmental transfers (*f64r*) is determined endogenously. Commodity tax receipts collected by each regional government (*b36r*) are set exogenously, and the region-specific uniform shift variable on commodity tax rates (*salestax*) is determined endogenously. Either total regional government production tax receipts (*b37r*), or (if the CPI-X pricing rule for utilities is implemented) regional government production tax receipts from non-utilities industries[73] (*prod_n_util*) are determined exogenously, with the region-wide shift variable on the rates of such taxes (*fprodr*) being determined endogenously. Finally, other regional government receipts (*b38r*) are determined exogenously, with the real value of such receipts (*f_getr*) being determined endogenously.

The nominal values of regional government transfers to persons (*t51*) are switched to being determined exogenously under the historical closure. To accommodate this, the shift variable measuring the real value of regional government transfers to persons (*f_transr*) is determined endogenously.

Under the historical closure, the foreign currency prices (*p_rexp*) of traditional export commodities from each region are determined exogenously. This is accommodated by

[73] Production taxes from utilities are essentially treated as quasi GBE profits when the CPI-X rule for determining utility prices is implemented.

setting endogenous the corresponding elements of the non-spreading phantom tax shift variables (*tax_nsph*) on per-unit phantom taxes on exports.

A number of changes to the standard comparative static closure are made to allow for the exogenous determination of the changes in the net asset positions of regional governments, regional households, and the Commonwealth Government. These changes effectively determine endogenously the net foreign income component of the current account. The changes in the nominal borrowing requirement of the Commonwealth Government (*cb2*) is determined exogenously, and the otherwise exogenous component of Commonwealth net foreign outlays (*t64*) is determined endogenously. The change in the net borrowing requirements of each regional government (*cb1r*) are determined exogenously, with the shift variable common to both residual regional government foreign outlays and receipts (*fni_shift*) determined endogenously. Regional household savings (*n_sav*) are determined exogenously, and the otherwise exogenous component of household net foreign income (*ex_hhnfi*) is determined endogenously.

The share of sales taxes in the total value of investment (*sh_stax2*) is determined exogenously under the historical closure. This allows this variable to be built up slowly to its required value in 1999/00 (See Section 5.3). This is accommodated by determining endogenously the capital component of the shift variable *fk_tc0_ind*.

In undertaking the historical simulations, I have assumed that the capital ownership shares of domestic agents adjust in response to changes in their savings, with the share of foreign capital ownership within each regional industry then adjusting as a residual[74]. This requires that Equation *E_fsk_owners* be made operational, by swapping the endogenous / exogenous status of $sk\_owners_{q,j,r}$ and $fsk\_owners_{q,j,r}$.

The prices of individual consumer commodities, in addition to the consumption expenditure deflator for one region, and both the regional and Commonwealth Government consumption deflators for each region, are determined exogenously during the historical simulations. The swaps between rows 144 and 159 of Table 4.1 make this possible. Consumer prices in each region for each national accounts commodity ($p3ncom_{na,r}$) are

[74] See Section 2.5.8.2.

determined exogenously, and the corresponding elements of the shift variable on Equation *E_p3_ff_na* ($fp3ncom_{na,r}$) are determined endogenously. The *i* indexed shift variable on Equation *E_p3_ff_na* ($p3shift_{i,r}$) is set exogenously, and the shift variable $fp3r_{i,r}$ on Equation *E_ffp3r* is determined endogenously. These swaps allow the exogenous determination of national accounts category consumption prices to drive the FEDERAL-F consumption prices by commodity and region. The link between the exogenous determination of national accounts prices and consumer prices in the FEDERAL-F model is then established by setting $ffp3r_{i,r,r}$ exogenous. The exogenous determination of consumer prices is then accommodated in the model by setting endogenous the phantom tax shifters on household consumption ($fphtax3_{i,r,r}$). Finally, the economy-wide collection of phantom taxes on household purchases (*phant3nat*) is set exogenously, and the economy-wide shift variable (*f_p3gen*) on national accounts commodity prices by region is determined endogenously.

A number of expenditure deflators are determined exogenously during the historical simulations, with the corresponding phantom tax shift variables determined endogenously. With the national consumer price index exogenous, the consumer price index for only one region ($p3reg_1$) can be determined exogenously. The corresponding element of the general regional shift variable in Equation *E_p3ncom* (f_p3r_1) is then determined endogenously. Finally, the investment price indices ($p2reg_r$), regional government consumption price indices ($p5reg_r$), and Commonwealth Government consumption price indices ($p6reg_r$) are determined exogenously, with the corresponding elements of the region-specific phantom tax shift variables ($fphtax2_r$, $fphtax5_r$, and $fphtax6_r$ respectively) determined endogenously.

The foreign currency import price index (*pMnat_fc*) is determined exogenously by determining the uniform shift variable on individual commodity import prices (*f_pmp*) endogenously.

Real consumer wages in each region ($prewage\_rr_r$) are determined exogenously by determining endogenously the region-specific shifters on real consumer wages ($fpre_r$) in Equation *E_prewage*.

The CPI-X pricing rule for utilities industries is brought into operation by setting exogenous the shift variable *fn_utility* on Equation *E_fp_utility*. Movements in the basic prices for utilities, now determined by this equation, are accommodated by movements in the (now endogenous) regional government production tax rates on the output of these industries (*fprodrj*).

4.2.2 The decomposition closure

Column 5 of Table 4.1 describes the endogenous / exogenous status of the key variables which describe the decomposition closure. The decomposition closure differs from the short run comparative static closure (Column 1) in only a few regards. The first of these relate to the variables described between rows (10) and (14) inclusive and row (23). The shift variable *del_f_ac_p_y* is exogenous, bringing the year-on-year capital accumulation equation *E_del_f_ac_p_y* into operation, which now determines *cap_at_t*. Equation *E_cap_at_tplus1* is rendered inoperative by determining endogenously the shift variable on that equation (*f_eqn54*), and the MONASH capital supply functions are brought into operation by setting exogenous the shift variables *d_f_eeqror_jr*. The variable *omega* now serves no function, so it is determined exogenously. National and regional investment is now determined by the positions of the regional industry capital supply schedules and expected rates of return, so the comparative static indexing relationship established by the exogenous status of *finv_com* is broken by setting that variable endogenous.

The second swap occurs at rows (21) and (22), which switches the numeraire from the nominal exchange rate (*x_rate*) to the economy-wide household consumption price index (*p3nat*).

The second option for tracking changes in capital ownership shares (see Section 2.5.8.2) is brought into operation at rows (142) - (143) by setting *sk_owners* endogenous, and *fsk_owners* exogenous.

The final set of swaps relates to phantom taxes. During the decomposition simulation, it is the powers of the phantom taxes that are shocked by the values that they attained under the historical simulation, not the per unit phantom taxes[75]. Hence the powers of the phantom taxes (*powtax2ph* through to *powtax6ph*) are determined exogenously (rows 164 - 168), requiring that the corresponding elements of the per unit phantom tax shift variables be

[75] See Section 2.3.1 for a discussion of the reasons for this.

determined endogenously. Hence *fphtax2isr* (row 169), *fphtax3* (row 148), *tax_nsph* (rows 33, 35, and 133), *fphtax5isr* (row 170) and *fphtax6is* (row 171) are determined endogenously.

4.2.3 Shocked exogenous variables under both the historical and decomposition simulations

Those elements of X(HD) that are shocked under both the historical and decomposition closures are described in Table 4.2. The first nine of these are homotopy variables, which together drive debt accumulation by both levels of government, capital accumulation, changes in capital ownership shares, population growth and inter-regional migration, and establish the lagged value of the consumer price index. Real outlays (whether capital or current) by each regional government and the Commonwealth Government, are also determined exogenously under both closures (rows 11 - 14). The remaining variables that are determined exogenously under both closures are regional participation rates (row 10), changes in the natural population growth rate (row 15), relative movements in the foreign currency prices of individual commodity imports (row 16), and regional industry differentials in real (consumer) wages (row 17).

Table 4.2: Shocked elements of X(HD)

Row	Variable description	Variable name
1	Commonwealth debt accumulation	*del_unity*
2	Capital accumulation	*del_unityr*
3	Closure of residuals	*del_unityr2*
4	Regional government debt accumulation	*del_unityr3*
5	Check coefficients	*del_unityr4*
6	Natural population growth	*del_unity_m1*
7	Inter-regional migration	*del_unity_m2*
8	Lagged CPI	*del_cpi_l*
9	Option 2 capital ownership	*del_own_H*
10	Regional participation rates	*p_pp_rate*
11	Real Commonwealth consumption	*f_xr_cg*
12	Real Commonwealth capital expenditure	*f_fed_capr*
13	Real regional government consumption	*f_x_sg*
14	Real regional government capital expenditure	*f_sg_invest*
15	Change in natural population growth rates	*del_natgrowth*
16	Relative movements in foreign currency import prices	*f_pmp_i*
17	Regional industry real consumer wage differentials	*fprejr*

4.3 VALIDATION OF SIMULATION RESULTS

A number of steps are undertaken to check the implementation of the model during the historical simulations. First, the model is subject to three homogeneity tests (two real and one nominal) at the commencement of each simulation year. These tests consist of a standard nominal homogeneity test; a standard real homogeneity test implemented by uniformly increasing factor availability; and a real homogeneity test implemented by uniformly increasing effective factor availability by increasing factor productivities. Each of these tests is conducted under both a comparative static closure, and a closure in which the year-on-year capital accumulation equations are operational, bringing the total number of homogeneity tests to six. These tests are implemented at the beginning of each simulation year to not only check the computer implementation of the model, but to ensure that the database has updated correctly during the previous simulation.

The second set of checks ensure that certain macroeconomic aggregates, when calculated on differing bases, nevertheless yield identical results. Hence, real aggregate investment at both the regional and national levels are calculated from both the commodity usage side, and the investment budget side. These are compared to ensure that they are equal. Similarly, real household consumption at both the national and regional levels are calculated from the commodity usage side and the consumption budget side, and again checked to ensure equality. Three definitions of gross regional product at factor cost are calculated, each yielding identical results. Gross regional and national product at market prices are calculated from both the expenditure and income sides, again producing identical results. Further details on the calculation of these regional and national macroeconomic indices are provided in Sections 2.13 and 2.14 respectively.

Finally, the updated database from the previous period's simulation is checked at the commencement of each simulation period to ensure that it has remained balanced.

4.4 DATA AND SHOCKS FOR THE HISTORICAL SIMULATION

4.4.1 Introduction

In Section 4.4, the sources of the data used to calculate the shocks to the model in the historical simulations are discussed. Most of the shocks were calculated from published and unpublished Australian Bureau of Statistics data. Some government accounts data were obtained from government budget papers.

4.4.2 Employment by industry

Quarterly data on employment by industry for both Tasmania and Australia were obtained from ABS (1999g). These data related to the period February 1992 to August 1999, and were classified at the two-digit ANZSIC level (See ABS 1993). These data were converted to a financial year basis by taking the average of the August, November, February, and May quarters within each financial year. The industrial classification system of the FEDERAL-F database is based on the ASIC system, which preceded the introduction of ANZSIC. To obtain a more precise correspondence between the two classification systems, it was necessary to both aggregate the data of some ANZSIC categories, and to re-classify some FEDERAL-F categories, into broad sectors. Table 4.3 describes these aggregations and reclassifications. The link between the two classification systems is provided by the broad employment sectors described in the central column. The ABS employment data were aggregated to these sectors. As described in Section 2.2.9, it is the percentage changes in employment within each of these employment sectors (*emp_s*) that form the shocks to employment by industry and region.

The Labour Force Survey is the only source of annual data on employment by industry for the Tasmanian and Mainland regions. Unfortunately, for many Tasmanian industries, the small sample estimates result in high relative standard errors. These manifest themselves in wide swings in employment from year to year for some Tasmanian industries. These employment swings do not accord with the changes in the ABS's estimates of value added by industry. If the Tasmanian employment by industry data from the Labour Force Survey were to be used uncritically and without amendment in the historical simulations, then the result would be wide and untenable year-to-year movements in factor productivity by industry.

Table 4.3: ANZSIC / Employment Sector / FEDERAL-F Concordance

ABS Categories (ANZSIC range in brackets)	Employment Sector	FEDERAL-F Categories
Agriculture (01) Services to agriculture-hunting & trapping (02)	1. Agriculture	1. Agriculture
Forestry & logging (03)	2. Forestry	2. Forestry and logging
Commercial fishing (04)	3. Fishing	3. Fishing and hunting
Coal Mining (11) Oil & gas extraction (12) Metal ore mining (13) Other mining (14) Services to mining (15)	4. Mining	4. Mining
Food, beverages & tobacco (21)	5. Food etc.	5. Meat, smallgoods, and poultry 6. Milk products 7. Fruit and vegetable products 8. Processed seafoods 9. Confectionary and cocoa 10. Cereal products, B&C's 11. Beverages and malts 12. Tobacco
Textile, clothing, footwear & leather (22)	6. Textiles etc.	13. Textile, clothing, footwear
Wood and paper product (23)	7. Wood etc.	14. Logs, sawmilling, and woodchips 15. Joinery, boards, furnitures and mattresses 16. Paper, paper boards, and other paper products
Printing, publishing & recorded media (24)	8. Printing etc.	17. Printing and other allied industries
Petroleum, coal, chemical & associated product (25)	9. Petroleum etc.	18. Basic chemicals 19. Petroleum
Non-metallic mineral product (26)	10. Non-met Min Prods.	20. Non-metallic mineral products
Metal product (27)	11. Metal products	21. Iron and other basic metal products 22. Structural, sheet and other fabricated metal products
Machinery & equipment (28) Other (29)	12. Machinery and Other	23. Ship and boat building, motor vehicles and parts 24. Machinery, equipment, and miscellaneous
Electricity and gas supply (36) Water supply, sewerage & drainage services (37)	13. Utilities	25. Electricity 26. Other utilities
General construction (41) Construction trade services (42)	14. Construction	27. Residential building 28. Other construction
Basic material wholesaling (45) Machinery & motor vehicle (46) Personal & household good (47) Food (51) Personal & household good (52) Motor vehicle retailing & services (53)	15. Trade	29. Wholesale, retail trade, and insurance
Accommodation, cafes & restaurants (57)	16. Accommodation etc.	31. Restaurants and hotels.
Road transport (61) Rail transport (62) Water transport (63) Air & space transport (64) Other transport (65) Services to transport (66) Storage (67)	17. Transport and Storage	30. Transport and storage

Table 4.3: ANZSIC / Employment Sector / FEDERAL-F Concordance (continued)

ABS Categories (ANZSIC range in brackets)	Employment Sector	FEDERAL-F Categories
Communication Services (71)	18. Communications	32. Communications
Finance (73) Insurance (74) Services to finance & insurance (75) Property services (77) Business services (78)	19. Finance	33. Finance, property, and business services
Government administration (81) Defence (82)	20. Public Admin and Def.	35. Public administration and defence
Education (84) Health services (86) Community services (87)	21. Community services	36. Community services
Motion picture, radio & television services (91) Libraries, Museums & the arts (92) Sport & recreation (93) Personal Services (95) Other services (96) Private households employing staff (97)	22. Recreation	37. Recreation, personal, and other services

Hence a proxy for the percentage rate of change in employment by Tasmanian employment sector was calculated in the following way. First, a linear trend line was fitted to the original six year's worth of Labour Force Survey data. For each sector, annual average rates of employment growth over the period 1992/93 to 1998/99 were then calculated from this equation using its estimates of the level of employment in 1992/93 and 1998/99. Second, for all Tasmanian employment sectors, the values for the year-on-year percentage changes in output were taken as a starting point for the values for the year-on-year percentage rates of change in employment. Of course, over the six years 1992/93-1998/99, the annual average percentage change in output by sector did not equal the (trend estimate) annual average percentage change in employment by sector. To ensure that the new estimates of year-on-year employment changes by Tasmanian employment sector produced a six year annual average equal to that implicit in the trend estimate, the starting estimates for year-on-year employment changes (ie. values of the output growth rates) for each sector were next adjusted by the addition of a (uniform) number in each year. The value of this number for each sector was chosen to ensure that the annual average growth rate over the period for the new estimate of the year-on-year percentage changes in each sector's employment equalled the annual average growth rate implicit in the original employment data for that sector.

A final adjustment was made to the Tasmanian employment data relating to the electricity component of the Utilities sector. First, rather than use Labour Force Survey data for this sector, actual employment data were obtained from the Tasmanian Hydro Electricity Corporation (HEC). Two further adjustments were then made to these data. Over the study period, some falls in the HEC's employment were due to the finalisation of the HEC's construction activity, and some were due to outsourcing. The HEC's Human Resources Manager made estimates of both available. The effects of both were then removed from the calculation of the annual percentage rate of change in electricity employment. Construction workers were subtracted from the data, as if they had not been originally employed by the HEC. Outsourced workers were added back to the original data, as if they continued to be employed by the HEC. In this way a better estimate of the labour input to the Tasmanian electricity sector was obtained, in preparation for the microeconomic reform simulations undertaken in Section 6.1.

4.4.3 Gross fixed capital formation by industry

Gross fixed capital formation by Australian industry by financial year were obtained from two Australian Bureau of Statistics publications. First, the Australian National Accounts (ABS 1999h) contains chain volume measures of national gross fixed capital expenditure for each 1-digit ANZSIC category. This is the only level of industrial classification for which these national accounts data are available, whether in published or unpublished format. The second source was unpublished ABS data (ABS1999j). These data are available for all 1-digit ANZSIC categories other than Agriculture and Government Administration, Education, and Health and Community Services. Furthermore, the private investment data are available at the 2-digit ANZSIC level for all 1-digit categories other than Mining. These data are available for both Australia and Tasmania. Unfortunately, much of the Tasmanian data was unpublishable for confidentiality reasons. Hence, for Tasmania, investment at the 2-digit ANZSIC level for each year between 1992/93 and 1998/99 was ultimately available for only four manufacturing industries: Petroleum, Coal and Chemical Manufacture; Food, Beverage, and Tobacco Manufacture; Wood and Paper Products; and Metal Products Manufacture. The number of 1-digit industries for which these data were available was also restricted by confidentiality. The data were available for Mining; Manufacturing; Wholesale Trade; Retail Trade; Transport and Storage; and Finance, and Property and Business Services.

Investment by investment sector at the national level is set exogenously in the historical simulation using data from both the Business Survey and the National Accounts. Chain volume measures of total gross fixed capital formation from the national accounts were used for all sectors other than those within manufacturing. For manufacturing sectors, the national accounts data were used to determine aggregate manufacturing investment by year. However, private investment data for 2-digit manufacturing industries were available from the Business Surveys publication. The National Accounts' manufacturing investment was apportioned among 2-digit manufacturing categories on the basis of the shares of private investment by 2-digit manufacturing in total manufacturing private investment as given by the Business Survey's data. The industrial categories given by this combination of both ABS National Accounts data and ABS Business Surveys data are listed in column 1 of Table 4.4. In the same manner as is discussed in Section 4.4.2 in relation to employment by industry data, a correspondence between the industries by which the ABS investment data were classified, and the FEDERAL-F industrial categories, was obtained by classifying both within common broad industry sectors. These broad industry sectors are located in the central column of Table 4.4. The ABS categories that they cover are adjacent in the left hand column, and the FEDERAL-F categories that they cover are adjacent in the right hand column. As described in Section 2.6.22, it is the percentage changes in investment within each of these (centre column) investment sectors (given by the shocks to y_s) that form the national investment by industry shocks to the model.

As discussed earlier, private investment at current prices for Tasmania were available for seven 1-digit ANZSIC categories and four 2-digit ANZSIC manufacturing categories from Business Surveys data. These had to be converted to real indices of private investment before being used to generate shocks to the model. ABS(1999h) presents both chain volume measures and current price measures for gross fixed capital formation by 1-digit ANZSIC industry. From these data I derived price indices for the national 1-digit ANZSIC categories, and used these to deflate the Tasmanian current price estimates of private investment by industry. Percentage rates of

Table 4.4: ABS / Investment Sector / FEDERAL-F Concordance - National Data

ABS National accounts / business survey category	Investment sector	FEDERAL-F category
Agriculture, forestry and fishing	1. Agriculture	1. Agriculture 2. Forestry and logging 3. Fishing and hunting
Mining	2. Mining	4. Mining
Food, Beverage and Tobacco Manufacturing	3. Food etc.	5. Meat, smallgoods, and poultry 6. Milk products 7. Fruit and vegetable products 8. Processed seafoods 9. Confectionary and cocoa 10. Cereal products, B&C's 11. Beverages and malts 12. Tobacco
Textile Clothing Footwear and Leather Manufacture	4. Textiles etc.	13. Textile, clothing, footwear
Wood and Paper Products	5. Wood etc.	14. Logs, sawmilling, and woodchips 15. Joinery, boards, furnitures and mattresses 16. Paper, paper boards, and other paper products
Printing, Publication and Recording Media	6. Printing etc.	17. Printing and other allied industries
Petroleum, Coal, Chemicals etc	7. Petroleum etc.	18. Basic chemicals 19. Petroleum
Non-Metallic Minerals Products	8. Non-met Min Prods	20. Non-metallic mineral products
Metal Products	9. Metal Products	21. Iron and other basic metal products 22. Structural, sheet and other fabricated metal products
Machinery and Equipment Other Manufacturing	10. Machinery and Other	23. Ship and boat building, motor vehicles and parts 24. Machinery, equipment, and miscellaneous
Electricity, gas, water	11. Utilities	25. Electricity 26. Other utilities
Construction	12. Construction	27. Residential building 28. Other construction
Wholesale trade Retail trade	13. Trade	29. Wholesale, retail trade, and insurance
Transport and storage	14. Transport and storage	30. Transport and storage
Accommodation, cafes, restaurants	15. Accommodation etc.	31. Restaurants and hotels.
Communications	16. Communications	32. Communications
Finance and insurance Property and business services	17. Finance	33. Finance, property, and business services
Ownership of dwellings	18. Ownership of dwellings	34. Dwellings
Government administration and defence	19. Public admin.	35. Public admin and defence
Education Health and community services	20. Community services	36. Community services
Cultural and recreational services Personal and other services	21. Recreation etc.	37. Recreation, personal, and other services

change in private real gross fixed capital expenditure were ultimately derived for nine broad sectors, which together represented 24 of FEDERAL-F's 37 industry sectors. These nine sectors, and the FEDERAL-F industries of which they are comprised, are summarised in Table 4.5.

Table 4.5: Tasmanian Investment Sector / FEDERAL-F Sector

Tasmanian Investment Sector	FEDERAL-F Sector
1. Mining	4. Mining
2. Food and beverages	5. Meat, smallgoods, and poultry 6. Milk products 7. Fruit and vegetable products 8. Processed seafoods 9. Confectionary and cocoa 10. Cereal products, B&C's 11. Beverages and malts
3. Wood and Paper Products	14. Logs, sawmilling, and woodchips 15. Joinery, boards, furnitures and mattresses 16. Paper, paper boards, and other paper products 17. Printing and other allied industries
4. Petroleum	18. Basic chemicals 19. Petroleum
5. Metal Products	21. Iron and other basic metal products 22. Structural, sheet and other fabricated metal products
6. Other Manufacturing	12. Tobacco 13. Textile, clothing, footwear 20. Non-metallic mineral products 23. Ship and boat building, motor vehicles and parts 24. Machinery, equipment, and miscellaneous
7. Trade	29. Wholesale, retail trade, and insurance
8. Transport and Storage	30. Transport and storage
9. Finance, Property, Business Services	33. Finance, property, and business services
10. Other[a]	1. Agriculture 2. Forestry and logging 3. Fishing and hunting 25. Electricity 26. Other utilities 27. Residential building 28. Other construction 31. Restaurants and hotels. 32. Communications 34. Dwellings 35. Public administration and defence 36. Community services 37. Recreation, personal, and other services

a. Investment data not available for this sector

4.4.4 Output by industry

Indices of output by industry were calculated from Australian Bureau of Statistics chain volume estimates of value added by industry. These data were sourced from ABS (1999h) and ABS (1999i). ABS (1999h) contains constant price estimates of value added at basic prices by 1-digit ANZSIC industry classification, and selected 2-digit ANZSIC industry classifications. These data were aggregated into 22 sectoral groupings, to one of which each of the 37 FEDERAL-F industry categories uniquely belongs (See Table 4.6). ABS (1999i) contains value added by 1-digit ANZSIC industry classification for Tasmania. This is the only level of industrial classification for which these Tasmanian data are available, whether in published or unpublished format. Also, the data on value added by industry at the state level are only available in current prices. The corresponding data at the national level are available in ABS (1999h) at both current and constant prices. From these data I derived national price deflators by industry, and used these to deflate the current price estimates for Tasmanian value added by industry as sourced from ABS (1999i). Percentage rates of change in activity for the following fourteen Tasmanian industrial sectors were then calculated: Agriculture, Mining, Manufacturing, Electricity Gas and Water, Construction, Trade, Accommodation etc, Transport and Storage, Communications, Finance, Public Administration and Defence, Ownership of Dwellings, and Recreation and Personal Services. Rather than add new equations to the model to provide for a mapping between this set of fourteen industries and the 37 Tasmanian industries recognised by the model, I used the existing set mapping between the 22 national industrial sectors, and the 37 Tasmanian industrial sectors (See Section 2.2.7. For example, the variable x_sr for Tasmanian sectors 4-11 (See Table 4.6) were all shocked by the same percentage rate of change – being that for the Tasmanian Manufacturing sector as a whole.

As discussed in Section 2.2.7, two techniques are used in the historical simulations to exogenise commodity outputs by industry for Tasmania. The first of these is to set endogenous source specific (that is, the Tasmanian source) technical change variables for those Tasmanian commodities the volume of which are being determined exogenously. In the present historical simulations, this technique is used solely for the margin commodities

Table 4.6: National Accounts / Output Sector / FEDERAL-F Concordance

National Accounts Industry	Output Sector	FEDERAL-F Sector
Agriculture	1. Agriculture	1. Agriculture
Forestry and fishing	2. Forestry and fishing	2. Forestry and logging 3. Fishing and hunting
Mining	3. Mining	4. Mining
Food, beverage and tobacco	4. Food etc.	5. Meat, smallgoods, and poultry 6. Milk products 7. Fruit and vegetable products 8. Processed seafoods 9. Confectionary and cocoa 10. Cereal products, B&C's 11. Beverages and malts 12. Tobacco
Textile, clothing and footwear	5. Textiles etc	13. Textile, clothing, footwear
Wood and paper products	6. Wood etc.	14. Logs, sawmilling, and woodchips 15. Joinery, boards, furnitures and mattresses 16. Paper, paper boards, and other paper products
Printing, publishing and recorded media	7. Printing etc.	17. Printing and other allied industries
Petroleum, coal, chemical etc.	8. Petroleum etc.	18. Basic chemicals 19. Petroleum
Non-metallic mineral products	9. Non-met mins prods	20. Non-metallic mineral products
Metal products	10. Met prods	21. Iron and other basic metal products 22. Structural, sheet and other fabricated metal products
Machinery and equipment Other manufacturing	11. Machinery and other	23. Ship and boat building, motor vehicles and parts 24. Machinery, equipment, and miscellaneous
Electricity	12. Electricity	25. Electricity
Gas Water supply, sewerage and drainage services	13. Other utilities	26. Other utilities
Construction	14. Construction	27. Residential building 28. Other construction
Wholesale trade Retail trade	15. Trade	29. Wholesale, retail trade, and insurance
Accommodation, cafes and restaurants	16. Accommodation	31. Restaurants and hotels.
Transport and storage	17. Transport and storage	30. Transport and storage
Communication services	18. Communications	32. Communications
Finance and insurance Property and business services	19. Finance	33. Finance, property, and business services
Government administration and defence	20. Public admin and defence	35. Public administration and defence
Health and community services	21. Community services	36. Community services
Cultural and recreational services Personal and other services	22. Recreation and personal services	37. Recreation, personal, and other services

(Trade and insurance margins, Transport and storage margins, and Restaurant and hotel margins) and utilities (Electricity, and Other Utilities) for which there is no interstate trade. Recall that margins on commodity flows are used in fixed proportions to the commodity flows to which they relate (See Appendix A, Section 9, and Section 2.11). Changes in source-specific margin using technology (that is, changes in the values of the variables $a1mar_{u,r,i,s,j,t}$, $a2mar_{u,r,i,s,j,t}$ and so on) have a direct impact on the usage of the corresponding margin commodity that is not mitigated by substitution induced by changes in the effective-price of the margin commodity. This can be contrasted with the operation of the source-specific commodity using technical change variables for the remaining non-margin (and non-utility) commodities. Changes in the required number of units of a source-specific commodity required to produce an effective unit of that commodity (ie. changes in the *ais*'s) also change the effective price of that source-specific commodity. Changes in the effective price of the source specific commodity induce substitution away from the commodity the effective price of which is increasing. This can lead to very large and unrealistic results for the Tasmanian-sourced commodity-specific technical change variables, when these are set endogenous to achieve Tasmanian commodity output targets. The reason for this is that the operation of these variables on demands for Tasmanian goods by Tasmanian agents and by Rest of Australian agents can have different signs. Hence a technological deterioration (improvement) in the use of a given Tasmanian sourced commodity can cause Tasmanian agents to increase (decrease) their usage of the commodity, while causing Rest of Australian agents to decrease (increase) their usage of the commodity. Hence the actions of Tasmanian and Rest of Australian agents will pull total output of the Tasmanian sourced good in different directions. As a result, if the technical change variable is set endogenous, and the Tasmanian output of the relevant commodity is set exogenous, very large technical changes can be required to achieve the exogenous output target. The problem arises because of differences between Tasmanian and Mainland agents in the relative shares of Tasmanian-sourced goods in the construction of an effective input of a given commodity. For Mainland agents, inputs sourced from the Mainland and from the rest of the world represent a much greater share of the total cost of constructing an effective input of most of the commodities that they use. Hence, for Mainland agents, the impact of the effective relative price change arising from a change in Tasmanian-source specific commodity technical change typically outweighs the direct effect of that technical change. The reverse is true for Tasmanian agents. For these agents, the direct effect of the technical change on the demand for the Tasmanian good typically outweighs the relative price effect. This is because Tasmanian sourced goods typically represent, for Tasmanian agents, a much higher share in the total cost of constructing an effective unit of any given commodity.

Rather than using source-specific technical change, the problem outlined above is overcome by setting endogenous the commodity-specific inter-regional twist shifter $twist\_src_i$ for all non-margin and non-utility commodities[76]. This variable then imparts that cost-neutral shift in the ratio of the usage of the Tasmanian and Mainland sourced commodity across all users, which is required to achieve the exogenous output target.

4.4.5 Commodity import prices

Indices of Australian dollar import prices for selected commodities are available from the ABS (1999c). The commodities for which data are available are the broad agriculture, mining, and manufacturing sectors, in addition to selected commodities within the broad agriculture and manufacturing sectors. The Australian dollar indices were converted to foreign currency terms using the annual average of monthly TWI figures (See Section 4.4.10). Percentage changes in the foreign currency import prices of FEDERAL-F commodities 1-24 could then be calculated. These formed the shocks to the relevant elements of $f\_pmp\_i_i$ over the historical period.

4.4.6 Household consumption and purchaser's prices by national accounts commodity

Current and constant price estimates of household final consumption by national accounts commodity categories for the period 1992/93 - 1998/99 were obtained from unpublished ABS data (ABS 1999f). These data were available for both Tasmania and Australia. From the constant price estimates I was able to calculate the annual percentage changes in household consumption by national accounts category (*x3ncom*). Using both the current and constant price estimates, I derived implicit price deflators by national accounts commodity in each region, and used these to shock *p3ncom*.

[76] That is, all non-margin and non-utility commodities other than Tobacco and Petroleum. The volume of production of these commodities in Tasmania is very close to zero (they are essentially treated as dummy industries). What little production is recognised in the database is treated as a sale to the Tasmanian regional government. Hence it is not appropriate to determine the output of these commodities by the exogenous setting of sectoral outputs.

4.4.7 Commonwealth Government accounts

Data on Commonwealth Government revenues (*b41 - b47*), net financing requirements (*cb2*), and outlays on unemployment benefits (*u_benefit*) and other transfers to persons (*transfers*) were obtained from ABS (1998a) and ABS (1999k) for the period 1992/93 to 1997/98. To calculate shocks to these variables for the 1998/99 year, I used the provisional estimates from Treasurer of the Commonwealth of Australia (1999). Estimates of real current and capital expenditure by region were sourced from ABS (1999i).

4.4.8 Regional government accounts

Data on regional government revenues and net financing requirements were sourced from ABS (1998a) for the period 1992/93 to 1997/98. For Tasmania, the percentage changes in regional government revenues over 1998/99 were calculated from provisional estimates in Treasurer of Tasmania (1999). A similar approach was not practical for the regional governments represented by the rest of Australia, and so movements in their revenues for the 1998/99 year were set equal to their average annual movements over the period 1992/93 to 1997/98. Data on current and capital outlays, and transfers to persons, by both Tasmanian and Mainland regional governments were available for the period 1992/93 to 1997/98 from ABS (1999k). The percentage change in Tasmanian current and capital outlays, borrowing requirement, and transfer payments, for the 1998/99 year were estimated from Treasurer of Tasmania (1999). Again, a similar approach was not practical for the rest of Australia. Instead, the percentage change in Mainland regional government capital and current outlays were set equal to the percentage changes in general government capital and current expenditures for that region over 1998/99 from ABS (1999i). The percentage change in Mainland expenditure on transfer payments, and the change in the borrowing requirement, over 1998/99 were set equal to the annual averages of the same for the period 1992/93 to 1997/98.

4.4.9 Traditional export commodity volumes and prices

Unpublished data on Australian and Tasmanian export volumes and values by ANZSIC category were obtained from ABS (1999l). Domestic currency price indices for each of these categories were then calculated on the basis of these volume and value data. These price indices were converted to foreign currency terms using movements in the average TWI in each year. Annual percentage changes in the prices (*pr_exp*(TRAD,r)) and volumes (*xr_exp*(TRAD,r)) of each of the elements of the set TRAD were then calculated from these data. The percentage change in export volumes for traditional export commodity *i* between year *t* and year *t*-1 was calculated as: $\left[\sum_k (q_k(t) \times p_k(t-1)) / \sum_k (q_k(t-1) \times p_k(t-1)) - 1\right] \times 100$, where $q_k(t)$ is the quantity of exports in period *t* of ANZSIC commodity *k* subsumed by FEDERAL-F commodity *i*, and $p_k(t)$ is the price of the same. Similarly, the percentage change in the foreign export price for traditional commodity *i* was calculated as: $\left[\sum_k (p_k(t) \times q_k(t-1)) / \sum_k (p_k(t-1) \times q_k(t-1)) - 1\right] \times 100$.

4.4.10 National and regional macroeconomic variables

Values for national gross fixed capital formation (*x2nat*), the national import volume index (*xMnat*), consumer price index (*p3nat*), and terms of trade (*tofi*), were sourced from ABS (2000a). Back issues of the same publication were used to compile monthly values for the TWI for the period 1992/93 to 1998/99, and percentage changes in the reciprocal of the annual averages of these monthly values were used as a proxy for the percentage changes in *x_rate*. Values for the domestic currency import price index were also sourced from ABS (2000a), and converted to foreign currency terms using the annual averages of the monthly TWI indices. This provided annual values for *pMnat_fc*. Values for the national export volume index (*x4nat*) and real national household consumption (*cR*), were sourced from ABS (1999i).

Values for Tasmanian real gross regional product, real consumption, real foreign export volumes, nominal household savings, and real private investment, were sourced from ABS (1999i). Total employment for Tasmania and the Mainland were sourced from ABS (1999g). An index for nominal pre tax wages was constructed from data from ABS (2000b). Deflated by the consumer price index, this provided *prewage_rr* for each region. Values for the regional investment, consumption, regional government, and Commonwealth Government expenditure deflators (*p2reg*, *p3reg*, *p5reg*, and *p6reg* respectively) were constructed from ABS(1999i), which contains both current and constant value estimates for these expenditure items.

4.4.11 Demographic variables

Regional participation rates by year were sourced from ABS (1999m). The annual number of inter-regional migrants from Tasmania were sourced from ABS (1999n). The natural[77] rates of population growth for each region by year were then calculated from these data using the formula: $g(t) = (P(t+1) + M(t))/P(t) - 1$, where $g(t)$ is the natural population growth rate for period t, $P(t)$ is the population aged 15 and over in year t, and $M(t)$ is the net emigrant numbers for period t. The annual changes in these growth rates provided the estimates for *del_natgrowth*.

4.4.12 Regional industry wage differentials

Average weekly adult full time ordinary time earnings by industry for Tasmania and Australia were sourced from ABS (2000c). These data were used to calculate shocks to regional industry wage differentials ($fprejr_{j,r}$) for all industries other than Rural, Forestry and Logging, Fishing and Hunting, and Dwellings.

4.5 THE HISTORICAL AND DECOMPOSITION SIMULATIONS

4.5.1 Introduction

As discussed in Section 4.2, the historical simulations produce results for a very large number of structural and policy shifts (the elements of $X(\overline{H}, D)$) for each year of the simulation period. The results for these variables, in addition to the values for $X(H, D)$, form the shocks to the model during each year of the decomposition simulation. The result for any element of $X(H, \overline{D})$ or $X(\overline{H}, \overline{D})$, in any given year of the decomposition simulation, can then be decomposed into the individual contributions of the shocks to each of the elements of $X(\overline{H}, D)$ and $X(H, D)$. The number of shocked elements of $X(\overline{H}, D)$ and

[77] I subsume within my definition of natural population growth that which is attributable to foreign migration.

$X(H,D)$ is very large, with these shocks being administered in each of the six years of the simulation period. Hence a number of strategies are adopted to condense the presentation of the results in order to make the task of interpreting them more tractable.

The first of these strategies is to focus on annual average percentage rates of change in the variables over the period 1992/93 to 1998/99, rather than annual values. This immediately reduces the number of variables by a factor of six. The many structural and policy shifts that were deduced from the historical simulation are then condensed down to eleven broad sets of factors. Table 4.7 summarises the impacts of each of these factors. A selection of macroeconomic variables, and industry results for a broad 12-sector industry classification[78], are presented for each region. In discussing the interpretation of these results, it is often helpful to refer to results that it is not convenient to individually report in the tables in this Chapter. This is the case particularly for commodity and industry results for the 37 sector classification, and for results of the decomposition equations discussed in Sections 2.12.12 and 2.12.13. To avoid confusion, those results not individually reported within the tables are indicated within the text by a "†" superscript. Finally, the more detailed discussion of results is typically reserved for those variables relating to the Tasmanian economy.

The columns in Table 4.7 have been arranged in ascending order of their importance in explaining the growth differential between the two regional economies over the period[79]. The growth rate in Tasmania's real gross regional product lagged that of the Mainland by an average of 2.53 percentage points per annum over the period. The least important set of factors explaining this gap were shifts in export supply schedules (Column 1). These caused the size of the Tasmanian economy to grow more quickly relative to that of the Mainland by approximately 0.53 percentage points per annum. The most important set of factors is presented in Column (11). These factors caused the annual average growth rate of the Mainland economy to exceed that of Tasmania by approximately 1.04 percentage points per annum.

[78] These are aggregated within the model from the 37 sector classification. See Section 2.12.10.
[79] The growth differential is given by the difference between the first and second rows in the table.

Table 4.7: Summary Table: Decomposition of Regional Macroeconomic and Sectoral Outcomes, 1992/93 - 1998/99

Variable	Export supply shifts (1)	Real wage (2)	House-hold related (3)	C'wealth Gov't (4)	Regional gov't (5)	Demo-graphic (6)	Domestic supply shifts (7)	Technical change (8)	Foreign factors (9)	Capital supply shifts (10)	Other (11)	Total (12)
Regional Macroeconomic Variables												
1 Real GRP (at factor cost)	-0.13	-1.50	-0.24	0.03	-0.04	-0.05	-0.24	3.19	-0.23	-0.05	1.28	2.02
2	-0.66	-1.55	-0.17	0.10	0.04	0.05	0.04	3.53	0.33	0.52	2.33	4.55
3 Capital stock (rental weights)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.65
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	1.60
5 Employment	-0.07	-1.96	-0.23	0.05	-0.01	-0.07	-0.33	1.87	-0.35	-0.08	1.39	0.20
6	-0.95	-2.16	-0.21	0.14	0.08	0.07	0.05	1.35	0.54	0.76	2.54	2.21
7 Real investment	-0.79	-2.86	0.97	-2.29	-0.96	-0.12	0.14	4.87	1.01	2.67	-1.93	0.71
8	-1.32	-2.53	0.83	-1.75	-0.42	0.09	0.56	4.45	0.79	7.55	-0.78	7.45
9 Real household consumption	-0.40	-0.78	1.41	-0.63	-0.37	0.01	-0.84	1.89	0.98	0.02	1.13	2.42
10	-0.45	-0.46	1.86	-0.54	-0.34	0.41	-0.31	1.44	0.80	0.29	1.22	3.93
11 Real exports	-1.77	-6.62	-7.45	3.02	-1.48	-0.77	0.63	14.72	-3.40	-3.08	10.33	4.13
12	-3.64	-5.76	-7.80	3.26	-0.58	-0.94	0.66	9.28	0.81	-3.53	15.00	6.75
13 Real regional government consumption	0.00	0.00	0.00	0.00	2.38	0.00	0.00	0.00	0.00	0.00	0.00	2.38
14	0.00	0.00	0.00	0.00	3.11	0.00	0.00	0.00	0.00	0.00	0.00	3.11
15 Real Commonwealth consumption	0.00	0.00	0.00	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.13
16	0.00	0.00	0.00	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.32
17 Foreign imports	-1.38	-2.41	-1.14	0.21	-0.65	-0.02	-0.06	3.51	0.65	0.91	5.06	4.68
18	-1.99	-1.87	0.16	-0.23	-0.27	0.12	0.07	3.20	1.26	2.42	5.79	8.67
19 Interstate imports	-0.18	-1.97	0.39	-0.50	-0.42	-0.09	-0.20	4.30	0.25	0.01	1.67	3.25
20	0.73	-1.48	0.13	-0.01	-0.16	0.26	0.15	1.94	-0.13	0.47	1.28	3.17
21 Interstate exports	0.73	-1.48	0.13	-0.01	-0.16	0.26	0.15	1.94	-0.13	0.47	1.28	3.17
22	-0.18	-1.97	0.39	-0.50	-0.42	-0.09	-0.20	4.30	0.25	0.01	1.67	3.25
23 Investment price index	0.26	0.86	-0.35	0.60	-0.07	-0.04	-2.11	-1.17	-0.25	0.07	1.96	-0.24
24	0.55	0.37	-0.62	0.36	-0.03	-0.04	-0.99	-1.22	-0.61	0.00	2.44	0.21
25 Consumption price index	-0.10	-0.04	0.33	-0.20	0.02	-0.05	-0.14	0.24	0.24	-0.07	1.40	1.62
26	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	1.98	1.98

Table 4.7: Summary Table: Decomposition of Regional Macroeconomic and Sectoral Outcomes, 1992/93 - 1998/99 (continued)

Variable	Export supply shifts (1)	Real wage (2)	House-hold related (3)	C'wealth Gov't (4)	Regional gov't (5)	Demo-graphic (6)	Domestic supply shifts (7)	Technical change (8)	Foreign factors (9)	Capital supply shifts (10)	Other (11)	Total (12)
27 Export price index	2.44	-0.26	-1.32	0.46	0.05	-0.10	0.08	-1.00	-1.33	-0.44	3.94	2.52
28	2.71	-0.23	-1.20	0.37	-0.03	-0.08	0.09	-0.64	-2.00	-0.34	3.38	2.02
29 Regional government price index	-0.07	0.77	-0.10	0.05	0.11	-0.01	-0.25	-0.91	0.00	-0.02	1.80	1.36
30	0.08	0.92	-0.28	0.12	0.13	-0.01	0.03	-1.36	-0.18	-0.01	2.07	1.51
31 Commonwealth government price index	-0.06	0.76	-0.11	0.05	0.11	-0.01	-0.25	-0.90	-0.01	-0.02	1.81	1.36
32	0.08	0.92	-0.28	0.12	0.13	-0.01	0.03	-1.36	-0.18	-0.01	2.07	1.51
33 Foreign import price index	2.24	-0.77	-1.94	0.69	-0.09	-0.17	0.15	0.20	-1.95	-0.68	4.72	2.41
34	2.23	-0.76	-1.94	0.69	-0.09	-0.17	0.15	0.20	-2.34	-0.68	4.72	2.00
35 Interstate import price index	0.05	0.27	-0.56	0.20	0.15	-0.01	0.09	-1.08	-0.31	-0.03	2.35	1.11
36	0.25	-0.02	-0.83	0.22	0.03	-0.03	0.14	-1.34	-0.58	-0.23	3.24	0.84
37 Interstate export price index	0.25	-0.02	-0.83	0.22	0.03	-0.03	0.14	-1.34	-0.58	-0.23	3.24	0.84
38	0.05	0.27	-0.56	0.20	0.15	-0.01	0.09	-1.08	-0.31	-0.03	2.35	1.11
39 Real pre tax wage	0.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55
40	0.00	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.93
41 GSP Deflator	0.32	0.20	0.09	-0.03	-0.02	-0.05	-0.54	-0.28	0.04	-0.12	1.82	1.44
42	0.18	0.36	0.00	0.02	0.03	0.01	-0.23	-0.66	-0.05	0.07	1.78	1.51

* *For each variable, the first row contains the Tasmanian results, and the second row contains the Mainland results.*

Table 4.7: Summary Table: Decomposition of Regional Macroeconomic and Sectoral Outcomes, 1992/93 - 1998/99 (continued)

Variable	Export supply shifts (1)	Real wage (2)	House-hold related (3)	C'wealth Gov't (4)	Regional gov't (5)	Demo-graphic (6)	Domestic supply shifts (7)	Technical change (8)	Foreign factors (9)	Capital supply shifts (10)	Other (11)	Total (12)
National Macroeconomic Variables												
43 Real GDP (at market prices)	-0.88	-1.59	-0.28	0.17	0.00	0.07	0.01	3.02	0.56	0.46	2.44	3.97
44 Real investment	-1.31	-2.54	0.84	-1.76	-0.43	0.08	0.55	4.45	0.78	7.47	-0.80	7.34
45 Real consumption	-0.44	-0.46	1.85	-0.54	-0.34	0.41	-0.33	1.45	0.80	0.28	1.22	3.90
46 Real exports	-3.62	-5.77	-7.80	3.26	-0.60	-0.94	0.66	9.38	0.74	-3.53	14.91	6.69
47 Real reg. gov. consumption	0.00	0.00	0.00	0.00	3.09	0.00	0.00	0.00	0.00	0.00	0.00	3.09
48 Real Com. Gov. consumption	0.00	0.00	0.00	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.32
49 Real imports	-1.99	-1.88	0.15	-0.22	-0.28	0.12	0.07	3.20	1.25	2.41	5.78	8.64
50 Investment price index	0.54	0.38	-0.61	0.37	-0.03	-0.04	-1.01	-1.22	-0.60	0.00	2.43	0.21
51 Consumption price index	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.97	1.97
52 Export price index	2.70	-0.23	-1.21	0.37	-0.03	-0.08	0.09	-0.65	-1.99	-0.34	3.39	2.03
53 Reg. gov. price index	0.07	0.92	-0.28	0.12	0.13	-0.01	0.02	-1.35	-0.18	-0.01	2.06	1.51
54 Com. Gov. price index	0.08	0.92	-0.28	0.12	0.13	-0.01	0.03	-1.35	-0.18	-0.01	2.07	1.51
55 Import price index	2.23	-0.76	-1.94	0.69	-0.09	-0.17	0.15	0.20	-2.34	-0.68	4.72	2.01
56 GDP Deflator	0.18	0.35	0.00	0.02	0.03	0.01	-0.23	-0.65	-0.05	0.07	1.78	1.51
57 Nominal exchange rate	2.17	-0.75	-1.92	0.68	-0.08	-0.16	0.15	0.20	-5.42	-0.67	4.65	-1.17
58 Real exchange rate (1)	-2.05	1.12	1.94	-0.67	0.11	0.18	-0.38	-0.85	2.29	0.75	-2.87	-0.43
59 Real exchange rate (2)	-0.72	0.71	0.89	-0.34	0.07	0.11	-0.05	-1.00	1.23	0.41	-1.68	-0.38
60 BOT / GDP ratio	-0.27	-0.66	-1.42	0.66	-0.04	-0.18	0.08	1.03	0.01	-1.13	1.50	-0.43
61 Terms of trade	0.43	0.54	0.73	-0.30	0.06	0.09	-0.06	-0.85	0.53	0.33	-1.36	0.12

Table 4.7: Summary Table: Decomposition of Regional Macroeconomic and Sectoral Outcomes, 1992/93 - 1998/99 (continued)

Variable	Export supply shifts (1)	Real wage (2)	House-hold related (3)	C'wealth Gov't (4)	Regional gov't (5)	Demo-graphic (6)	Domestic supply shifts (7)	Technical change (8)	Foreign factors (9)	Capital supply shifts (10)	Other (11)	Total (12)
Tasmanian Sectoral Outputs												
62 1. Agriculture	0.41	-1.42	-1.98	0.73	-0.10	-0.12	0.07	3.91	-2.30	-0.78	4.34	2.74
63 2. Mining	-8.76	-8.34	-6.87	3.14	-1.27	-0.56	0.70	18.36	-0.96	-2.24	18.88	12.07
64 3. Manufacturing	1.09	-2.49	-1.87	0.50	-0.60	-0.05	0.17	3.91	-1.35	-0.35	1.75	0.71
65 4. Utilities	0.72	-1.98	-1.28	0.49	-0.55	-0.03	-0.07	5.02	-0.95	-0.42	1.66	2.61
66 5. Construction	-0.53	-2.55	0.82	-1.94	-0.82	-0.09	0.16	4.39	0.71	2.72	-3.80	-0.94
67 6. Margin industries	-0.47	-1.16	0.41	-0.37	-0.27	-0.01	-0.85	3.06	0.49	-0.02	1.42	2.23
68 7. Communications	-0.37	-1.33	4.14	-0.67	0.04	-0.09	-1.28	6.95	0.94	0.03	-1.45	6.93
69 8. Finance	-0.33	-1.29	0.53	-0.23	-0.17	-0.06	-0.15	4.14	0.19	-0.18	-2.37	0.07
70 9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	3.26	3.82
71 10. Public administration	0.00	-0.02	0.00	0.51	1.76	0.00	-0.01	0.05	0.00	0.00	0.04	2.32
72 11. Community services	-0.18	-0.53	1.13	0.01	0.99	-0.03	-0.43	1.09	0.47	-0.01	0.23	2.74
73 12. Entertainment and recreation	-0.40	-1.61	0.90	-0.57	-0.42	-0.06	-1.17	1.47	0.92	-0.01	2.25	1.30
Mainland Sectoral Outputs												
74 1. Agriculture	1.32	-0.87	-1.37	0.70	-0.08	-0.09	0.06	4.92	-3.03	-0.55	2.66	3.67
75 2. Mining	3.02	-2.05	-1.74	0.94	-0.14	-0.13	0.08	3.33	-6.02	-0.65	6.87	3.50
76 3. Manufacturing	-0.20	-2.66	-1.37	0.37	-0.31	0.00	0.39	3.80	-0.06	0.16	2.14	2.26
77 4. Utilities	-0.13	-1.52	-0.38	0.23	-0.21	0.09	0.05	1.40	-0.11	0.06	2.22	1.70
78 5. Construction	-1.38	-2.10	1.42	-1.69	-0.26	0.09	0.41	4.53	1.16	5.14	-0.70	6.61
79 6. Margin industries	-1.73	-2.00	-0.56	0.28	-0.25	0.10	-0.07	4.56	1.34	0.38	3.35	5.40
80 7. Communications	-2.22	-2.16	-0.40	0.43	-0.08	-0.05	0.13	9.34	1.95	-0.13	3.17	9.97
81 8. Finance	-1.05	-1.66	0.16	-0.03	-0.19	0.08	0.13	4.92	0.88	0.38	2.52	6.16
82 9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	3.21	3.58
83 10. Public administration	-0.28	-0.42	0.20	0.58	1.61	0.01	0.00	0.89	0.26	0.04	0.53	3.43
84 11. Community services	-0.44	-0.60	0.57	0.27	1.06	0.06	-0.38	1.11	0.56	0.07	0.82	3.11
85 12. Entertainment and recreation	-1.35	-1.07	1.30	-0.15	-0.18	0.10	0.12	2.23	1.54	0.21	0.74	3.48

Table 4.7: Summary Table: Decomposition of Regional Macroeconomic and Sectoral Outcomes, 1992/93 - 1998/99 (continued)

Variable	Export supply shifts (1)	Real wage (2)	House-hold related (3)	C'wealth Gov't (4)	Regional gov't (5)	Demo-graphic (6)	Domestic supply shifts (7)	Technical change (8)	Foreign factors (9)	Capital supply shifts (10)	Other (11)	Total (12)
Tasmanian Sectoral Employments												
86 1. Agriculture	0.70	-2.26	-3.14	1.17	-0.17	-0.19	0.08	2.14	-3.67	-1.26	7.73	1.14
87 2. Mining	-9.25	-9.34	-7.75	3.35	-1.44	-0.66	0.89	10.67	-0.96	-2.47	20.58	3.62
88 3. Manufacturing	1.97	-3.25	-2.39	0.67	-0.81	-0.07	0.20	2.73	-2.00	-0.46	2.84	-0.57
89 4. Utilities	1.63	-4.34	-2.85	1.06	-1.24	-0.05	-0.11	-6.29	-2.00	-0.94	9.46	-5.68
90 5. Construction	-0.55	-2.77	0.95	-2.12	-0.91	-0.10	0.15	2.65	0.81	2.97	-4.27	-3.19
91 6. Margin industries	-0.60	-1.61	0.67	-0.52	-0.39	-0.01	-1.26	1.65	0.71	-0.03	2.06	0.66
92 7. Communications	-0.35	-1.28	3.99	-0.65	0.03	-0.09	-1.23	-3.71	0.95	0.03	-1.39	-3.69
93 8. Finance	-0.39	-1.62	0.67	-0.29	-0.23	-0.07	-0.19	7.88	0.24	-0.22	-3.93	1.85
94 9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
95 10. Public administration	0.00	-0.02	0.00	0.51	1.75	0.00	-0.01	-3.75	0.00	0.00	0.04	-1.50
96 11. Community services	-0.19	-0.54	1.17	0.01	1.01	-0.03	-0.44	-0.09	0.48	-0.01	0.25	1.62
97 12. Entertainment and recreation	-0.53	-2.21	1.19	-0.77	-0.60	-0.08	-1.65	4.53	1.29	0.01	1.17	2.34
Mainland Sectoral Employments												
98 1. Agriculture	2.87	-1.60	-2.56	1.23	-0.13	-0.16	0.12	2.24	-5.38	-1.06	5.32	0.89
99 2. Mining	7.42	-4.56	-3.77	1.93	-0.32	-0.32	0.21	2.31	-13.83	-1.44	11.01	-1.37
100 3. Manufacturing	-0.08	-3.27	-1.61	0.43	-0.38	0.01	0.46	1.60	-0.29	0.19	2.88	-0.06
101 4. Utilities	-0.18	-3.53	-0.89	0.49	-0.54	0.22	0.12	-13.50	-0.18	0.13	11.54	-6.31
102 5. Construction	-1.54	-2.33	1.48	-1.82	-0.27	0.10	0.48	0.84	1.32	5.84	-1.05	3.06
103 6. Margin industries	-2.23	-2.60	-0.76	0.38	-0.31	0.12	-0.08	1.32	1.75	0.45	4.30	2.33
104 7. Communications	-4.12	-3.93	-0.69	0.73	-0.17	-0.10	0.27	4.09	3.89	-0.24	4.20	3.92
105 8. Finance	-1.64	-2.60	0.24	-0.05	-0.30	0.13	0.22	4.56	1.44	0.60	2.67	5.28
106 9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
107 10. Public administration	-0.28	-0.42	0.20	0.59	1.62	0.01	0.00	-3.32	0.26	0.04	0.57	-0.74
108 11. Community services	-0.46	-0.62	0.61	0.28	1.10	0.07	-0.40	0.26	0.59	0.07	0.87	2.36
109 12. Entertainment and recreation	-1.83	-1.44	1.75	-0.20	-0.25	0.14	0.14	3.87	2.18	0.28	-1.19	3.45

Table 4.7: Summary Table: Decomposition of Regional Macroeconomic and Sectoral Outcomes, 1992/93 - 1998/99 (continued)

Variable	Export supply shifts (1)	Real wage (2)	House-hold related (3)	C'wealth Gov't (4)	Regional gov't (5)	Demo-graphic (6)	Domestic supply shifts (7)	Technical change (8)	Foreign factors (9)	Capital supply shifts (10)	Other (11)	Total (12)
Tasmanian Sectoral Exports												
110 1. Agriculture	-23.23	0.80	-3.22	1.39	-0.22	-0.59	1.10	11.78	14.54	-0.93	-0.13	1.30
111 2. Mining	-32.46	-14.74	-12.13	6.78	-1.05	-0.85	0.91	38.97	5.67	-4.86	16.33	2.56
112 3. Manufacturing	7.75	-6.35	-7.31	2.61	-1.78	-0.79	0.50	10.67	-7.88	-3.11	10.83	5.14
113 4. Utilities	-10.74	-7.44	-9.54	3.71	-0.17	-0.83	-0.23	5.08	8.46	-4.98	19.22	2.54
114 5. Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
115 6. Margin industries	-10.74	-7.44	-9.54	3.71	-0.17	-0.83	-0.23	5.08	8.46	-4.98	19.22	2.54
116 7. Communications	-10.74	-7.44	-9.54	3.71	-0.17	-0.83	-0.23	5.08	8.46	-4.98	19.22	2.54
117 8. Finance	-10.74	-7.44	-9.54	3.71	-0.17	-0.83	-0.23	5.08	8.46	-4.98	19.22	2.54
118 9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
119 10. Public administration	-10.74	-7.44	-9.54	3.71	-0.17	-0.83	-0.23	5.08	8.46	-4.98	19.22	2.54
120 11. Community services	-10.74	-7.44	-9.54	3.71	-0.17	-0.83	-0.23	5.08	8.46	-4.98	19.22	2.54
121 12. Entertainment and recreation	-10.74	-7.44	-9.54	3.71	-0.17	-0.83	-0.23	5.08	8.46	-4.98	19.22	2.54
Mainland Sectoral Exports												
122 1. Agriculture	2.11	1.05	-3.16	1.17	-0.33	-0.77	0.62	7.41	-4.07	-0.83	2.85	6.05
123 2. Mining	4.28	-1.79	-1.84	1.26	0.03	-0.17	0.03	4.31	-9.13	-1.00	10.34	6.33
124 3. Manufacturing	-2.85	-7.93	-10.16	3.81	-1.01	-1.27	0.87	12.29	0.29	-4.55	16.96	6.45
125 4. Utilities	-15.26	-8.21	-11.25	4.40	-0.72	-1.34	1.19	10.38	13.90	-4.97	20.06	8.19
126 5. Construction	-15.26	-8.20	-11.24	4.39	-0.72	-1.34	1.19	10.38	13.93	-4.97	20.05	8.21
127 6. Margin industries	-15.26	-8.21	-11.25	4.40	-0.72	-1.34	1.19	10.38	13.90	-4.97	20.06	8.19
128 7. Communications	-15.26	-8.21	-11.25	4.40	-0.72	-1.34	1.19	10.38	13.90	-4.97	20.06	8.19
129 8. Finance	-15.26	-8.21	-11.25	4.40	-0.72	-1.34	1.19	10.38	13.90	-4.97	20.06	8.19
130 9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
131 10. Public administration	-15.26	-8.21	-11.25	4.40	-0.72	-1.34	1.19	10.38	13.90	-4.97	20.06	8.19
132 11. Community services	-15.26	-8.21	-11.25	4.40	-0.72	-1.34	1.19	10.38	13.90	-4.97	20.06	8.19
133 12. Entertainment and recreation	-15.26	-8.21	-11.25	4.40	-0.72	-1.34	1.19	10.38	13.90	-4.97	20.06	8.19

Table 4.7: Summary Table: Decomposition of Regional Macroeconomic and Sectoral Outcomes, 1992/93 - 1998/99 (continued)

Variable	Export supply shifts (1)	Real wage (2)	House-hold related (3)	C'wealth Gov't (4)	Regional gov't (5)	Demo-graphic (6)	Domestic supply shifts (7)	Technical change (8)	Foreign factors (9)	Capital supply shifts (10)	Other (11)	Total (12)
Tasmanian Sectoral Basic Prices												
134 1. Agriculture	0.37	-0.84	-1.33	0.50	-0.06	-0.08	-0.01	-0.53	-1.64	-0.50	4.39	0.26
135 2. Mining	-0.39	0.21	-1.14	0.40	-0.01	-0.11	0.09	-2.31	-0.80	-0.35	3.65	-0.75
136 3. Manufacturing	0.49	-0.03	-0.91	0.26	0.03	-0.04	0.08	-1.12	-0.81	-0.26	3.35	1.03
137 4. Utilities	1.34	-0.66	-1.74	0.44	3.33	-0.04	0.01	-7.17	-1.42	-0.58	7.81	1.31
138 5. Construction	0.01	1.18	-0.09	-0.14	-0.11	-0.03	-0.04	-1.17	-0.05	0.11	1.57	1.24
139 6. Margin industries	-0.19	-0.22	0.21	-0.14	-0.16	-0.02	-0.47	0.28	0.21	-0.01	1.38	0.87
140 7. Communications	-0.17	0.90	-0.36	0.17	0.05	-0.02	0.01	-4.28	0.03	-0.07	2.13	-1.61
141 8. Finance	-0.18	-0.24	0.08	-0.02	-0.07	-0.02	-0.08	2.80	0.17	-0.04	-0.54	1.87
142 9. Dwellings	-0.94	-1.45	3.13	-1.41	-0.74	-0.20	-1.92	3.38	2.26	0.02	-1.25	0.88
143 10. Public administration	-0.06	1.00	-0.12	0.06	0.09	-0.01	-0.04	-2.32	0.03	-0.03	1.95	0.55
144 11. Community services	-0.07	0.74	-0.06	0.04	0.12	0.00	-0.03	-0.49	0.04	0.00	1.73	2.00
145 12. Entertainment and recreation	-0.20	1.60	0.31	-0.22	-0.21	-0.03	-0.62	2.71	0.47	0.00	-0.65	3.15
Mainland Sectoral Basic Prices												
146 1. Agriculture	2.25	-1.06	-1.82	0.79	-0.05	-0.11	0.10	-0.40	-3.60	-0.70	4.79	0.19
147 2. Mining	3.85	-0.78	-1.94	0.84	-0.09	-0.17	0.16	-0.14	-6.64	-0.66	4.08	-1.48
148 3. Manufacturing	0.74	0.06	-0.99	0.31	0.02	-0.04	0.10	-1.23	-1.04	-0.22	3.04	0.75
149 4. Utilities	0.80	-0.36	-0.90	0.36	2.80	0.06	0.12	-8.69	-1.31	-0.10	7.86	0.63
150 5. Construction	0.09	0.86	-0.13	-0.11	-0.03	-0.01	0.08	-2.23	-0.10	0.24	1.73	0.39
151 6. Margin industries	-0.57	0.16	-0.50	0.21	-0.02	0.01	0.02	-1.28	0.41	0.03	2.25	0.70
152 7. Communications	-1.54	0.12	-0.71	0.43	-0.04	-0.07	0.17	-1.25	1.44	-0.18	1.98	0.35
153 8. Finance	-0.72	0.58	-0.09	0.05	0.00	0.05	0.13	0.76	0.65	0.24	0.72	2.37
154 9. Dwellings	-0.89	-0.81	3.48	-0.94	-0.63	0.06	-0.86	2.24	1.60	0.54	-0.20	3.59
155 10. Public administration	0.13	1.33	-0.39	0.15	0.15	-0.02	0.05	-2.65	-0.21	-0.06	2.31	0.79
156 11. Community services	0.00	0.87	-0.15	0.08	0.13	0.00	0.00	-0.68	-0.05	-0.01	1.95	2.13
157 12. Entertainment and recreation	-0.21	0.03	-0.06	0.10	0.07	0.02	0.06	0.89	0.19	0.00	0.12	1.20

To further facilitate the discussion of the results, I have concentrated on the results in Column (1) and Columns (7) through (11) of Table 4.7. These explain the bulk of the difference between the growth rates of the two economies. It is important to note that each column in Table 4.7 consists of an aggregation of the impacts of a large number of sub-shocks. Tables D.1 through to D.6 in Appendix D go some way towards disaggregating the individual impacts of these sub-shocks, at least for those summarised within Columns (1) and (7) through to (11) in Table 4.7. However, even the results presented in Tables D.1 through D.6 are themselves typically the sum of the results of a very large number of sub-shocks, of which space does not permit individual identification. To make this point more concrete, it is worth noting that in total, Table 4.7 and Tables D.1 through D.6 summarise the results of approximately 1,600 individual shocks[80] delivered to the model in each of the six years between 1992/93 and 1998/99. Some aggregation of these results is required to make tractable the task of presenting and explaining them.

One of the conclusions from the investigation of these results will be that no single factor or set of factors adequately explains a large proportion of the observed changes in economic activity within the two regions. On the contrary, these changes in activity can be traced to a very large number of individual shocks, each with varying and countervailing impacts on the observed economic outcomes for the two regional economies. However, while the results cannot be used to tell a simple story about the causes for the observed changes in regional economic activity, they can be used to answer questions about what were the relative impacts on the two economies of the many and various shocks to which they were subject. The discussions that follow concentrate on those shocks and sets of shocks that had the largest economic consequences.

Ultimately, the large number of shocks and results requires that the presentation and discussion of the results be directed towards more modest ends than that of a complete discussion of the determinants of the changes in both Tasmania's and Australia's economic activity over the period. These ends are threefold. First, to both identify and explain those factors that had the largest effect on the relative growth rates of the two economies. Second, to provide a ranking of the impacts of the various exogenous shocks to which the two economies were subject; that is, to distinguish the unimportant from the important

[80] Counting variables upon which the homotopy shocks operate.

shocks. And finally, to make clear that the results of the model are explicable by reference to the model's theory and data, thus demonstrating the successful implementation of the model.

4.5.2 Shifts in Export Supply Schedules

4.5.2.1 Introduction

Column (1) of Table 4.7 summarises the impacts of the shifts in export supply schedules that occurred in both regions over the study period. As discussed in Sections 2.17 and 4.2.1, shifts in export supply schedules are implemented via shocks to non-spreading phantom taxes on exports from each region. These shifts caused the annual average growth rate of the Mainland economy to lag that of the Tasmanian economy, and also had relatively large impacts on the industrial structure of both economies. The growth rate in the Mainland's real gross regional product lagged that of the Tasmanian economy by approximately 0.53 per cent per annum, reflecting a gap in employment growth rates between the two economies of approximately 0.87 per cent per annum. In Tasmania, there was a strong shift in economic activity away from Mining (employment and output declined by 9.25 and 8.76 per cent per annum, respectively) due to rising phantom taxes on exports from this sector. The impact of these shocks on the Tasmanian economy was somewhat attenuated by the nominal depreciation of the exchange rate brought about by rising phantom taxes on Mainland non-traditional exports. The latter ultimately caused output of the Tasmanian Manufacturing sector to expand, averting what would otherwise have been a contraction in the output of this sector arising from rising phantom taxes on Tasmanian non-traditional exports. There were smaller shifts in activity towards the Utilities, and Agriculture sectors in Tasmania. These shifts reflected rising export and intermediate input sales by these sectors, brought about by the indirect effects of rising phantom taxes levied on Mainland non-traditional exports. In the Mainland economy, there were shifts in activity towards Agriculture and Mining, reflecting expanding intermediate and export sales by these two industries. Other Mainland sectors contracted. This was largely due to a fall in the volume of export sales by these sectors, brought about by upward shifts in their export supply schedules in response to rising non-traditional phantom tax rates.

A more complete picture of the factors underlying the results in Column 1 of Table 4.7 can be obtained from Table D.1 in Appendix D. This table contains a disaggregation of the results in Column (1), identifying six broad sub-shocks. These six sub-shocks in turn summarise the results of the shocks to the non-spreading phantom tax rates on individual commodity exports from each of the model's two regions. The results for these shocks have been aggregated according to the type of export (traditional, non-traditional, or exogenous) and the export's region of origin (Tasmania or Mainland). Specifically, the columns in Table D.1 aggregate the results for:

Column 1: $powtax4ph_{i,1}$ $i \in$ TRAD

Column 2: $powtax4ph_{i,1}$ $i \in$ NTRAD

Column 3: $powtax4ph_{i,1}$ $i \in$ EXOG

Column 4: $powtax4ph_{i,2}$ $i \in$ TRAD

Column 5: $powtax4ph_{i,2}$ $i \in$ NTRAD

Column 6: $powtax4ph_{i,2}$ $i \in$ EXOG

In examining the consequences of these shocks in more detail, we shall find that the factors most important in explaining the Tasmanian results in Column (1) of Table 4.7 are rising phantom taxes on: i. Tasmanian traditional and non-traditional exports; and ii. Mainland non-traditional exports[81].

It is clear from Table D.1 that, *ceterus paribus*, traditional and non-traditional export supply shifts in Tasmania alone caused the size of the Tasmanian economy to contract at an annual average rate of 1.30 per cent (C4;R1[82]). However, this contraction was almost entirely offset by the expansionary impact on the Tasmanian economy (+1.23 per cent per annum) of the contraction in mainland non-traditional exports (C6;R1). The latter shock effectively left the net impact on the Tasmania economy of nation-wide export supply shifts as mildly contractionary (-0.13 per cent contraction - C9;R1). Furthermore, the contraction in non-traditional export volumes from the Mainland caused the Mainland

[81] The two exogenous export industries (Residential Construction, and Dwellings) have virtually no exports. Hence shifts in their export demand schedules have no discernible impact on the model results. They are included in Table D.1 for completeness only.

[82] "Column 4; Row 1"

economy to contract at an annual average rate of 0.64 per cent (C6;R2). Overall, the three sets of factors summarised by Columns (1), (2) and (6) opened a net gap in the growth rates of the two economies of +0.56[83] per cent per annum. The results for these three columns are discussed in more detail in the remainder of this section.

4.5.2.2 Shifts in Tasmanian foreign export supply schedules

In general, phantom tax rates increased on both traditional (Column 1) and non-traditional (Column 2) Tasmanian exports over the study period. The resulting shifts in Tasmanian export supply schedules lifted the Tasmanian foreign export price index by an annual average of 0.85 per cent per annum (C4;R27 & 57). This generated an annual average reduction in total export volumes of 9.76 per cent per year (C4;R11). The Mining sector was the hardest hit, with export volumes declining by 45.37 per cent per annum, output declining by 16.18 per cent, and employment declining by 17.26 per cent (C4; R111, R63, & R87 respectively). The decline in activity in this sector was due almost entirely to the direct impact of the rising phantom tax on its own export volumes[84] (Column 1).

Exports of the Tasmanian Agriculture sector also experienced a substantial volume reduction (27.87 per cent per annum, C1;R110), however this translated into a relatively small (0.45 per cent per annum) reduction in output (C1;R62). This mitigation of the output response was in part due to Tasmanian Agriculture exporting a smaller proportion of its output (approximately 18%) relative to Mining (approximately 30%). This attenuated the impact of declining export volumes on the sector's output: *ceterus paribus*, the decline in export volumes caused Agriculture's output to contract at an annual average rate of approximately 4.5† per cent per annum. The second attenuating factor was increasing inter-industry sales, particularly to the Tasmanian Meat Small Goods and Poultry industry (sales to which accounted for almost one third of Tasmanian Agriculture's output). This industry experienced an annual average reduction in the power of its export phantom tax of approximately 7† per cent per annum, leading to sharply rising export volumes (+77† per cent per annum) and output (+23† per cent per annum). *Ceterus paribus*, rising intermediate sales caused Agriculture's output to grow by approximately

[83] (0.01 + 0.00 + -0.64) - (-0.69 + -0.61 + 1.23)

[84] The power of the phantom tax on Mining exports from Tasmania rose at an annual average rate of approximately 5† per cent per annum over the study period.

4.0† per cent per annum - largely offsetting the negative impact on its output of its own declining export sales.

Operating on their own, the phantom taxes on Tasmanian traditional exports induced a fall in the Tasmanian non-traditional export price deflator of approximately 0.05† per cent per annum. This reflected the declining economic activity, and hence price level, in the state as a whole. In the absence of rising phantom taxes on non-traditional export volumes (Column 2) this would have provided for a small rise in non-traditional export volumes. Hence, when combined with the increasing exports of the Meat Small Goods and Poultry industry[85], exports of the Manufacturing sector would have risen by approximately 7.00 per cent (C1;R112). The growth in export sales contributed approximately 0.75* percentage points per annum to the growth rate of Manufacturing, leaving this the only Tasmania sector to expand its output in the face of rising phantom taxes on traditional exports (C1;R64). Exports of other non-traditional export commodities also rose, by approximately 0.6 per cent (C1;R113-121). However, the expansion in exports from each of these sectors was inadequate to offset the impact on their outputs of declining sales to consumers, investors, and other industries. In particular, the Communications, Community Services, and Entertainment and Recreation sectors were each adversely affected by declining Tasmanian consumption spending. The largest factor explaining the contractions in activity in both Utilities and Finance were declining intermediate sales. The Construction sector contracted in the face of declining Tasmanian investment expenditure.

Over the study period, phantom tax rates were also rising on Tasmanian non-traditional exports (Column 2). These generated a rise in the foreign-currency price of non-traditional exports (up by 2.73* per cent per annum), and hence a significant reduction in non-traditional export volumes. The output of two industries in the Manufacturing sector (Meat Small Goods and Poultry, and Iron Ore and Basic Metal Products) were each treated as traditional export commodities during the simulations. Hence, Manufacturing exports only contracted by a total of -7.07 per cent (C2;R112), since exports of the two traditional export industries expanded as their foreign currency export prices declined. Overall, output of the Manufacturing sector contracted by 1.66 per cent per annum (C2;R64), due largely to falling export volumes. Output of Mining rose by approximately 0.38 per cent

[85] Which is treated as a traditional export.

per annum (C2;R63). This was due almost entirely to rising export volumes from this sector, the foreign currency price of which was falling due to the depressing effect on Tasmanian activity and prices of the rising phantom taxes on non-traditional exports. However, the same effect did not translate into an increase in activity for the Tasmanian Agriculture sector. Instead, the Tasmanian Agriculture sector contracted by 1.25 per cent, due to a fall in inter-industry sales to the Tasmanian Manufacturing sector.

Column (4) provides the total effect of the shifts in Tasmanian export supply schedules. With declining export volumes inducing a contraction in the output of Tasmanian export industries, this in turn required those industries to reduce employment. With capital / labour ratios (ultimately) rising in all industries (C4; R86-R97), and the cost of constructing capital in Tasmania falling more slowly than the GSP deflator (C4; R23 & R42 respectively), rates of return on Tasmanian capital fell, and hence so too did Tasmanian investment. Tasmanian real investment declined by 2.47 per cent (C4;R7). This is reflected in Construction being the second worst affected sector (output declined by 1.98 per cent, C4;R66). With employment and rental rates falling across all sectors, the gross income of Tasmanian households also fell (by approximately $2.0^{\dagger}$ per cent). Approximately one third of this fall ($0.7^{\dagger}$ percentage points) was due to declining rentals on capital, and just over one-half ($1.1^{\dagger}$ percentage points) was due to declining wage income. With export volumes having fallen faster than phantom tax rates rose, falling phantom tax revenues also contributed approximately $0.2^{\dagger}$ percentage points to the decline in gross income. The impact on disposable income of the fall in gross income was somewhat mitigated by rising unemployment benefit payments. However, overall, real Tasmanian household disposable income declined by $0.81^{\dagger}$ per cent, causing the same reduction in real household consumption (C4;R9).

The contractions in Tasmanian real private consumption and investment expenditure are reflected in the results for those sectors that exported a relatively small share of their output. Around four-fifths of the declines in the outputs of the Tasmanian Communications, Finance, Community Services, and Entertainment and Recreation sectors were attributable to declining Tasmanian real consumption expenditure. Essentially all of the contraction in the Construction sector was attributable to the decline in Tasmanian gross fixed capital formation.

Leaving aside Dwellings (the output of which is fixed by a fixed capital stock) and both Public Administration and Community Services (the outputs of which are largely fixed by exogenous government consumption), the Manufacturing sector was ultimately the Tasmanian sector least adversely affected by rising export supply schedules within Tasmania (its output declined by 0.84 per cent (C4;R64). The worst affected was the Mining sector (-16.18 per cent), followed by Construction (-1.98 per cent).

4.5.2.3 Shifts in Mainland foreign export supply schedules

The contraction in the size of the Tasmanian economy induced by rising phantom taxes on Tasmanian exports was almost entirely offset by the effects of phantom taxes on Mainland non-traditional exports (C6;R1). These taxes caused the Mainland non-traditional foreign currency export price index to increase by approximately 1.50[†] per cent per annum, reducing Mainland non-traditional export volumes by approximately 14.15 per cent per annum (C6;R125-R133). Aggregate Mainland export volumes contracted by significantly less than this amount (3.37 per cent per annum, C6;R12) reflecting the rise in volumes of traditional exports, which benefited from a nominal depreciation of the exchange rate. The latter caused the output of Mainland Agriculture and Mining to rise, while the output of all other Mainland sectors contracted. Falling export volumes accounted for approximately two thirds of the contraction in the Mainland Margins sector; approximately one half of the contraction in the output of both the Communications and Community Services sectors; and approximately one third of the contraction in the Entertainment and Recreation sectors. The remaining reductions in the activity of both the Community Services and Entertainment and Recreation sectors were due to declining Mainland consumption expenditure (which was down by 0.52 per cent per annum, C6;R10). The latter fell as total Mainland employment fell (down by 0.95 per cent per annum, C6;R6). Overall, real gross regional product in the Mainland economy contracted at an annual average rate of 0.64 per cent (C6;R2).

While the rise in these taxes caused the Mainland economy to contract, they caused the Tasmanian economy to expand at an annual average rate of 1.23 per cent (C6;R1). At the national level, the decline in the volume of Mainland exports caused real GDP to fall at an annual average rate of 0.87 per cent (C6;R43). However, real domestic absorption did not fall as quickly as GDP: real consumption expenditure declined by only 0.50 per cent and real government expenditure was exogenous (and unchanged). With real GDP falling faster than real absorption, the ratio of the balance of trade surplus to GDP fell by 0.18 percentage points per annum (C6;R60). This fall occurred despite an apparent depreciation in the real exchange rate (C6;R58 & 59) because the phantom taxes on Mainland non-traditional exports caused the Australian dollar export price index to increase so strongly (at an annual average rate of 2.75 per cent, C4;R52). The rise in the domestic currency export price index was sufficiently great that they were associated with a nominal depreciation of 2.26 per cent per annum (C4;R57), bringing the increase in the foreign currency export price to approximately 0.5 per cent per annum.

The depreciation in the nominal exchange rate caused the foreign currency prices of Tasmanian exports (which were of course not subject to the Mainland non-traditional phantom taxes) to fall. This provided an immediate fillip to the Tasmanian Agriculture, Mining and Manufacturing sectors. Activity in these sectors expanded by 2.30, 7.52, and 2.05 per cent per annum respectively (C6;R62-R64). Activity in both the Utilities and Finance sectors expanded, due largely to increased intermediate input sales to Tasmanian firms, but also helped by rising Tasmanian consumption expenditure. The Construction sector expanded by 1.65 per cent per annum (C6;R66), due to a rise in Tasmanian real investment (up by 1.87 per cent per annum, C6;R7). With Tasmanian household consumption expenditure rising at an annual average rate of 0.36 per cent (C6;R9), activity in the Community Services and Entertainment and Recreation sectors also expanded. Overall, employment in the Tasmanian economy increased by 1.61 per cent per annum (C6;R5), leading to an increase in real gross regional product of 1.23 per cent per annum (C6;R1). As indicated earlier, this increase was almost sufficient to offset the contractionary impact on Tasmania of rising Tasmanian phantom export taxes. Furthermore it opened a gap in the relative growth rates of the two economies of 1.87 per cent per annum.

4.5.3 Supply shifts to domestic usages

4.5.3.1 Introduction

Column (7) of Table 4.7 aggregates the effects of the shifts in phantom taxes on domestic usages of domestically sourced commodities, which were deduced during the historical simulation. As discussed in Sections 2.17 and 4.2.1, these phantom taxes explain the difference between exogenously determined commodity purchaser's prices (for households) and price deflators on final demands (for other users), and the values the model would otherwise have calculated for these variables had the phantom taxes not been determined endogenously.

The phantom taxes on domestic usage caused the relative annual average growth rate of the Tasmanian economy to lag that of the Mainland by an average of almost one third of one per cent per annum. Table D.2 in Appendix D disaggregates the results in Column 7, and makes clear that this gap was due largely to phantom taxes on Mainland sourced inputs to both Mainland capital formation and Mainland household consumption (Columns 4 and 8). Mainland phantom taxes on Mainland-sourced inputs to capital formation opened a gap in the relative growth rates of the two regional economies of approximately 0.14 percentage points per annum (C4; R1 & R2). Mainland phantom taxes on Mainland-sourced inputs to household consumption added a further 0.10 percentage points per annum to this gap (C8; R1 & R2).

4.5.3.2 Mainland sourced inputs to Mainland capital formation

Mainland phantom tax rates on Mainland sourced inputs to capital formation (Column 4) were falling over the period, such that the Mainland investment price index fell at an annual average rate of 0.95 per cent (C4;R24). This was a faster rate of decline than the Mainland gross regional product deflator (which fell by 0.21 per cent per annum, C4;R42), leading to a rise in expected rates of return on capital. Hence, Mainland real investment increased at an annual average rate of 0.75 per cent (C4;R8). This caused activity in the Mainland Construction sector to expand, with investment demands accounting for over four fifths of the 0.61 per cent per annum increase in activity in this sector (C4;R78). Rising investment expenditure also contributed to the expansions in activity experienced by both the Manufacturing and Finance sectors, explaining about one third of the extra activity in each.

While the increase in Mainland investment expenditure caused Mainland employment (and hence Mainland gross wage income) to rise, Mainland real household consumption expenditure fell at an annual average rate of 0.25 per cent (C4;R10). Tasmanian real household consumption expenditure also fell, at a slightly faster rate. These falls in real consumption were due to the effects on both Mainland and Tasmanian household gross income of the falling phantom tax receipts on sales of Mainland-sourced goods to Mainland capital creators. The falls in these receipts were borne by the owners of Mainland capital in proportion to their capital ownership shares. Nearly all the physical capital owned by Mainland households is located on the Mainland. Hence the implications of falling phantom tax receipts for the gross income of Mainland households is clear. Tasmanian households receive approximately half of their capital rentals from the Mainland. Hence, their gross incomes were not insulated from the falling Mainland phantom tax receipts either.

Real consumption expenditure at the national level fell by 0.25 per cent per annum (C4;R45), allowing an expansion in the balance of trade surplus. The ratio of the balance of trade to GDP increased at an annual average rate of 0.09 percentage points (C4;R43). This required a real depreciation of the exchange rate, which was associated with a nominal depreciation of 0.20 per cent per annum (C4;R57). Hence, the aggregate regional foreign currency export price index declined in both regions, at an annual average rate of approximately 0.06 per cent per annum (C4;R27, R28 & R57). This caused export volumes to expand in both Tasmania and the Mainland, by 0.72 and 0.63 per cent per annum respectively (C4;R11 & R12). However, unlike the Mainland, aggregate activity in Tasmania did not receive a stimulus from increased investment expenditure. On the contrary, the decline in household consumption expenditure precipitated a decline of 0.35 per cent per annum in regional investment expenditure, due largely to declining investment in Dwellings. With the increase in Tasmanian export volumes having provided only a partial offset against the impacts on output from the declines in both real consumption and real investment expenditure, real gross regional product fell, by 0.03 per cent per annum (C4;R1).

Examining the impact of the shocks subsumed by Column (4) on Tasmanian sectoral outputs, it is clear that activity in sectors supplying traditional export commodities expanded, while those sectors supplying inputs to capital formation and consumption contracted. Agriculture expanded by 0.22 per cent per annum (C4;R62), with approximately one third of this expansion attributable to increasing export sales, and approximately two-thirds attributable to increasing inter-industry sales to Tasmanian

Manufacturing. Mining output expanded by 0.76 per cent per annum (C4;R63), with approximately half of this absorbed by rising foreign export volumes and the remainder absorbed by rising inter-industry sales to Tasmanian firms. The output of Manufacturing rose by 0.20 per cent per annum (C4;R64), due largely to rising export volumes. Construction activity contracted by 0.29 per cent per annum (C4;R66), due to the fall in real Tasmanian investment expenditure. Activity in the Communications, Finance, Community Services, and Entertainment and Recreation sectors also contracted, with these falls being largely attributable to the decline in real Tasmanian household consumption expenditure.

4.5.3.3 Mainland sourced inputs to Mainland household consumption

Over the study period, there was a small overall rise in phantom taxes on Mainland-sourced commodities consumed by Mainland consumers (Column 8). This caused a small rise in the national CPI deflator relative to the national GDP deflator (C8;R51 & R56). With nominal wages indexed to the CPI, this caused a rise in the real producer wage, and hence a rise in the marginal product of labour as national employment declined (by 0.10 per cent per annum, C8; R5 & R6[86]). This caused real GDP to fall by approximately 0.07 per cent per annum (C8;R43). Real GDP fell faster than real consumption (which only fell by 0.03 per cent per annum) because a high proportion of the phantom tax revenue was returned to Mainland consumers in recognition of their ownership of capital in those industries producing the commodities upon which the tax revenue accrued. This effectively compensated Mainland consumers via higher nominal disposable income for what would otherwise have been a decline in real consumption expenditure brought about by the rising national CPI. While national investment expenditure also declined, as the capital-labour ratio rose, the absolute value of this fall was inadequate to account for the decline in real GDP. With real government expenditure fixed, the difference between the fall in real output and the fall in domestic absorption was met via a decline in the balance of trade surplus. The ratio of the balance of trade surplus to GDP declined at an annual average rate of 0.01 per cent (C8;R60). This required an appreciation of the real exchange rate, which was associated with a nominal appreciation of 0.09 per cent per annum (C8;R57).

Tasmanian real gross regional product declined by 0.16 per cent per annum (C8;R1). This decline was caused by two factors. The most important of these was the fall in Tasmanian nominal gross income arising from the decline in phantom tax receipts from the Mainland. Tasmanian households did not benefit from an increase in their aggregate receipts of phantom tax revenue in the same way as Mainland households did. On the contrary - receipts of phantom tax revenue by Tasmanian households declined. The extent of this decline was alone sufficient to reduce Tasmanian household nominal gross income by approximately 0.20[†] per cent per annum. This followed from two features of the database. First, approximately half of the capital owned by Tasmanian households was located in the Mainland. Second, this capital was weighted towards (relative to the distribution of the capital ownership of Mainland households) industries producing commodities on which phantom tax receipts were declining[87]. As a result, real Tasmanian consumption expenditure fell at an annual average rate of 0.23 per cent per annum (C8;R9).

The second factor was declining export volumes. Total exports declined by 0.02 per cent per annum (C8;R11), due to the appreciation in the nominal exchange rate. Traditional export volumes experienced the largest declines (Agriculture's exports declined by 0.12 per cent and Mining exports declined by 0.03 per cent, C8; R110 & R111). Manufacturing exports were insulated from the effects of the appreciation in the nominal exchange because this sector subsumes a number of commodities that feature more prominently (relative to traditional exports) in the budget of Tasmanian households. The decline in real Tasmanian consumption expenditure caused the Australian dollar price of these commodities to fall at approximately the same rate as the nominal exchange rate appreciated.

Declining Tasmanian real consumption and real exports caused a contraction in employment and hence a rise in the Tasmanian capital-labour ratio. This caused rates of return on Tasmanian capital to fall, leading to a decline in real investment. Tasmanian real gross fixed capital formation declined at an annual average rate of 0.45 per cent per annum (C8;R7). With real investment, consumption, and exports all contracting, real Tasmanian

[86] A good approximation of the national employment result is {0.02 x -0.21} + {0.98 x -0.09}.
[87] In particular, industries 23. *Motor Vehicles*; 24. *Machinery, Equipment, and Miscellaneous Manufacturing*; and 33. *Finance*.

gross regional product declined at an annual average rate of 0.16 per cent (C8;R1), reflecting declining employment of 0.21 per cent per annum (C8;R5).

Both the Tasmanian Agriculture and Mining sectors experienced small contractions in output (by 0.06 and 0.09 per cent per annum, C8; R62 & R63). This was attributable to contracting intermediate and export sales, with declines in the former being the more important of the two factors. Output of Manufacturing declined by approximately 0.17 per cent per annum (C8;R64). Approximately half of this was due to declining sales to Mainland households, with the remainder due to declining intermediate sales (both to Tasmanian and Mainland firms) and declining sales to Tasmanian households. Declining Tasmanian consumption expenditure accounted for the bulk of the contractions in the Tasmanian Communications, Finance, Community Services, and Entertainment and Recreation sectors. Output of the Construction sector declined by 0.39 per cent per annum (C8;R66), in response to the fall in Tasmanian investment expenditure.

4.5.4 Technical Change

4.5.4.1 Introduction

Results for four types of technological change[88] are computed during the historical simulations: (i) that relating to primary factor usage[89]; (ii) that relating to the usage of all inputs into current production[90]; (iii) that relating to inputs to capital formation[91]; and (iv) that relating to the usage of specific commodities[92]. Column (8) of Table 4.7 summarises the impacts of the movements in these types of technological change over the study period. Technological change caused economic activity to expand strongly in both regions. However the Mainland experienced a more rapid growth in real output (3.53 per cent per annum, C8;R2) than that experienced by Tasmania (3.19 per cent per annum, C8;R1). As

[88] Excluding the various twists, which, while also embodying technological change, are of a nature that leaves costs unaffected. The effects of the various twists are discussed in Section 4.5.7.

[89] Measured by movements in $f\_a\_facjr_{j,r}$. See Sections 2.2.9 and 2.2.10.

[90] Measured by movements in $a\_in1_{j,r}$. See Sections 2.2.7 and 2.2.8.

[91] Measured by movements in $a\_in2_{j,r}$. See Sections 2.2.7 and 2.2.8.

[92] Measured by movements in ai_i and ais_s. See Section 2.2.7.

a result, technological change caused the relative growth rate of the Tasmanian economy to lag that of the Mainland by an annual average of approximately 0.34 percentage points.

A clearer picture of the factors contributing to this difference in regional growth rates can be obtained by disaggregating the individual impacts of the shocks subsumed within Column (8). Table D.3 goes some way towards this, disaggregating Column (8) into the individual contributions of eight sets of sub shocks. In turn, each of the columns in Table D.3 summarises the individual contributions of a large number of shocks, as follows:

Column (1): Sum of Tasmanian primary factor technical change by industry ($f\_a\_facjr_{j,1}$);

Column (2): Sum of Mainland primary factor technical change by industry ($f\_a\_facjr_{j,2}$);

Column (3): Sum of Tasmanian all-input using technical change by industry ($a\_in1_{j,1}$);

Column (4): Sum of Mainland all-input using technical change by industry ($a\_in1_{j,2}$);

Column (5): Sum of Tasmanian all-input using technical change in capital creation by industry ($a\_in2_{j,1}$);

Column (6): Sum of Mainland all-input using technical change in capital creation by industry ($a\_in2_{j,2}$);

Column (7): Sum of commodity-using technical change across all users, Tasmanian sourced inputs ($ais_{i,1}$); and

Column (8): Sum of commodity-using technical change across all users, regardless of source, (ai_i).

The most important of these shocks, in terms of explaining the gap in the relative growth rates of the two regional economies, are contained in Columns (3) and (4) (which summarise the effects of all-input using technical change). Properly classified, the remaining categories had a minor impact on relative regional growth rates. Primary factor technical change (Columns (1) and (2)) had little effect on the relative sizes of the economies, causing only a very small contraction (-0.04 percentage points per annum[93]) in the relative growth rate of the Tasmanian economy. Likewise, technical change in capital creation had little effect on relative growth rates, causing the Tasmanian economy to grow at a faster rate than the Mainland by only 0.05 percentage points per annum[94]. Similarly, commodity-using technical change in the two economies (Columns (7) and (8)) caused

[93] +2.33 + 1.41 - 0.01 - 3.76.

[94] +0.10 - 0.02 -0.00 -0.03.

only a very small (-0.03 percentage points per annum[95]) reduction in the relative growth rate of the Tasmanian economy. Given the relative importance of all-input using technical change in explaining the difference between the growth rates of the two economies, the remainder of the discussion in this section will concentrate on Columns (3) and (4) of Table D.3.

4.5.4.2 All-input using technical change in Tasmania

Over the study period, changes in all-input using technical change in Tasmania favoured the production of private and public consumption goods, while decreasing the efficiency with which export and investment goods were produced. The inputs required per unit production increased by approximately 0.8†, 1.3† and 0.8† percentage points per annum in the Tasmanian Mining, Manufacturing, and Construction sectors, respectively. The inputs required per unit of production decreased for all other sectors, favouring, in particular, the production of private and public consumption goods. These improvements ranged from a low of -0.1 percentage points per annum for Agriculture, through to a high of -1.0 percentage points per annum for Communications. The impacts of these changes in technical efficiency can be seen in the price deflators for the various components of GSP. Price deflators for public and private consumption fell: the Tasmanian private consumption deflator fell at an annual average rate of 0.68 per cent (C3;R25), while both the regional and Commonwealth government consumption deflators fell at an annual average rate of 0.73 per cent (C3; R29 & R31). However, the Tasmanian investment price index (C3;R23); foreign export price index (C3;R27), and interstate export price index (C3;R37), all increased. These price rises reflected the deterioration in the technical efficiency with which Tasmanian Mining, Manufacturing, and Construction were being produced over the period.

The increase in the price of Tasmanian exports and investment goods caused sharp contractions in both Tasmanian real investment and export volumes. The Tasmanian foreign currency export price index increased at an annual average rate of 0.50 per cent (C3; R27 & R57). This caused Tasmanian export volumes to contract at an annual average rate of approximately 4.79 per cent per annum (C3; R11). The interstate export price index

[95] -0.13 + 0.09 - 0.01 - -0.01.

(C3; R37) increased by 0.60 per cent per annum, causing a reduction in interstate export volumes of 1.25 per cent per annum (C3; R21). The Tasmanian investment price index increased at an annual average rate of 0.35 per cent (C3; R23), due to the deterioration in all-input using technical efficiency in the Tasmanian Construction sector. By driving up the asset price of capital, and hence reducing expected rates of return, this added to the contraction in real investment expenditure (-2.38 per cent per annum, C3; R7) that would otherwise have occurred from the declining capital rental rates arising from falling foreign and interstate exports.

Overall, employment in Tasmania declined by approximately 1.22 per cent per annum (C3; R5). Despite the fall in employment, real consumption expenditure declined by only 0.35 per cent per annum (C3; R9), with the impact of declining employment on this variable being mitigated by the decline in the regional household consumption deflator (C3; R25). Real gross regional product declined by approximately 0.88 per cent per annum. Surprisingly, this result is close to that which one would expect from a 1.22 per cent reduction in employment (1.22 x approx. 0.7 = 0.85) in the absence of technical change, implying that, overall, changes in all-input using technical efficiency had little direct impact on total output. As it was, the value-added weighted-average of the changes in all-input using technical efficiency within Tasmania over the period was quite close to zero. The impact of these changes on real GRP arose because deteriorations in technical efficiency were weighted towards sectors selling output to price sensitive agents (foreigners, interstate agents, investors), while improvements in technical efficiency were weighted towards sectors selling output to agents that were not as price sensitive (particularly government and, to a lesser extent, Tasmanian consumers).

The Tasmanian sectoral results reflected the pattern of technological change, with the worst affected sectors being Mining, Manufacturing, and Construction. Mining output contracted by 3.41 per cent per annum (C3; R63) with just under two-thirds† of this reduction being attributable to reduced export sales, as the technological deterioration caused Mining's foreign currency export price to rise. The remainder of the contraction in Mining output was due to reduced intermediate sales to Tasmanian firms, as the local economy contracted. Manufacturing output declined by approximately 2.45 per cent per annum (C3; R64). Approximately two-thirds† of this reduction was attributable to declining foreign export sales, approximately one-quarter† was attributable to declining interstate export sales, and the remainder was largely attributable to declining intermediate input sales to Tasmanian firms. Construction output contracted by 2.07 per cent per annum (C3; R64), reflecting the decline in Tasmanian real investment expenditure. The declines in activity in Communications and Finance were largely a reflection of declining intermediate input sales to Tasmanian firms, with a small contribution being made by declining Tasmanian real consumption expenditure. Just under one-third† of the decline in activity in the Entertainment and Recreation sector was attributable to declining local intermediate input sales, with the remainder being due to declining Tasmanian real consumption expenditure. The Dwellings sector was the only sector to increase its output. The only primary factor used by this sector is capital, implying that, with fixed capital stocks, only technical change can cause a change in its output. Over the study period, all input using technical efficiency for this sector increased at an annual average rate of 0.56 per cent per annum, causing an identical increase in output.

Considered in isolation, the shocks subsumed by Column (3) of Table D.3 caused the Tasmanian economy to contract relative to the Mainland at an annual average rate of 0.89[96] per cent per annum. However, changes in all-input using technical efficiency on the Mainland (Column 4) caused the Tasmanian economy to grow faster than the Mainland by an annual average of 0.57[97] percentage points per annum. The results in Column (4) are now considered in more detail.

4.5.4.3 All-input using technical change in the Mainland economy

Mainland all-input using technological change was weighted in favour of the non-traded goods sector and against the traded goods sector. While Agriculture and Mining were subject to relatively small movements in all-input using technical change, Manufacturing experienced a deterioration of roughly 1.4† per cent per annum. The Utilities sector (which primarily supplies intermediate inputs and inputs to household consumption) and Construction (which primarily supplies inputs to capital creation) experienced all-input using technological deterioration of approximately 0.8† and 0.7† per cent per annum respectively. The remaining Mainland sectors experienced improvements in all-input

[96] +0.01 - -0.88

[97] -0.28 - 0.29

using technical efficiency ranging from -0.1 per cent per annum (Community Services) and -0.8 per cent per annum (Communications).

These changes in technical efficiency caused a sharp rise in the traded goods price index (0.81 per cent per annum, C4; R57 & R59) which, for a given nominal exchange rate, induced a contraction in real export volumes. Ultimately, this contraction was isolated to the export sector suffering the technical deterioration - Manufacturing - but it was sufficient to precipitate a decline in investment (down by 1.08 per cent per annum) and real consumption (down by 0.37 per cent per annum). Overall, real GDP fell faster than real domestic absorption (-0.5 per cent per annum compared to -0.4 per cent per annum) implying a deterioration in the balance of trade deficit. This was associated with a real exchange rate appreciation (0.10 per cent per annum, C4;R59). However, the rise in the domestic currency index of traded goods prices was more than sufficient to secure the required real appreciation, and so a nominal depreciation (0.71 per cent per annum, C4;R57) was required.

The depreciation in the nominal exchange rate caused the foreign currency price of Tasmanian exports to fall by approximately 0.12 per cent per year (C4;R27 & R57). As a result, Tasmanian export volumes increased, by approximately 1.69 per cent per annum (C4;R11). While increasing Tasmanian export volumes, Mainland all-input using technical change dampened what would otherwise have been expansions in investment (C4; R7) and consumption (C4;R9). Rising prices for Mainland Manufactured goods caused the Tasmanian investment price index to rise sharply (by 0.55 per cent per year, C4;R23), dampening changes in expected rates of return and hence also dampening the investment response to the increase in activity in the Tasmanian traded goods sector. Household real consumption actually fell, by approximately 0.09 percentage points per annum. This was due to a number of factors. First, the real consumer wage in Tasmania fell by approximately 0.17 percent per annum (C4; R25). The rise in the Tasmanian CPI reflected both increasing prices for both Tasmanian and Mainland sourced Manufacturing, as well as rising import prices as the nominal exchange rate depreciated. Second, despite a rise in the demand for capital in Tasmania, the net capital rental receipts of Tasmanian households were subdued, due to declining receipts from their ownership of Mainland capital. Finally, the nominal depreciation increased the domestic currency cost of annual payments to foreigners by Tasmanian households.

The pattern of Tasmanian sectoral results largely reflected the strong growth in exports and subdued changes in investment and consumption experienced at the level of the regional macroeconomy. The fastest growing sector was Mining (2.29 per cent per annum, C4;R63), which benefited from the nominal depreciation (growth in exports added about 1.4† percentage points to its annual growth rate) and rising intermediate sales to Tasmanian firms (which added about 0.8† percentage points to its annual growth rate). Manufacturing activity expanded by 0.79 per cent per annum (C4; R64). About forty per cent of this growth (0.3† percentage points per annum) was due to rising sales to Mainland firms and consumers, as these substituted away from the relatively more expensive Mainland-sourced Manufacturing goods. Approximately the same proportion of Tasmania's Manufacturing's growth was attributable to rising foreign exports, and the remaining twenty percent of the sector's growth was due to rising intermediate sales to Tasmanian firms. The Tasmanian Agriculture sector grew at 0.61 per cent per annum (C4;R62). The growth in this sector was due in part (+0.2† percentage points per annum) to rising foreign exports, with this somewhat offset by falling interstate exports (-0.1† percentage points per annum). The remaining 0.5† percentage points of annual growth were due to rising intermediate input sales to the food processing sectors of the Tasmanian Manufacturing sector. The only other Tasmanian sectors to experience strong growth were Utilities (0.32 per cent per annum) and Finance (0.25 per cent per annum). The expansion of both sectors was attributable to rising sales of intermediate inputs to Tasmanian firms. The output of the remaining Tasmanian sectors was largely unaffected by the changes in Mainland productivity. The experience of these sectors reflected the subdued changes in Tasmanian real investment and real consumption expenditures.

4.5.5 Foreign factors

4.5.5.1 Introduction

Column (9) of Table 4.7 aggregates the effects of the shocks to the positions of foreign export demand schedules and foreign currency import prices experienced by the two regional economics over the period. The decision to aggregate these shocks within Column (9) follows Dixon, Menon, and Rimmer (2000), who consider the effects of these shocks simultaneously in recognition of the fact that import and export markets are interrelated. That is, shifts in export demand schedules and foreign currency import prices reflect changes in both the international business cycle and the relative prices of the major economies, and hence are properly considered jointly. Considering the first two rows of Column 9, changes in foreign markets created a gap in the relative growth rates of the two regional economies of 0.56[98] per cent per annum.

Table D.4 disaggregates Column (9) of Table 4.7 into 9 sets of shocks. Columns (1) and (5) aggregate the effects of the shocks to the foreign export demand schedules for the commodities 1.*Rural* and 2.*Fishing and Hunting*, for Tasmania and the Mainland respectively. Columns (2) and (6) contain the effects of the shocks to the demand schedules of, respectively, Tasmanian and Mainland commodity 4.*Mining*. Columns (3) and (7) aggregate, for Tasmania and the Mainland respectively, the shocks to the foreign export demand schedules for commodities 5.*Meat, Small Goods and Poultry*, 8.*Processed Seafoods*, 13.*Textiles Clothing and Footwear*, and 21.*Iron Ore and Basic Metal Product*s. Columns (4) and (8) contain the effects of the shocks to the general export demand shifters for Tasmania and the Mainland respectively. Column (9) aggregates the effects of the shocks to foreign currency import prices for individual commodity imports.

Relative to the shocks that have so far been discussed with reference to Tables D.1, D.2, and D.3, nearly all of the factors summarised in Table D.4 could be deemed to have had a significant effect on the relative sizes of the two regional economies. Among the factors summarised within Table D.4, however, four stand out as being particularly important. These are the general shocks to the export demand schedules for both regions (Columns 4 and 8), and the shocks to the regional export demand schedules for the commodities subsumed within the Manufacturing sector (Columns 3 and 7). The discussion in the remainder of Section 4.5.5 is devoted to these shocks.

4.5.5.2 Regional general foreign export demand shifts

As discussed in Section 4.2.1, during the historical simulations the general shifter on all regional export demand schedules (*ffeq_generalr*$_r$) is determined endogenously, with the aggregate volume of exports (*x4reg*$_r$) from each region determined exogenously. The historical simulations revealed that over the study period, both the Tasmanian and

[98] +0.33 - -0.23

Mainland economies were subject to strong positive uniform shifts to their foreign export demand schedules. The impacts of these shifts are summarised within column (4) (for $ffeq\_generalr_1$) and column (8) (for $ffeq\_generalr_2$). The net effect of these shifts was to cause the Tasmanian economy's growth rate to lag that of the Mainland by an annual average of 1.59[99] percentage points. This was largely due to two factors. First, in each year on average, the horizontal shift in foreign demand schedules for Mainland exports was approximately 17 per cent higher than that for Tasmanian exports. Second, the overall price elasticity of demand for Tasmanian exports was slightly higher than that for Mainland exports. Relative to the Mainland, this rendered the aggregate volume of Tasmanian exports less responsive to shifts in foreign demands, and more sensitive to the appreciation in the real exchange rate.

Considering the shocks to both the Tasmanian and Mainland general export demand shifters jointly, one can see that these caused the national terms of trade to improve by 6.31 per cent per annum (C4 & C8; R61). This was associated with a rise in the GDP deflator relative to the CPI, causing the real producer wage to fall and hence the marginal product of labour to fall. That is, national employment increased, by approximately 2.10 per cent per annum (C4 & C8; R5 & R6). With the capital / labour ratio falling, the marginal product of capital increased, causing a rise in rates of return on capital. This caused an increase in national investment spending of approximately 4.89 per cent per annum (C4 & C8; R44). With national employment rising, real GDP also rose, by approximately 1.57 per cent per annum (C4 & C8; R43). However this growth was concentrated in the Mainland. Mainland real gross regional product increased by approximately 1.46 per cent per annum, while Tasmanian real GRP contracted at approximately 0.13 per cent per annum.

To see why the Tasmanian economy contracted, it is useful to examine Column (8) separately from Column (4). On their own, the rise in foreign demands for Mainland exports caused a rise in the national terms of trade (6.23 per cent per annum C8;R61), causing a rise in national employment as the real producer wage fell (by -0.90 per cent per annum, C8;R56). As a result real GDP increased by 1.54 per cent per annum (C8;R43). With fixed capital stocks, and rising employment, rental rates on capital also increased, and

[99] -0.03 + 1.49 - 2.97 - -3.10

hence so too did national investment. Real consumption also increased (by 2.28 per cent per annum), rising faster than the increase in real GDP because of the increase in the national terms of trade. With both real national investment and real consumption expenditure growing faster than real GDP, import volumes (C8;R48) increased much faster than export volumes (C8;R45), leading to an increase in the real balance of trade deficit. This required the real exchange rate to appreciate (C8;R58 & R59), which was associated with a nominal appreciation of 6.67 per cent per annum (C8;R57). Despite the decrease in the real balance of trade surplus, the ratio of the domestic currency balance of trade surplus to nominal GDP increased by an average of 0.44 percentage points per annum (C8;R60), because of the improvement in the terms of trade.

Still considering Column (8) in isolation, we can see that the effect of the appreciation in the exchange rate on activity in Tasmania is clearly negative. The Tasmanian foreign currency export price index increased by an annual average of 2.34 per cent (C8;R27 & R57). Hence, Tasmanian export volumes contracted, at an annual average rate of 29.45 per cent (C8;R11). This caused the regional terms of trade to move against Tasmania, as the domestic currency value of foreign and interstate export prices declined (C8;R27 & R37). The resulting fall in the Tasmanian GSP deflator relative to the national CPI implied a rise in the Tasmanian real producer wage of approximately 1.97 per cent per annum (C8;R41), leading to a fall in employment of 4.08 per cent per annum (C8;R5). As a result, real GRP contracted at an annual average rate of 3.10 per cent (C8;R1). The contraction in the state's economic activity was associated with lower real investment expenditure, which fell at an annual average rate of 4.35 per cent. Despite the significant fall in employment, real Tasmanian consumption expenditure only fell at an annual average rate of 0.16 per cent (C8;R9). The effect of the contraction in aggregate activity upon real consumption spending was ameliorated by a number of factors. First, while rental rates on Tasmanian capital were declining, they were rising on Mainland capital. Approximately half of the capital receipts by Tasmanian households were derived from their ownership of Mainland capital. Second, the appreciation in the nominal exchange rate reduced the domestic currency value of payments by Tasmanian households to foreigners[100]. Finally, the decrease in employment was associated with an increase in Commonwealth unemployment payments to Tasmanian households.

[100] See coefficient OHHNI in Equation *E_n_ginc*.

Column (4) summarises the effects of the annual shocks to the Tasmanian general export demand shift variable. These were only sufficient to lift Tasmanian export volumes at an annual average rate of 23.3 per cent per annum (C4;R11), whereas the appreciation in the real exchange rate caused by the increase in Mainland exports caused Tasmanian export volumes to contract by 29.5 per cent per annum (C8;R11). This was due largely to the difference between the shifts in export demand experienced by the two regional economies, with those experienced by the Tasmanian economy being lower than those of the Mainland by an annual average of approximately 17 per cent. A smaller part was also played by differences between the two economies in their price elasticities of export demand. Overall, the weighted average of these was higher for Tasmania. Relative to the Mainland, this rendered their export volumes more sensitive to an appreciation in the exchange rate and less sensitive to a given exogenous increase in foreign export demand.

4.5.5.3 Shifts in traditional manufacturing foreign export demands

Columns (3) and (7) summarise the effects of the shifts in the foreign export demand schedules of those Manufacturing exports that are classified as traditional exports. The net impact of these two columns on the relative sizes of the two economies was close to zero. The shocks in Column (3) opened a gap in the relative growth rates of the two economies of approximately 0.65 per cent per annum, while the shocks in Column (7) opened a gap of approximately -0.64 per cent per annum. For Tasmania, the most important shocks subsumed by column (3) are those to the export demand schedules of the 5.*Meat Small Goods and Poultry* industry, and the 21.*Iron Ore and Basic Metal Products* industry. For the Mainland, the most important shocks subsumed by column (7) were to the export demand schedules for 13.*Textiles Clothing and Footwear*, and 21.*Iron Ore and Basic Metal Products*. Foreign demands for these commodities from these regions were contracting over the period. The results in Columns (3) and (7) are now considered in turn.

The contraction in foreign demands for Tasmanian 5.*Meat Small Goods and Poultry* caused exports of this commodity to contract at an annual average rate of 93.5† per cent. The contraction in foreign demands for Tasmanian 21.*Iron Ore and Basic Metal Products* caused exports of this commodity to contract at an annual average rate of 8.4† per cent. These shocks (offset somewhat by an increase in foreign demands for Tasmanian

13.*Textiles Clothing and Footwear*) caused total Tasmanian export volumes to decline by 4.51 per cent per annum (C3;R11), causing Tasmanian prices to fall (the GSP deflator fell by 0.38 per cent per annum, C3;R41) as rental rates on fixed capital fell. With nominal wages indexed to the national CPI, the real Tasmanian producer wage increased and hence employment fell, at an annual average rate of 0.92 per cent per annum (C3;R5). With employment falling, real Tasmanian gross regional product fell at an annual average rate of 0.65 per cent (C3;R1). With rates of return on capital falling so too did real investment, by 0.81 per cent per annum (C3;R7). Despite the fall in employment, Tasmanian real consumption remained largely unaffected (C3;R9) by these shocks. This was because, over the study period, exports of the Tasmanian 5.*Meat, Small Goods and Poultry* sector were subject to a relatively high rate of phantom subsidisation. With exports of this commodity almost eliminated by the exogenous reduction in foreign demands, so too was the phantom subsidisation. This increased Tasmanian nominal gross income by, on average, about 2/5th of a percentage point per annum, relative to what it would otherwise have been.

Turning to the sectoral results, it is somewhat surprising to find that the worst affected sector was Agriculture, the output of which declined by 2.06 per cent per annum (C3;R62). In comparison, activity in Manufacturing, the sector experiencing the shock, declined by only 1.56 per cent per annum. Activity in Agriculture fell sharply because of declining intermediate sales to the 5.*Meat, Small Goods and Poultry* industry within the Manufacturing sector. On their own, declining intermediate sales would have reduced Tasmanian Agriculture's output by 4.1† per cent per annum, were it not for rising export sales, which added 2.0† per cent per annum to its growth rate. Output of the Mining sector also contracted, by 0.60 per cent per annum, reflecting declining intermediate sales to the 21.*Iron Ore and Basic Metal Products* industry within the Manufacturing sector. Again, the impact of declining intermediate sales on this sector's output was ameliorated by rising export sales. Activity in the Tasmanian Construction sector also contracted sharply, following the contraction in real Tasmanian investment spending.

The Mainland Manufacturing sector was most affected by falling foreign demands for 13. *Textiles Clothing and Footwear*, and 21. *Iron Ore and Basic Metal Products*. Exports of the former fell at an annual average rate of 27.3† percent, while those of the latter fell at an annual average rate of 26.5† per cent. Overall, the combined effects of shocks to foreign demands for Manufacturing sector commodities caused national export volumes to fall by 0.47 per cent per annum (C7;R46), and the terms of trade to decline at 0.74 per cent per annum (C7;R61). With the terms of trade declining, import volumes fell faster than export volumes, implying an improvement in the real balance of trade. This was associated with a real exchange rate depreciation of around 0.75 per cent per annum (C7;R58 & R59). This caused Tasmanian export volumes to increase by 3.99 per cent per annum (C7;R11). The increase in exports allowed economic activity in Tasmania to expand, even as activity in the Mainland economy contracted. The contraction of the latter however still had two immediate negative consequences for Tasmanian activity. The first was via lower inter-state exports, which contracted by 0.93 per cent per annum (C7;R21). The second was via lower capital rental receipts from the holdings by Tasmanian households of Mainland capital. Hence, despite an increase in employment of 0.49 per cent, Tasmanian real consumption spending only increased by 0.12 per cent. The increase in Tasmanian real consumption spending was also dampened by the nominal depreciation, which increased the Australian dollar value of payments by Tasmanians to foreigners. The contraction in Tasmanian interstate exports was most felt by the Agriculture and Mining sectors. Contracting intermediate sales to the Mainland by these sectors reduced their output growth by approximately 0.3† and 0.4† percentage points per annum. Ultimately, the two sectors expanded however, due to both rising intermediate sales to Tasmanian firms, and rising export sales as the exchange rate depreciated. These two factors added, respectively, approximately 0.9† and 2.0† percentage points per annum to the growth rates of these sectors. Output of the Tasmanian Manufacturing sector expanded by approximately 0.73 per cent per annum, due largely to rising export sales, although again offset somewhat by declining intermediate sales to Mainland firms.

4.5.6 Shifts in Capital Supply Functions

During the historical simulations, the positions of the schedules determining the relationship between regional industry expected rates of return and capital growth rates[101] were determined endogenously, allowing for the exogenous determination of sectoral investments. Column (10) in Table 4.7 aggregates the impacts of the corresponding shocks to the positions of these schedules during the decomposition simulation. It is clear that these shocks caused the Mainland economy to grow by approximately 0.52 per cent per year, a rate of growth that exceeded that of the Tasmanian economy by approximately 0.57 per cent per year. Table D.5, which disaggregates the results in Column (10) of Table 4.7 into three broad sets of shocks, makes clearer the factors that contributed to this decline in the relative size of the Tasmanian economy. In turn, it should be recalled that each of the columns in Table D.5 still represents an aggregation of the results of the actual shocks administered to the individual model variables in each year of the decomposition simulation[102].

Considering Column (1) of Table D.5 in isolation, it is apparent that shifts in the positions of Tasmanian capital supply functions had an expansionary effect on the size of the Tasmanian economy. Overall, these shifts expanded the level of investment in Tasmania (8.64 per cent per year, C1;R7), implying that, on the whole, rate of return schedules for Tasmanian industries shifted downwards over the period. The increase in investment stimulated a rise in employment and hence output, with the latter having increased by 0.76 per cent per annum (C1;R1). However this growth was eliminated by the contractions in activity induced by both shifts in Mainland capital schedules (Column (2)) and shifts in industry-specific capital supply schedules operating Australia-wide (Column (3). The latter caused both the Tasmanian and Mainland economies to contract at about the same rate (1/3 of a percent per annum, C3; R1 & R2). This is not a surprising result, since Column (3) aggregates the effects of the shocks to *d_f_eeqror_j*, which operate on the positions of industry-specific capital supply functions in all regions. This leaves Column (2) as the most important factor explaining the annual net 0.57 per cent gap in the relative growth rates created by shifts in capital supply schedules. The results in Column (2) are now discussed in more detail.

Shifts in Mainland rate of return schedules caused a significant increase in Mainland investment (11.82 per cent per annum, C2;R8), implying that, on average, rate of return schedules for Mainland industries were shifting downwards over the period. Mainland investment represented approximately 98% of national investment, hence national investment increased by a similar amount (11.58 per cent per annum, C2;R44). The resulting increase in real domestic absorption caused a decrease in national export volumes

[101] See Sections 2.6.1, 2.6.12 and 4.2.1.

(-6.30 per cent per annum, C3;R46) and increase in import volumes (3.68 per cent per annum, C3;R49), facilitated by real appreciation of the exchange rate (approximately 1 per cent per annum, C3;R58 & R59). The appreciation of the exchange rate caused the foreign currency price of Tasmanian exports to rise (0.42 per cent per annum, C3; R27 & R57), and hence export volumes to contract (-5.09 per cent per annum, C3;R11). On its own, a contraction in export volumes of this size would have been sufficient to reduce Tasmanian real gross regional product by almost 1 per cent per annum. The actual result was about half that (-0.45 per cent per annum, C3;R1) for two reasons. First, there was a small rise in Tasmanian real consumption expenditure (0.09 per cent, C3;R9) despite the fall in Tasmanian employment, due to the combined effects of rising capital rental receipts from the Mainland and falling Australian-dollar equivalent payments to foreigners. Second, with activity falling in Tasmania, the price of Tasmanian goods fell relative to Mainland goods, allowing an expansion in the interstate balance of trade surplus (C2; R19 & R 21).

Considering the effects of Columns (1) through (3) together, it is clear that the relative size of the Tasmanian economy contracted because the stimulus to investment afforded by shifts in Tasmanian capital supply functions (Column (1)) was not sufficient to offset the negative consequences for Tasmanian activity of the real exchange rate appreciation arising from the expansion in investment on the Mainland (Column (2)).

4.5.7 Other Shocks

4.5.7.1 Introduction

The final column of Table 4.7 summarises a set of shocks which, when considered together, had the most dramatic effect on the relative growth rates of the two regional economies. The factors summarised in Column (11) caused the Mainland economy to expand at an annual average rate of 2.33 per cent. This exceeded the growth rate of the Tasmanian economy by just over 1 percentage point per annum.

Table D.6 in Appendix D disaggregates the results for Column (11) of Table 4.7 into the individual contributions of seven sets of shocks. These are:

[102] In particular, Column (1) aggregates the results of the shocks to *d_f_eeqror* 1; *d_f_eeqror_jr* 1-37, and *del_unityr2* 1; Column (2) aggregates the results of the shocks to *del_unitryr2* 2; and, Column (3) aggregates the results of the shocks to *d_f_eeqror_j* 1-37.

Column (1): Import / domestic twist variable (*twist_src_bar*);

Column (2): Labour / capital twist variable (*f_twistlk*);

Column (3): Inter-regional preference twists (*twist_isbot$_i$*);

Column (4): Capital accumulation in Tasmania (*del_unityr$_1$*);

Column (5): Capital accumulation in the Mainland (*del_unityr$_2$*);

Column (6): Changes in the lagged rate of inflation (*del cpi_l*);

Column (7): Changes in the consumer price index (*p3nat*);

Each of these is now considered in turn.

4.5.7.2 Import / domestic twist

As discussed in Section 4.2.1, during the historical simulations the national quantity index for imports (*xMnat*) was determined exogenously and shocked equal to values from ABS statistics. These values, and the values for this variable that the model would otherwise have calculated given changes in relative prices and activity levels, were reconciled by movements in the import / domestic twist shift variable (*twist_src_bar*). The average annual value of this variable was 11.0 per cent, indicating an 11.0 per cent per annum exogenous increase in the ratio of imports to domestically sourced goods. Column (1) in Table D.6 summarises the impacts of this preference shift.

At the national level, the shift in preferences towards imports caused import volumes to rise at an annual average rate 3.77 per cent per year (C1; R49). There was a fall in the demand for labour (-0.25 per cent per annum), as the GDP deflator declined (-0.06 per cent, C1; R56) relative to the household consumption deflator, indicating a rise in real producer wages. Hence real GDP declined, by 0.11 per cent per annum (C1;R43). Real domestic absorption declined by 0.17 per cent per annum. This was faster than the rate of decline in real GDP because of the decline in the terms of trade. The terms of trade declined because, with the decline in real GDP being matched by a (roughly) similar decline in real absorption, export volumes had to expand at about the same rate as import volumes. The rise in export volumes (4.13 per cent per annum) was brought about via a depreciation in the real exchange rate, which required a nominal depreciation of 0.56 per cent per annum (C1;R57).

The shift in preferences for imports over local products initially hits the Mainland harder than it does Tasmania. The initial impact of the sourcing twist on any given individual regional industry will depend on two main factors: i. the import share in total domestic usage of the output of that industry - the higher this share, the greater the negative impact of a given twist in favour of imports; and ii. the share of the total sales of the industry accounted for by goods that compete directly with imports of the same goods - the higher this share, the greater the negative impact on the industry's activity of a given twist in favour of imports. The initial impact of the sourcing twist on regional activity levels will depend on the relative shares in total regional activity of those industries that face relatively high competition from imports. Tasmania is shielded from the impact of the twist in preferences towards imports by a number of factors. First, it has a lower share of activity accounted for by industries producing goods that account for a high share of Australia's imports. In particular, the manufacture of 23.*Ship and boat building, motor vehicles and parts*, and 24.*Machinery, equipment, and miscellaneous*, accounts for approximately 1.6 per cent of Tasmanian value added, but accounts for approximately 3.2 per cent of value added on the Mainland. Imports of these commodities represent approximately one half of total imports. Tasmania is further shielded from the twist in favour of imports by the fact that it exports a higher share of its output of those commodities that would otherwise have been affected. The consequences of these two factors are apparent in a comparison of the results for the Manufacturing sectors in Tasmania and the Mainland. The two industries 23.*Ship and boat building, motor vehicles and parts*, and 24.*Machinery, equipment, and miscellaneous* account for approximately 30 per cent of the value added in the Mainland Manufacturing sector, but only about 10 per cent of the value added in the Tasmanian Manufacturing sector. As a result, Mainland Manufacturing output declined by 1.26 per cent per annum, over three times the rate of decline of the Tasmanian Manufacturing sector (0.38 per cent per annum). With import competition being far more important for Mainland producers than Tasmanian producers, the contraction in national activity was concentrated on the Mainland. Mainland real GRP declined by 0.18 per cent per annum, whereas Tasmanian real GRP grew slightly, by 0.05 per cent per annum.

4.5.7.3 Labour / capital twist

During the historical simulations, the economy-wide level of employment was determined exogenously. To ensure that this level of employment was compatible with what would otherwise have been the model's solution for employment, a variable imparting cost-neutral changes in the capital / labour ratio was determined endogenously. This variable (*f_twistlk*) recorded a cost-neutral shift in the labour / capital ratio of approximately 3.9 per cent per annum. Column (2) records the results of applying this shock during the decomposition simulations.

The shock to the labour / capital ratio did not increase employment by the full 3.9 per cent, but rather, by approximately 1.7 per cent per year. The reason for this was that as the shift in the labour / capital ratio caused employment to rise, it also caused the terms of trade to decline (C2;R6). This caused the GDP deflator to decline relative to the CPI deflator, indicating a rise in the real producer wage (C2;R56). The terms of trade declined because exports had to expand, since domestic absorption did not expand as quickly as output. The change in domestic absorption was less than that of real output for a number of reasons. First, real government consumption expenditure was unchanged. Second, the shock to the labour / capital twist variable caused a reduction in the demand for capital. Since this was in fixed supply in any given year of the simulation period, the capital rental rate declined, causing real investment to fall (C2;R44). Third, with rental rates declining, and hence household capital rental receipts falling, the increase in consumption expenditure was more subdued (C2;R45), relative to what would otherwise have occurred given the rising level of employment. The resulting increase in the real balance of trade surplus was facilitated by a real exchange rate depreciation (C2; R58 and R59), which was associated with a depreciation of the nominal exchange rate.

Since the shock to the labour / capital twist variable was economy-wide, both regions were subjected to it, and employment and hence output expanded in both regions by approximately the same amount. However the growth in employment on the Mainland still exceeded that of Tasmania by 0.28 per cent per annum (C2; R5 & R6). This equated to a higher growth rate in real GRP of approximately 0.15 per cent per annum (C2; R1 & R2). This was due to two factors, each of which acted to restrain the growth in Tasmanian real private consumption expenditure. The more important of these factors was that the ownership of capital on the part of Tasmanian households was more heavily weighted towards sectors experiencing the larger declines in capital rental rates, relative to Mainland households. The second factor was that Tasmanian gross household income was more sensitive to the depreciation in the nominal exchange rate, via its effects on the Australian dollar value of net payments by Tasmanian households to foreigners.

4.5.7.4 Inter-regional sourcing twists

During the historical simulations, the outputs of Tasmanian sourced goods were determined exogenously, and shocked equal to their values as reported in the official statistics over the period. For the output of each commodity thus determined exogenously, either an inter-regional sourcing twist variable (for non-margin and non-utilities commodities), or a Tasmanian source-specific technical change variable (for margin commodities and utilities) was determined endogenously. The endogenous commodity-specific twist variables imparted cost neutral changes in the preferences of non-government domestic agents, located both in Tasmania and the Mainland, for each commodity from either Tasmania or the Mainland. For example, if the relative price changes and activity levels calculated within the model generated a total demand for a particular Tasmanian commodity that fell short of the exogenously specified total output of that commodity, then a preference twist in favour of that commodity and away from the Mainland commodity was calculated endogenously by the model. Over the period under investigation, these preference twists tended to shift the preferences of domestic agents away from Tasmanian sourced goods and towards their Mainland substitutes. These shifts were independent of any changes in the demand for Tasmanian goods that were induced by changes in relative prices or changes in the activity levels of purchasing agents.

At the national level, the shifts in domestic sourcing preferences had a negligible impact on economic activity. This reflects the fact that these shifts, by construction, do not affect industry costs, but merely switch demand for a given quantity of each input between the two domestic sources for the input. This switching of demand did, however, have a marked impact on Tasmanian economic activity. Overall, the shifts in domestic preferences were away from Tasmanian sourced goods, causing contractions in activity within Tasmania. At the sectoral level, two notable exceptions were Agriculture and Mining. Tasmanian Agriculture grew at an annual average rate of 1.13 per cent per annum, as Tasmanian and Mainland agents switched away from Mainland sourced Agriculture. This increase in activity was associated with a rise in the price of Agriculture, and hence a fall in Tasmanian Agriculture exports (-4.55 per cent per annum C3; R110). Similarly, there was a strong twist towards Tasmanian sourced Mining. Tasmanian Mining output rose by 6.87 per cent per annum, despite a fall in exports of 9.51 per cent per annum. However the gains in activity within these sectors were not sufficient to offset the contractions occurring in sectors experiencing preference twists towards the output of their Mainland competitors. Manufacturing, Communications, Finance, and, to a lesser extent, Construction, all experienced preference twists away from the Tasmanian source and towards the Mainland source. Each of these sectors, other than Manufacturing, experienced large contractions in output. For Finance and Communications, these contractions in activity were directly due to the shift in preferences away from their output. The fall in Tasmanian Construction output was largely due to the fall in Tasmanian investment, with a small contribution by shifts in preferences by Tasmanian agents towards Mainland Construction. Tasmanian Manufacturing output was largely unchanged, with the falling output of those manufacturing industries experiencing adverse shifts in preferences being offset by those manufacturing industries experiencing increases in output as their export volumes expanded.

The net effect of the shifts in inter-regional sourcing preferences was a contraction in Tasmanian real GRP of 0.33 per cent per annum, reflecting a decline in employment of 0.54 per cent per annum. These changes were matched by approximately equal (in absolute terms) increases in real GRP and employment in the Mainland economy. Overall, changes in inter-regional sourcing twists caused the Tasmanian growth rate to lag that of the Mainland by 0.34 percentage points per annum (C3; R1 & R2).

4.5.7.5 Capital accumulation

The growth rate in the Tasmanian capital stock lagged that of the Mainland over the simulation period, creating a gap in the relative annual growth rates of the two economics of 0.77[103] percentage points. Columns (4) and (5) of Table D.6 distinguish the separate impacts of capital growth within Tasmania (Column 4) and capital growth within the

[103] +0.01 - 1.25 - -0.24 - 0.74.

Mainland (Column 5). Whereas the Mainland capital stock expanded at an annual average rate of 1.60 per cent, the Tasmanian capital stock only expanded at an annual average rate of 0.65 per cent.

Changes in industry capital stocks in Tasmania (Column 4) caused Tasmanian real gross regional product at factor cost to contract by 0.24 per cent per annum. This fall in output occurred despite a rise in the aggregate Tasmanian capital stock (+0.65 per cent[104]). Examining the employment result (C4;R5), one can see that the net fall in real GRP was attributable to declining employment. To understand why employment fell despite the aggregate capital stock rising, it is necessary to examine the industrial composition of the changes in capital availability. In particular, it is important to note that growth in the capital stock of the Dwellings industry accounted for a significant proportion of the aggregate growth in capital. The Dwellings industry does not use labour as a primary factor input, hence changes in capital availability to this industry cannot have a direct effect on Tasmanian employment. The capital stock in this industry grew at an annual average rate of approximately 3.26 per cent (C4;R70). The share of rental receipts from Dwellings capital in total rental receipts from Tasmanian capital was approximately 37% over the period. This indicates that aggregate capital stocks in the remainder of the Tasmanian economy fell by approximately 0.85 per cent per annum[105]. This caused total Tasmanian employment to contract. For a given wage / rental ratio, a 0.85 per cent fall in the capital stock of the non-Dwellings sectors would be associated with a fall in employment of approximately 0.85 per cent. However, employment only fell by -0.48 per cent (C4;R5), implying a decline in the capital / labour ratio within these sectors. This ratio declined because, with the availability of capital to these sectors falling over the period, rental rates increased, lowering the wage / rental ratio, and, via the factor price frontier, requiring a lower capital / labour ratio.

The rise in capital availability to the Dwellings sector also explains a second interesting result in Column (4) - namely, the rise in real household consumption expenditure (+0.44 per cent), despite the fall in employment. This was due to the CPI falling faster than nominal disposable income: the Tasmanian consumer price index declined by 0.77 per cent

[104] Computed as the rental value share weighted sum of the percentage changes in regional industry capital stocks.

[105] $-0.85 = (0.65 - 0.365 \times 3.26)/(1 - 0.365)$

per annum, while nominal household disposable income declined by 0.33 per cent per annum. The fall in the Tasmanian CPI was due largely to falling rental rates on Dwellings, reflecting the increase in capital availability to this sector.

Both foreign and interstate export volumes declined, by 2.74 and 0.62 per cent per annum respectively. This reflected the rising costs of production in industries producing for these export markets, which were indicated by rising foreign (+0.27 per cent) and interstate (+0.40 per cent) export price indices. Real investment also declined (-1.93 per cent), despite rental rates rising in most industries. This was due to two factors. First, just over two-thirds of the decline in aggregate Tasmanian investment was due to declining investment in Dwellings, with the latter being driven by falling rental rates on Dwellings capital. Second, by examining the operations of Equations *E_d_f_eeqror*, *E_del_k_gr*, and *E_cap_at_tplus1*,[106] it is apparent that a fall in capital availability to a regional industry exerts two countervailing influences on that industry's real investment. The direct effect of a fall in capital of n% is to lower real investment by n%. The indirect effect is to raise investment via an increase in expected rates of return as capital rental rates rise, reflecting the greater scarcity of capital in the current period. The strength of the latter effect depends on the slope of the industry's capital supply function and the industry's capital / investment ratio. For most industries, the indirect effect on investment of rising rental rates outweighed the direct effect of declining capital stocks. However this was not the case for a number of industries, which together accounted for a sufficiently large share of Tasmanian investment to turn the change in total non-Dwellings investment negative.

Turning now to Column (5), it is apparent that growth in Mainland capital stocks also added to the difference in the growth rates between the two regional economies. Mainland capital growth caused the Mainland GRP growth rate to exceed that of Tasmania by approximately one half a percent per annum (C5;R1 & R2).

In considering the mechanisms through which the increase in Mainland capital growth affected the Tasmanian economy, it is useful again to consider the composition of the change in the aggregate capital stock. From C5;R82 we can see that the capital stock in Mainland Dwellings was rising at an annual average rate of 3.21 per cent. The share of

[106] Substitute *del_k_gr* from Equation *E_del_k_gr* using *E_d_f_eeqror_jr*. Then use the resulting expression to substitute *cap_at_tplus1* from Equation *E_cap_at_tplus1*, and re-arrange for *y_p56*.

Mainland Dwellings in total Mainland capital rentals was approximately 25 per cent. Hence capital stocks in non-Dwellings industries increased at an annual average rate of approximately 1.06 per cent. This is approximately the same as the rise in Mainland employment over the period (+1.08 per cent per annum). For a given wage / rental ratio we might have expected just such a result. However, with capital stocks rising within these industries, their capital rental rates were falling. This should have kept the growth rate for employment below the growth for the non-Dwellings capital stock.

The explanation for this somewhat counter-intuitive result begins with the effect on the national CPI of growth in capital in Dwellings. Ignoring changes in capital stocks in other industries, the rise in capital availability to Mainland Dwellings lowered the price of Dwellings nationally, relative to the CPI, by approximately 3.1[†] per cent[107]. The weight of Dwellings in the model's national household consumption deflator was approximately 0.16 over the simulation period. Since this deflator was also the numeraire, this meant that the remaining elements of the consumer basket had to increase in price by approximately 0.7 per cent. Since the real consumer wage was exogenous, this implied a significant fall in the real producer wage, generating a large increase in employment. The effect on national employment of the increase in Mainland Dwellings capital stocks alone was approximately 0.7 per cent per annum[103]. The remaining 0.38[108] percentage points of employment growth were due to the increase in the non-Dwellings capital stock.

With both the Mainland capital stock and the national employment level rising, real GDP increased, by approximately 1.25 per cent per annum (C5;R43). The increase in real domestic absorption was less than the increase in real GDP for a number of reasons. First, the growth in real household consumption lagged the growth in factor availability. The growth in real consumption was restricted by a number of factors, the most important being falling receipts of unemployment benefits, declining capital rental rates, and a rise in the domestic currency value of foreign payments as the nominal exchange rate depreciated. Second, real regional and Commonwealth Government consumption expenditure was unchanged. Third, real national investment expenditure only increased by 0.57 per cent (C5;R44). With real domestic absorption growing more slowly than real GDP, it was

[107] Based on a separate simulation, not reported here, in which capital stocks in Mainland Dwellings alone were increased under a decomposition closure

[108] 1.08 - 0.70

necessary for the balance of trade to expand. Hence the balance of trade as a share of GDP increased by 0.53 percentage points of nominal GDP (C5;R60). This was facilitated by a real exchange rate depreciation, which was associated with a nominal depreciation of 1.37 per cent.

The depreciation in the nominal exchange rate caused the foreign currency price of Tasmanian exports to fall by 0.26 per cent per annum (C5;R27 & R57). This caused Tasmanian foreign export volumes to expand by 3.44 per cent per annum (C5;R11). Rising real export volumes provide a demand-side fillip to activity in Tasmania, causing both real consumption and real investment expenditure to also increase. While real investment grew strongly (+1.11 per cent), the growth in Tasmanian real household consumption expenditure was more suppressed (relative to the growth in employment). This was due to the rising domestic currency value of payments to foreigners by Tasmanian households. Overall, Tasmanian real gross regional product at factor cost increased by 0.74 per cent (C5;R1). This was approximately half a per cent less than the growth in Mainland output.

4.5.7.6 Changes in the rate of inflation

The results in Column (6) and (7) had little effect on the relative growth rates of the two regional economies. This is not a surprising result when one considers the nature of the shocks summarised by these two columns. Column (6) summarises the results for the annual shocks to *del_cpi_l*, and Column (7) summarises the results for the annual shocks to *p3nat*. Considered together, The results in Columns (6) and (7) come close to being a nominal homogeneity shock, raising the domestic price level (by approximately 1.97 percent), while leaving the values of all real variables largely unchanged. This is because the inflation rate over the historical period was relatively stable, meaning that there were only small changes in the rate of inflation from year to year. Only changes in the rate of inflation can have real effects in the model, by changing expected rates of return on capital[109]. Certainly within any given year, *t*, of the historical period, the results for the

[109] Changes in the rate of inflation affect expected rates of return on capital through two routes. First, via an adaptive expectations framework, changes in the rate of inflation affect investors expectations of both the value of rentals that they will receive on capital in the future, and the cost of constructing those units of capital. Second, changes in the inflation rate affect the rate at which expected net receipts from capital are discounted, via its effect on the value of the nominal discount rate. See Sections 2.6.16 - 2.6.20.

shocks to *del_cpi_l* and *p3nat* can be expressed precisely as a nominal homogeneity shock of *N* per cent via an appropriate weighting of the two sets of results, where:

N is a constant equal to $n_j^{(t)p3nat} - n_j^{(t)del\_cpi\_l} / R$;

$n_j^{(t)p3nat}$ is the result for nominal variable *j* arising from the shock to *p3nat* in year *t*;

$n_j^{(t)del\_cpi\_l}$ is the result for nominal variable *j* arising from the shock to *del_cpi_l* in year *t*;

R is a constant equal to $x_i^{(t)del\_cpi\_l} / x_i^{(t)p3nat}$;

$x_i^{(t)p3nat}$ is the result for real variable *i* arising from the shock to *p3nat*; and

$x_i^{(t)del\_cpi\_l}$ is the result for real variable *i* arising from the shock to *del_cpi_l* ;

This relationship will not hold *precisely* for annual average results (i.e., the results in Columns (6) and (7)), because the strengths of the relationships between the model's variables change between simulations (due to changes in the structure of the database). Nevertheless, comparing the results between Column (6) and (7), it is apparent that they can nevertheless be re-weighted as a homogeneity shock of approximately 1.97 per cent using a value for *R* of approximately 1.05.

4.5.8 Conclusion

The historical simulations generated results for a large number of structural and policy variables. When these were applied to the model as exogenous shocks during the decomposition simulations, a large number of results were generated for national and regional macroeconomic variables, and industry and commodity level variables. Three choices were then made to make manageable the task of presenting and discussing the results of the decomposition simulations. First, the number of categories of exogenous shock to be considered were reduced by aggregating the individual shocks within appropriate groups. Second, in discussing the results, the focus was on the contributions made by the exogenous shocks to the changes in the relative growth rates in real gross product of the two regional economics. This choice was made because this tends to be the centrepiece of public debate on the question of economic development at the state level. Third, the discussion was restricted to those sets of shocks that had the largest impact on relative growth rates.

Three conclusions are immediately apparent from the results of the historical and decomposition simulations. The first of these is that the relatively slow growth experienced by the Tasmanian economy was the net effect of a very large number of exogenous factors. There is no simple answer for why the Tasmanian economy has experienced a significantly slower rate of growth than the country as a whole. This conclusion is not unimportant, since it suggests that we should be very cautious when presented with simple or mono-causal explanations for regional decline and growth.

The second observation is that it is possible to make definite statements about what *did not* contribute to the relative decline in the size of the Tasmanian economy. These factors are summarised by Columns (2) to (6) of Table 4.7. While taken together, these factors explain 0.27 percentage points per annum of the growth difference between the two regional economies, no single factor explains more than one-tenth of a percentage point per annum. Hence, changes in regional industry wage rates (Column 2), household related variables[110] (Column 3), Commonwealth Government policy variables[111] (Column 4), regional government policy variables[112] (Column 5), and demographic variables[113] (Column 6), individually had little impact on the relative size of the Tasmanian economy.

The final observation is that we can make a clear statement about those factors that made the largest contributions to the difference in the relative growth rates of the two regional economies. These factors are summarised by Column (1) and Columns (7) through to (11) of Table 4.7. However Column (11) aggregates four independent factors, each explaining a relatively large proportion of the difference in growth rates. Hence, in total, nine factors stand out as having had an important effect on the relative size of the Tasmanian economy:

i. Shifts in the rates of non-spreading phantom taxation of regional commodity exports. These caused the Tasmanian economy to grow faster than the Mainland by 0.53 percentage points per annum.

[110] Changes in regional household preferences, changes in regional propensities to consume, exogenous changes in regional household foreign net income, and differences in regional household capital ownership.
[111] Changes in Commonwealth consumption, investment, and transfer expenditures, and changes in the various Commonwealth Government taxation rates.
[112] Regional government consumption, investment, and transfer expenditures, and changes in the various regional government taxation rates.
[113] Changes in participation rates, natural population growth rates, and inter-regional migration.

ii. Shifts in the preference for imports over domestic goods. These caused the Tasmanian economy to growth faster than the Mainland by 0.24 percentage points per annum.

iii. A shift in the labour / capital ratio, causing a cost-neutral increase in labour requirements per unit of capital. This caused the Mainland economy to grow faster than the Tasmanian economy by 0.15 percentage points per annum.

iv. Shifts in the phantom taxation of domestically sourced goods used by domestic agents. These caused the Mainland economy to grow faster than the Tasmanian economy by 0.28 percentage points per annum.

v. Shifts in technical change, causing changes in per-unit production costs in each region. These caused the Mainland economy to grow faster than the Tasmanian economy by 0.34 percentage points per annum.

vi. A shift in the preferences of domestic agents away from Tasmanian sourced goods and towards Mainland sourced goods. This caused the Mainland economy to grow faster than the Tasmanian economy by 0.34 percentage points per annum.

vii. Shifts in foreign markets, causing changes in foreign export demands and import prices. These caused the Mainland economy to grow faster than the Tasmanian economy by 0.56 percentage points per annum.

viii. Shifts in regional industry capital supply functions, changing the relationship between expected rates of return and rates of capital accumulation. These caused the Mainland economy to grow faster than the Tasmanian economy by 0.57 percentage points per annum

ix. Differences in rates of physical capital accumulation in the two economies. These caused the Mainland economy to grow faster than the Tasmanian economy by 0.77 percentage points per annum.

A final question to be considered is the strength of the relationship between the slower rate of capital accumulation in Tasmania (factor ix) and the slower rate of growth in real investment expenditure within Tasmania (factor viii). To the extent that there is a connection, shifts in capital supply functions explain a higher proportion of the difference in relative regional growth rates than is given simply by factor (viii) above. Investment plays both a demand-side and a supply-side role in explaining the relative growth rates of the two economies. Changes in capital supply schedules exert an immediate demand-side impact on regional activity via their effect on real investment in the current period. However changes in real investment also exert a supply-side impact on regional activity in future periods via their effect on the supply of physical capital. It is clear from Table 4.7 that shifts in capital supply schedules explain a very high proportion of the difference between Tasmanian and Mainland investment growth rates[114]. The question to be answered then is how the difference in economic growth rates (via capital accumulation[115]) would have appeared had shifts in capital supply functions (Column 10 of Table 4.7) been other than they were. For example, the difference in annual investment growth rates between Tasmania and the Mainland in Column (10) of Table 4.7 is just under 5 percentage points. What would have been the impact, via capital accumulation, on Tasmanian GRP if shifts in Tasmanian capital supply schedules had reflected more favourable investor sentiments with respect to Tasmania, allowing Tasmanian real investment to have been 5 percentage points higher in each year? The weighted average Tasmanian depreciation rate over the period was approximately 6.3 per cent, and the average Tasmanian K / I ratio over the period was approximately 18.9. This is enough information to do a "back of the envelope" calculation of how much larger the Tasmanian capital stock would have been in 1998/99 had the growth rate in Tasmanian real investment been 5 percentage points higher in each year. The answer turns out to be relatively large: approximately 4.0 per cent. With returns to capital being just over one fifth of Tasmanian real GRP at factor cost, and other costs (which move in line with real GRP) accounting for just over one-tenth of real GRP at factor cost, this would have left

[114] Compare (C12;R7 & R8) with (C10;R7 & R8).

[115] The question is, what is the importance of the link between changes in growth in real investment and changes in the capital growth rate (that is, what is the strength of the supply side link). A rise in the growth rate of Tasmanian real investment will of course have a significant demand side impact on Tasmanian real GRP. For example, in Column (10) an increase in the growth rate of Tasmanian investment to a value equal to that of the Mainland would increase the growth rate in Tasmanian real GRP from -0.05 to approximately 1.2 per cent per annum ($\left[\frac{+7.55 - 2.67 + 8.64}{8.64}\right] \times 0.76$ See Table D.5)

Tasmanian real GRP approximately 1.03[116] percent higher in 1998/99 than it was otherwise. This translates into a higher annual average growth rate in Tasmanian real GRP of 0.17 percentage points - a number comparable in magnitude to those distinguished by points (i) - (ix) above. It is also worth noting that a 4.0 per cent higher level of capital in 1998/99 translates into a higher annual average growth rate in Tasmania's capital stock of approximately 0.66 per cent. Considering that Tasmania's annual average capital growth rate over the period was 0.65 per cent, whereas that of the Mainland was 1.60 per cent, this suggests that the slower investment growth in Tasmania can account for approximately 70 per cent of the difference in capital growth rates between the regions. The remainder of the difference between the capital growth rates of the two regions arose from Tasmania having, relative to the Mainland, both a lower aggregate investment / capital ratio in the initial database, and a slightly higher weighted-average depreciation rate.

[116] $1.03 = [0.23/(1 - 0.11)] \times 4.0$, where 0.23 and 0.11are the average shares of capital receipts and other costs respectively, in Tasmanian real GRP at factor cost.

5 ILLUSTRATIVE APPLICATIONS II: FORECASTING SIMULATIONS

5.1 INTRODUCTION

In this chapter I describe five types of simulation, each of which was required to generate the baseline forecasts for the period 1999/00 to 2002/03. Different closures of the model are used for different segments of this time period. In particular, four different closures are used, covering the periods 1999/00, 2000/01, the two years 2001/02 and 2002/03, and the final year 2003/04. These different closures reflect the changing availability of extraneous forecasts relating to the macroeconomy and the government accounts, and the need to model the introduction of the GST.

The first of the five simulations brings the model forward one year, to 1999/00 (recall that the last year of the historical simulation is 1998/99). While the 1999/00 year is now in the past, at the time of undertaking these simulations, official statistics were available for only a limited number of variables. For simplicity, I treat this year as the first of the forecast simulations[117], and use information from an independent forecaster (Access Economics 2000) to provide values for the exogenous variables (see Section 5.2).

The second simulation models the various tax reforms associated with the introduction of the goods and services tax (GST). This represents a significant and complex change in the distribution of Australia's taxation burden across tax bases, demanding a separate modelling treatment from those of the remainder of the forecasting simulations. The output of this modelling is a set of shocks that captures the features of the modified ANTS package (see Section 5.3).

Having modelled the shocks that comprise the introduction of the GST, the third simulation involves overlaying these GST shocks with a forecasting simulation for the

[117] At least from the perspective of demonstrating the capabilities of the model, little is lost in treating 1999/00 as a forecast year. There will always be some transition year or period between the historical and forecast simulations for which a complete set of historical data from official statistics are not available.

period 2000/01. This simulation provides a forecast for the period 2000/01, in addition to making the necessary GST related changes to tax bases and intergovernmental transfers (See Section 5.4).

The penultimate set of simulations provides the forecasts for the periods 2001/02 and 2002/03. While the shocks administered to the model differ in both years, the closure under which the model is run is identical in each. The model closure and data sources for these shocks are described in Section 5.5. The final simulation relates to the financial year 2003/04, and is described in Section 5.6.

5.2 SIMULATION FOR THE 1999/00 FINANCIAL YEAR

5.2.1 Introduction

The first simulation brings the model's database up to the year 1999/00. The closure of the model in this simulation does not have a clear analogue with any of the closures employed in Chapter 4. First, many of the structural variables describing industry, factor, and commodity using productivities, household preferences, positions of capital supply schedules, relative industry wage rates, and relative foreign currency import prices, remain exogenous (as they were in the decomposition simulations). These variables are shocked equal to the annual average values that they were calculated to have attained under the historical simulations. The assumption here is that the historical values for these structural variables will continue to be realised over the forecast period. Nevertheless, the macroeconomic variables describing aggregate activity for both Tasmania and the nation as a whole are determined exogenously, as they were in the historical simulation. The constraining of the Tasmanian macroeconomic variables in this way is unique to the 1999/00 simulation. This is done because the Access Economics "forecasts" for Tasmania for this period are an amalgam of both official statistics where available, and forecasts for those quarters where official statistics are not yet available. I believe that using this information is superior to relying on the model to determine macroeconomic outcomes for Tasmania for 1999/00. At the national level, the values for variables describing the macroeconomy are also exogenously imposed, not just for 1999/00, but for each year of the forecast period. This approach is justified in the following discussion.

The FEDERAL-F model can be thought of as being primarily a microeconomic model, with the macroeconomic variables in the model being aggregations of the relevant endogenous microeconomic variables. The standard exogenous variables in the model are also primarily microeconomic - such as technical and tasted change variables, state, local, and Commonwealth government taxation rates and commodity demands, commodity import prices, and positions of foreign demand schedules for individual export commodities. This view of the model suggests a "bottom-up" approach to the use of the model in undertaking forecast simulations:

i. ensure that the set of exogenous variables in the model covers all expected exogenous influences on the economy over the forecast period;
ii. obtain forecasts for the model's exogenous variables over the forecast period; then
iii. shock the appropriate exogenous variables with these forecasts.

Unfortunately using this approach to conduct forecast simulations with Johansen models presents significant practical difficulties due to the very large number of exogenous variables such models contain (Powell 1981). This problem is compounded by the fact that many of the exogenous forces that will influence the economy over the forecast period are not explicitly identified in the model.

Another issue related to adopting the "bottom-up" approach to forecasting with a computable general equilibrium model such as FEDERAL-F is that there is no guarantee that the results thus generated will reconcile with the forecasts produced by researchers using models that are primarily macroeconomic. Clearly one of the most important explanations for such a divergence in results is the differences in the theoretical structures of the models, such as the absence of lagged relationships, rational expectations effects, and monetary phenomena in FEDERAL-F. Differences may also arise if the macroeconomic forecasters base their analyses on different explicit or implicit assumptions about changes in structural and other policy variables that are exogenous in the FEDERAL-F model.

A second approach to forecasting with CGE models capitalises on their differences relative to standard macroeconomic forecasting models. One of the strengths of CGE models is their microeconomic structure, which allows them to be used to develop complex scenarios about changing economic structures across industries, commodities, and regions. The large number of policy variables that are typically embodied in the structure of CGE models also lends them to the analysis of a diverse range of government policy packages. The models are less suited to the production of convincing medium to long-run macroeconomic forecasts, generated from forecast shocks to their standard exogenous variables.

This recognition of the strengths and limitations of CGE models opens the way to a second method of applying them to the task of undertaking forecasting simulations. This method was pioneered in Australia by the Centre of Policy studies in their applications of the MONASH model, and involves determining exogenously the forecast values for key macroeconomic variables. I have applied this approach with my forecast simulations with FEDERAL-F, shocking the national macroeconomic variables with extraneous forecasts. Hence ultimately, the results of the model under this approach can be interpreted as the consequences for industrial structure, the pattern of household consumption, and the regional distribution of economic activity, of both the national macroeconomic environment and the aforementioned structural shocks.

In the remainder of Section 5.2 I describe both the closure of the model for the 1999/00 simulation and the sources for the shock values.

5.2.2 Model closure for the 1999/00 simulation

Table 5.1 summarises those variables, the changes in the endogenous / exogenous status of which, distinguish the comparative-static and forecasting closures. For expository purposes it is useful to view the forecasting closure as being developed through a number of steps, with certain swaps in the endogenous / exogenous status of relevant variables being undertaken at each step. These steps are summarised by Columns 1-7 of Table 5.1. Each of these steps represents a valid closure of the model. The starting point is the standard comparative-static short-run closure (Column 1), and the end points are the forecasting closures for each of the forecast periods (Columns 4-7)

Table 5.1 Derivation of the forecast closures from the short-run comparative static closure

Row	Variable Description	Variable name	Preliminary steps			Forecast closures			
			SR Comparative Static (1)	Year-on-year and MONASH macro closure (2)	National Macro variables (3)	1999/00 (4)	2000/01 (5)	2001/02 and 2002/03 (6)	2003/04 (7)
1	Shift on year-to-year capital accumulation equation	*del_f_ac_p_y*	N	X	X	X	X	X	X
2	Capital stocks at commencement of year	*cap_at_t*	X	N	N	N	N	N	N
3	Shift on comp. stat. relationship between ROR and K growth	*f_eqn54*	X	N	N	N	N	N	N
4	Positions of regional industry capital supply functions	*d_f_eeqror_jr*	N	X	X	X	X	X	X
5	Economy-wide expected ROR (comparative static definition(	*omega*	N	X	X	X	X	X	X
6	Economy-wide shift on regional industry capital supply functions	*d_f_eeqror*	X	N	N	X	N	N	N
7	Real economy-wide consumption - household budget side	*cR*	N	N	X	X	X	X	X
8	Ratio of real consumption and real GNE	*r_cr_rgne*	N	X	N	N	N	N	N
9	Economy-wide APC	*f_eq19*	X	N	N	X	N	N	N
10	Real national gross fixed capital formation	*x2nat*	N	N	X	X	X	X	X
11	Ratio of real economy-wide gross investment to real GNE	*r_ir_rgne*	N	X	N	N	N	N	N
12	Ratio of real private investment to real consumption	*finv_com*	X	N	N	N	N	N	N
13	Real national imports	*xMnat*	N	N	X	X	X	X	X
14	Shift on national / foreign sourcing twists	*twist_src_bar*	X	X	N	N	N	N	N
15	Real national exports	*x4nat*	N	N	X	X	X	X	X
16	General export demand shift variable	*feq_general*	X	X	N	X	N	N	N
17	General shift on real economy-wide government outlays	*f_govcon_gen*	X	N	X	X	X	X	X
18	Economy-wide shift variable on primary factor productivity	*f_a_fac*	X	X	N	X	N	N	N
19	Change in the Australian dollar BOT / nominal GDP ratio	*del_bt_gdp*	N	X	N	N	N	N	N
20	Nominal exchange rate	*x_rate*	X	N	X	X	X	X	X

Table 5.1 Derivation of the forecast closures from the short-run comparative static closure (continued)

Row	Variable Description	Variable name	Preliminary steps			Forecast closures			
			SR Comparative Static (1)	Year-on-year and MONASH macro closure (2)	National Macro variables (3)	1999/00 (4)	2000/01 (5)	2001/02 and 2002/03 (6)	2003/04 (7)
21	Terms of trade	*toft*	N	N	X	X	X	X	X
22	General shifter on export prices (other than trad exports)	*fpentrad*	X	X	N	N	N	N	N
23	Real consumer wage shift variable	*fpre*	X	X	X	X	X	X	X
24	National employment	*l_emp*	N	N	X	X	X	X	X
25	Economy-wide cost neutral shift in labour / capital ratio	*f_twistlk*	X	X	N	X	N	N	N
26	Real GDP	*r_gdpe*	N	N	N	N	N	N	N
27	Shift on Equation *E_xr_expn1*: individual treatment of NTRAD	*f_eq24N_ir*	X	N	N	N	N	N	N
28	Shift on Equation *E_xr_expn2*: block treatment of NTRAD exports	*f_ntrad*	N	X	X	X	X	X	X
29	Economy-wide household consumption price index	*p3nat*	N	X	X	X	X	X	X
30	Shift on Equation *E_p_rexp_exog*	$p\_rexp\_exog_{NTRAD,REG}$	N	N	X	X	X	X	X
31	Non-spreading phantom tax rate - selected elements	$tax\_nsph_{NTRAD,REG}$	X	X	N	N	N	N	N
32	Shift on Equation *E_p_rexp_imp*	$p\_rexp\_imp_{EXOG,REG}$	N	N	X	X	X	X	X
33	Non-spreading phantom tax rate - selected elements	$tax\_nsph_{EXOG,REG}$	X	X	N	N	N	N	N
34	Mainland APC	f_apc_2	X	X	X	N	X	X	X
35	Region-specific export demand shift	$ffeq\_generalr_2$	X	X	X	N	X	X	X
36	Mainland general capital supply shift variable	$d\_f\_eeqror\_r_2$	X	X	X	N	X	X	X
37	Mainland labour/capital twist variable	$fr\_twistlk_2$	X	X	X	N	X	X	X
38	Mainland general shift variable on primary factor tech. change	$f\_a\_facr_2$	X	X	X	N	X	X	X
39	National number of unemployed	*nat_unemp*	N	N	N	X	N	N	N
40	Mainland participation rate	fr_ppr_2	X	X	X	N	X	X	X
41	Mainland population	pop_15_2	N	N	N	X	N	N	N

Table 5.1 Derivation of the forecast closures from the short-run comparative static closure (continued)

Row	Variable Description	Variable name	Preliminary steps			Forecast closures			
			SR Comparative Static (1)	Year-on-year and MONASH macro closure (2)	National Macro variables (3)	1999/00 (4)	2000/01 (5)	2001/02 and 2002/03 (6)	2003/04 (7)
42	Shift on Equation *E_popA2*	$f\_pop\_15_2$	X	X	X	N	X	X	X
43	Tasmanian real regional consumption expenditure	$x3reg_1$	N	N	N	X	N	N	N
44	Tasmanian average propensity to consume	f_apc_1	X	X	X	N	X	X	X
45	Tasmanian real investment expenditure	$x2reg_1$	N	N	N	X	N	N	N
46	Tasmanian general capital supply shift variable	$d\_f\_eeqror\_r_1$	X	X	X	N	X	X	X
47	Tasmanian real exports	$x4reg_1$	N	N	N	X	N	N	N
48	Tasmanian region-specific export demand shift	$ffeq\_generalr_1$	X	X	X	N	X	X	X
49	Tasmanian employment	lr_emp_1	N	N	N	X	N	N	N
50	Tasmanian labour/capital twist variable	$fr\_twistlk_1$	X	X	X	N	X	X	X
51	Tasmanian real GRP	r_grpe_1	N	N	N	X	N	N	N
52	Tasmanian general shift variable on primary factor tech. change	$f\_a\_facr_1$	X	X	X	N	X	X	X
53	Tasmanian number of unemployed	x_unemp_1	N	N	N	X	N	N	N
54	Tasmanian participation rate	fr_ppr_1	X	X	X	N	X	X	X
55	Tasmanian household consumption price index	$p3reg_1$	N	N	N	X	N	N	N
56	Tasmanian general phantom tax shift on household consumption	$fphtax3r_1$	X	X	X	N	X	X	X
57	Tasmanian regional government borrowing requirement	$cb1r_1$	N	N	N	X	X	X	X
58	General Tasmanian government tax shift variable	tax_shiftr_1	X	X	X	N	N	N	N
59	Mainland regional government debt to GSP ratio	$debt\_gsp\_t1_2$	N	N	N	X	X	X	X
60	Tasmanian regional government debt to GSP ratio	$debt\_gsp\_t1_1$	N	N	N	N	N	N	X
61	Commonwealth debt to GDP ratio	$debt\_gdp\_t1$	N	N	N	N	N	N	X
62	Mainland general regional government tax shift variable	tax_shiftr_2	X	X	X	N	N	N	N
63	Shift on average of PAYE tax	$fswitch\_paye$	X	X	X	N	X	X	X
64	Commonwealth PAYE receipts	$b41$	N	N	N	X	N	N	N
65	Shift on per unit taxes on capital and land	f_o_it	X	X	X	N	X	X	X
66	Other Commonwealth income tax receipts	$b42$	N	N	N	X	N	N	N

Table 5.1 Derivation of the forecast closures from the short-run comparative static closure (continued)

Row	Variable Description	Variable name	Preliminary steps: SR Comparative Static (1)	Preliminary steps: Year-on-year and MONASH macro closure (2)	Preliminary steps: National Macro variables (3)	Forecast closures: 1999/00 (4)	Forecast closures: 2000/01 (5)	Forecast closures: 2001/02 and 2002/03 (6)	Forecast closures: 2003/04 (7)
67	General shift variable on tariff rates	*f_t3*	X	X	X	N	X	X	X
68	Commonwealth import duty receipts	*b43*	N	N	N	X	N	N	N
69	General shift variable on industry production tax rates	*ffprod*	X	X	X	N	X	X	X
70	Commonwealth production tax revenues	*b44*	N	N	N	X	N	N	N
71	General shift variable on Commonwealth commodity tax rates	*com_tax*	X	X	X	N	X	X	X
72	Commonwealth commodity tax revenues	*b45*	N	N	N	X	N	N	N
73	General shift on export tax rate	*ft4*	X	X	X	N	X	X	X
74	Commonwealth export tax revenues	*b46*	N	N	N	X	N	N	N
75	Real value of other Commonwealth receipts	*fswitch_f47*	X	X	X	N	X	X	X
76	Commonwealth other receipts	*b47*	N	N	N	X	N	N	N
77	Change in the Commonwealth net financing requirement	*cb2*	N	N	N	X	N	X	N
78	Ratio of other Commonwealth outlays to nominal GDP	*t64*	X	X	X	N	X	X	X
79	Share of sales tax in economy-wide investment	*sh_stax2*	N	N	N	X	N	N	N
80	Purpose-specific shift in Commonwealth sales tax - selected elements.	*fk_tc0_ind*	X	X	X	N	X	X	X
81	Regional traditional export commodity demand shifts	*f_eq24t_ir*	X	X	X	N	N	N	N
82	Export volumes of traditional exports commodities	$xr\_exp_{TRAD,r}$	N	N	N	X	X	X	X
83	Export prices of traditional export commodities	$p\_rexp_{TRAD,R}$	N	N	N	X	X	X	X
84	Non-spreading phantom tax shift variable	$tax\_nsph_{TRAD,r}$	X	X	X	N	N	N	N
85	Shift variable on Equation *E_fp_utility*	$fp\_utility_{UTILITY,r}$	N	N	N	X	X	X	X
86	Regional government production tax shift variable on utility industries	$fprodrj_{UTILITY,r}$	X	X	X	N	N	N	N
87	Shift variable on Equation *E_t61*	*f64r*	X	X	X	X	X	N	N
88	Shift variable on Equation *E_ft61*	*ft61*	N	N	N	N	N	X	X

Table 5.1 Derivation of the forecast closures from the short-run comparative static closure (continued)

Row	Variable Description	Variable name	Preliminary steps			Forecast closures			
			SR Comparative Static (1)	Year-on-year and MONASH macro closure (2)	National Macro variables (3)	1999/00 (4)	2000/01 (5)	2001/02 and 2002/03 (6)	2003/04 (7)
89	General shift on Commonwealth taxes other than consumption taxes	*f_ngst*	X	X	X	X	X	N	N
90	General shift on Tasmanian government consumption	*f_x_sg*$_1$	X	X	X	X	X	X	N
91	General shift on Tasmanian government capital expenditure	*f_sg_invest*$_1$	X	X	X	X	X	X	N
92	Shift on Equation *E_fx5reg*	*fx5reg*$_1$	N	N	N	N	N	N	X
93	Shift on Equation *E_fr_sginv*	*fr_sginv*$_1$	N	N	N	N	N	N	X
	Shocked exogenous variables:								
94	Industry-specific shift in capital supply functions	*d_f_eeqror_j*	X			*	*	*	*
95	Regional industry specific shift in capital supply functions	*d_f_eeqror_jr*	X			*	*	*	*
96	Regional industry shifts in primary factor productivity	*f_a_facjr*	X			*	*	*	*
97	Economy-wide commodity i augmenting technical change	*ai*	X			*	*	*	*
98	All-input using technical change in current production	*a_in1*	X			*	*	*	*
99	All-input using technical change in capital creation	*a_in2*	X			*	*	*	*
100	Shift in commodity i augmenting change in regional household preferences	*f_a3_kr*	X			*	*	*	*
101	Source specific shift in commodity *i,s* augmenting technical change	*ais*	X			*	*	*	*
102	Change in the natural population growth rate	*del_natgrowth*$_2$	X			*			
103	Shift in commodity specific foreign currency import prices	*f_pmp_i*	X			*	*	*	*
104	Economy-wide shift in foreign currency import prices	*f_pmp*	X			*	*	*	*
105	Regional industry specific real wage shift variables	*fprejr*	X			*	*	*	*

Table 5.1 Derivation of the forecast closures from the short-run comparative static closure (continued)

Row	Variable Description	Variable name	Preliminary steps			Forecast closures			
			SR Comparative Static (1)	Year-on-year and MONASH macro closure (2)	National Macro variables (3)	1999/00 (4)	2000/01 (5)	2001/02 and 2002/03 (6)	2003/04 (7)
106	Region specific real wage shift variables	*fprer*	X			*			
107	Economy wide real wage shift variable	*fpre*	X				*	*	*
108	Tasmanian government general consumption shift variable	$f\_x\_sg_1$	X			*	*	*	
109	Mainland government general consumption shift variable	$f\_x\_sg_2$	X			*	*	*	*
110	Tasmanian government general investment shift variable	$f\_sg\_invest_1$	X			*	*	*	
111	Mainland government general investment shift variable	$f\_sg\_invest_2$	X			*	*	*	*
112	Commonwealth government general consumption shift variable	*f_x_cg*	X			*	*	*	*
113	Commonwealth government general investment shift variable	*f_fed_capr*	X			*	*	*	*
114	GST shocks (See Section 5.3)	*(various)*	X				*		
115	Commonwealth government debt accumulation	*del_unity*	X			*	*	*	*
116	Regional industry capital accumulation	*del_unityr*	X			*	*	*	*
117	Closure of rate of return residuals	*del_unityr2*	X			*	*	*	*
118	Regional government debt accumulation	*del_unitryr3*	X			*	*	*	*
119	Calculation of checking coefficients	*del_unityr4*	X			*	*	*	*
120	Calculation of regional population growth	*del_unity_m1*	X			*	*	*	*
121	Movement of inter-regional migrant numbers to equilibrium	*del_unity_m2*	X			*	*	*	*
122	Regional household capital accumulation	*del_own_H*	X			*	*	*	*
123	CPI-X pricing rule	*del_X*	X			*	*	*	*

Note: "X" denotes exogenous, "N" denotes endogenous, "*" denotes those variables that remain exogenous and which are shocked during the forecasting simulations

Starting with the standard short-run comparative static closure, we first "turn-on" the year-on-year capital accumulation equations, and also institute a stylised MONASH structural closure for the national macroeconomy (Column 2). From this closure, we then undertake another set of swaps, which exogenise the national macroeconomic variables (Column 3). This column then provides a convenient starting point for the descriptions of the development of the forecast closures for 1999/00, 2000/01, 2001/02-02/03, and 2002/03-03/04 (Columns 4-7).

5.2.2.1 Turn on the year-on-year equations

The first set of swaps in Column (1) of Table 5.1 "switch-off" the comparative-static rate of return theory and "switch-on" the year-on-year capital accumulation and rate of return theory. First, the year-on-year capital accumulation equation *E_del_f_ac_p_y* is brought into operation by setting exogenous the shift variable on that equation (*del_f_ac_p_y*), and then allowing that equation to determine regional industry capital stocks by setting endogenous *cap_at_t*. Next the FEDERAL relationship between rates of return and capital growth (Equation *E_cap_at_tplus1*) is rendered inoperative by determining endogenously the shift variable on that equation (*f_eqn54*). In their stead are placed the MONASH inverse-logistic regional industry specific capital supply functions, given by Equation *E_d_f_eeqror_jr*. This requires that the shift variables on this equation (*d_f_eeqror_jr*) be determined exogenously. The general shift variable on the positions of these functions (*d_f_eeqror*) is then determined endogenously to ration economy-wide investment. With Equation *E_cap_at_tplus1* now inoperative, this function is no longer served by *omega*, which must now be determined exogenously.

5.2.2.2 Stylised MONASH structural closure

In moving to a stylised version of the MONASH model macroeconomic structural closure, the first step is to determine exogenously the ratio (*r_ir_rgne*) of real economy-wide investment (*x2nat*) to real gross national expenditure (*real_gne*). In so doing, the ratio of real private investment to real consumption expenditure (*finv_com*) is now determined endogenously. The relationship between real economy-wide consumption and the FEDERAL-F definition of real household disposable income is then broken by setting endogenous the economy-wide average propensity to consume (*f_eq19*), and setting exogenous the ratio of real consumption to real gross national expenditure (*r_cr_rgne*). Next, the MONASH treatment of non-traditional export volumes is instituted by setting endogenous the positions of the individual commodity and region specific FEDERAL-F non-traditional export demand schedules (*f_eq24N_ir*), and setting exogenous the corresponding shift variables (*f_ntrad*) on Equation *E_xr_expN2*. Equation *E_xr_expN2* then allows the volume of exports of individual non-traditional export commodities from each region to respond as a block in response to movements in region-specific non-traditional export price indices. The numeraire is switched from the nominal exchange rate (*x_rate*) to the economy-wide household consumption price index (*p3nat*). Finally, the change in the ratio of the balance of trade to GDP (*del_bt_gdp*) is determined exogenously, and aggregate demand is reconciled with aggregate supply via the endogenous determination of real government-wide consumption expenditure (*f_govcon_gen*).

5.2.2.3 Exogenous determination of national macroeconomic variables

The first of the swaps relating to the national macroeconomy (Column 3) sets real national consumption spending (*cR*) exogenous, and the ratio of national consumption to national GNE (*r_cr_rgne*) endogenous. Under this closure the economy-wide APC adjusts to reconcile the exogenously determined national consumption with economy-wide household disposable income. Economy-wide real investment (*x2nat*) is determined exogenously, requiring that the indexing relationship with real GNE (*r_ir_rgne*) be determined endogenously. Real national export volumes (*x4nat*) are determined exogenously, and the general shift variable on the position of each regional-commodity export demand schedule (*feq_general*) is determined endogenously. The national volume of imports (*xMnat*) is determined exogenously, and the general shift variable on the ratio of imports to domestically consumed goods by non-government purchasers (*twist_src_bar*) is determined endogenously. Real government expenditure (*f_govcon_gen*) is determined exogenously. With all the major elements of real aggregate demand determined exogenously, aggregate supply must be determined endogenously, which is achieved by setting endogenous the general shift variable on economy-wide primary factor productivity (*f_a_fac*).

The terms of trade is transferred to the set of exogenous variables in two steps. First, the shift variables *p_rexp_exog* and *p_rexp_imp* are switched to exogenous, and the corresponding elements (i.e. the elements of the sets NTRAD and EXOG in each region) of the non-spreading phantom tax rates (*tax_nsph*) are determined endogenously. This brings equations *E_p_rexp_exog* and *E_p_rexp_imp* into operation. The general shifter on these two equations (*fpentrad*) is then switched to being determined endogenously, and the terms of trade (*tofi*) is determined exogenously.

Economy-wide employment (*l_emp*) is switched to the set of exogenous variables. The real pre-tax wage (*fpre*) is already exogenous. The exogenous status of these two variables is reconciled via the endogenous determination of a uniform cost-neutral change in the ratio of labour and capital usage across all regional industries (*f_twistlk*).

Finally, the nominal exchange rate (*x_rate*) is set exogenous. With aggregate import quantities and export quantities determined exogenously, and foreign currency import prices and export prices (via the terms of trade) also determined exogenously, this effectively determines the nominal Australian dollar value of net exports. Hence the ratio of the Australian dollar balance of trade to nominal GDP (*del_bt_gdp*) must now be determined endogenously.

5.2.2.4 Forecast closure for 1999/00

Starting with the closure described by Column (3), the forecast closure for 1999/00 is now developed in a number of steps. These are summarised in Column (4). First, the volumes of individual traditional exports ($xr\_exp_{TRAD,r}$) are determined exogenously. This requires that the positions of the foreign demand schedules ($f\_eq24T\_ir_{TRAD,r}$) for these exports be determined endogenously. The foreign currency export prices of individual traditional exports from each region ($p\_rexp_{TRAD,r}$) are also determined exogenously, requiring that the non-spreading phantom tax shift variable ($tax\_nsph_{TRAD,r}$) be determined endogenously.

Under the forecast closure, I determine exogenously most of the variables describing both the national and Tasmanian macroeconomies. Under the closure described by Column (3), endogenous macroeconomic shift variables support the exogenous status of the national macroeconomic variables. However a number of swaps are now made in Column (4) to switch these endogenous economy-wide variables to exogenous, and instead determine endogenously variables that pertain only to the Mainland. These swaps recognise that, when both a national macroeconomic variable (such as real national consumption, for example) and a Tasmanian macroeconomic variable (such as real Tasmanian consumption, to continue the example) are determined exogenously, the corresponding Mainland variable (real Mainland consumption) is effectively determined as a residual. Under the new closure then, when the Tasmanian macroeconomy is later described exogenously, it will be the Mainland shift variables that adjust in the face of the exogenously determined national macroeconomy, and the Tasmanian shift variables that adjust given the exogenously specified Tasmanian macroeconomic variables.

The first of these swaps sets the economy-wide average propensity to consume (*f_eq19*) exogenously, and instead the APC for the Mainland (f_apc_2) is determined endogenously. Next, The economy-wide export demand shift variable (*feq_general*) is determined exogenously, and the Mainland general export demand shift variable ($ffeq\_generalr_2$) is determined endogenously. The economy-wide shift variable on the positions of capital supply schedules (*d_f_eeqror*) is determined exogenously, and in its place the Mainland capital supply shift variable ($d\_f\_eeqror\_r_2$) is determined endogenously. Next, the economy-wide labour / capital twist shift variable (*f_twistlk*) is determined exogenously, and the Mainland labour / capital twist shift variable ($fr\_twistlk_2$) is determined endogenously in its place. Next, instead of the economy-wide shift variable on primary factor productivity (*f_a_fac*) being determined endogenously, the Mainland shift variable on primary factor productivity ($f\_a\_facr_2$) is determined endogenously in its place. Finally, the national number of unemployed (*nat_unemp*) is determined exogenously, and the Mainland participation rate ($p\_pp\_rate_2$) is determined endogenously.

The next set of swaps allows for the exogenous determination of the major variables describing the Tasmanian macroeconomy. Tasmanian real consumption expenditure ($x3reg_1$) is determined exogenously, and the Tasmanian average propensity to consume (f_apc_1) is determined endogenously. Tasmanian real investment expenditure ($x2reg_1$) is determined exogenously, and the positions of Tasmanian capital supply schedules ($d\_f\_eeqror\_r_1$) are determined endogenously. The volume of Tasmanian exports ($x4reg_1$) is determined exogenously, and the general shift variable on Tasmanian foreign export schedules ($ffeq\_generalr_1$) is determined endogenously. Tasmanian employment (lr_emp_1) is determined exogenously, and the Tasmanian labour / capital twist variable ($fr\_twistlk_1$) is determined endogenously. Tasmanian real gross regional product (r_grpe_1) is determined exogenously, and a common shift variable on Tasmanian primary factor productivity ($f\_a\_facr_1$) is determined endogenously. Tasmanian unemployment (x_unemp_1) is determined exogenously, and the Tasmanian participation rate ($p\_pp\_rate_1$) is determined endogenously. The Tasmanian consumer price index ($p3reg_1$) is determined exogenously, and the shift variable on Tasmanian phantom taxes on household consumption (*fphtax3r*$_1$) is determined endogenously.

Both the Tasmanian and Mainland government accounts are closed by setting endogenous the general shift variable on regional government tax rates (*tax_shiftr*). Since projected borrowing requirements are available for the Tasmanian government (*cb1r*$_1$), this variable is determined exogenously. The borrowing requirement for the Mainland regional government is determined by setting exogenous the ratio of regional government debt to gross regional product (*debt_gsp_t1*$_2$). The CPI-X pricing rule for utilities industries is brought into operation by setting exogenous the shift variable *fp_utility* on Equation *E_fp_utility*. Movements in the basic prices for utilities, now determined by this equation, are accommodated by movements in the (now endogenous) regional government production tax rates on the output of these industries (*fprodrj*).

Forward estimates of Commonwealth Government receipts of PAYE tax (*b41*), other income taxes (*b42*), import duty (*b43*), production tax revenues (*b44*), commodity tax revenues (*b45*), export tax revenues (*b46*), and other Commonwealth receipts (*b47*) are available from Treasurer of the Commonwealth of Australia (1999). Hence, these variables are determined exogenously. This requires that the shift variable on average PAYE tax rates (*fswitch_paye*), the shift variable on per-unit taxes on capital and land (*f_o_it*), the general shift variable on tariff rates (*f_t3*), the general shift variable on production tax rates (*ffprod*), the general commodity tax shift variable (*com_tax*), the general Commonwealth export tax shift variable (*ft4*), and the general shift variable on other Commonwealth receipts (*fswitch_f47*) be determined endogenously. Finally, the Commonwealth borrowing requirement (*cb2*) is determined exogenously, and the ratio of other Commonwealth outlays to nominal GDP (*t64*) is determined endogenously.

As discussed in Section 2.16.3.5, the natural rate of population growth in each region is determined by the coefficient NATGROWTH_r. By the end of the forecast period, the value for the Mainland element of this coefficient in the parameter file ELAS99 generates a slower rate of growth in Mainland population (*pop_15*$_2$) over the year 1999/00 than that implied by the Access Economics (2000) forecast for national population growth. To use the Access Economics forecast, I determine *pop_15*$_2$ exogenously in the 1999/00 simulation, and set the shift variable on Equation *E_popA2* (*f_pop_15*$_2$) endogenous. The variable *pop_15*$_2$ is then shocked equal to the percentage change in the national population as forecast by Access Economics (2000). At the same time, *del_natgrowth*$_2$ is shocked equal to the difference between the population growth rate between 1998/99 (as given by the value for NATGROWTH$_2$) and 1999/00 (as forecast by Access Economics 2000). This allows *pop_15*$_2$ to be determined endogenously in subsequent years of the simulation, while still achieving the Access Economics' forecasts for population growth in each year. The coefficient measuring natural population growth rate for Tasmania is left unchanged

Finally, a number of variables that are exogenous in the short-run comparative static closure remain exogenous, and are shocked equal to the annual average of the values with which they were shocked under the decomposition closure of the historical period. These variables are *d_f_eeqror_j*, *d_f_eeqror_jr*, *f_a_facjr*, *ai*, *a_in1*, *a_in2*, *f_a3_lkr*, selected elements of *ais*, *f_pmp_i*, and *fprejr*. The general shift variable on foreign currency import prices (*f_pmp*), the regional pre-tax real wages (*fprer*$_r$), and the shift variables on regional government consumption and investment expenditure (*f_x_sg* and *f_sg_invest*) also remain exogenous, and are shocked equal to their forecast values. Finally, the following homotopy variables are shocked equal to 1: *del_unity*, *del_unityr*, *del_unityr2*, *del_unitryr3*, *del_unityr4*, *del_unity_m1*, *del_unity_m2*, *del_own_H*, and *del_X*.

5.2.3 Data for the 1999/00 simulation

Forecasts for the exogenous national and regional macroeconomic variables were obtained from Access Economics (2000). Forecasts for the exogenous elements of the Tasmanian government accounts were obtained from Treasurer of Tasmania (1999). The percentage rates of change in real Mainland government consumption expenditure and real Mainland capital expenditure, were set equal to the Access Economics (2000) forecasts for the percentage rates of change in economy-wide real government consumption expenditure and real economy-wide government investment expenditure, respectively. Percentage rates of change in Commonwealth Government revenues, and the change in the Commonwealth borrowing requirement, were obtained from Treasurer of the Commonwealth of Australia (1999).

ABARE (2000) was used as the basis for volume and price forecasts for Tasmanian and Mainland traditional exports. The ABARE forecasts were available for a more disaggregated commodity classification system than that used in FEDERAL-F. Therefore before the ABARE forecasts could be applied to the model, they had to be weighted and aggregated to the FEDERAL-F commodity classification system. The weights were calculated from ABS data on the value of exports by commodity by state for 1998/99. For Tasmania, ABARE(2000) formed the basis for volume forecasts for 3. *Fishing and Hunting*, 4. *Mining*, 13. *Textiles Clothing and Footwear*, and 21. *Iron Ore and Basic Metal Products*. The publication was also used for calculating foreign currency export price forecasts for all Tasmanian traditional export commodities other than 1. *Rural*, 5. *Meat Small Goods and Poultry*, and 8. *Processed Seafoods*. For the Mainland, ABARE(2000) publication formed the basis for the volume forecasts for all traditional exports other than 8. *Processed Seafoods*. The publication was also used for calculating foreign currency export price forecasts for all Mainland traditional export commodities other than 8. *Processed Seafoods*. For those traditional export commodities from either region for which it was not possible to calculate either volume or price forecasts from ABARE (2000), their forecast values were set equal to the trend annual percentage change over the historical period 1992/93 to 1998/99. Finally, as already mentioned, the variables *d_f_eeqror_jr*, *d_f_eeqror_j*, *f_a_facjr*, *ai*, *a_in1*, *a_in2*, *f_a3_kr*, selected elements of *ais*, *f_pmp_i*, and *fprejr*, were shocked equal to their average annual values for the historical period 1992/92-1998/99.

5.3 Modelling the GST

5.3.1 Introduction

The GST, which took effect from July 1 2000, represents a significant re-allocation of the taxation burden across tax bases. This re-allocation must form part of the forecast shocks for the 1999/00 - 2000/01 year. That is, these fiscal adjustments will not be captured by the shocks that normally comprise a forecast simulation: explicit modelling of the GST is required.

The modelling of the GST is undertaken in two steps: the original proposal (detailed in Treasurer of the Commonwealth of Australia (1998) is modelled first. This is then followed by the modelling of the final proposal that actually received the assent of the Senate in 1999. While it is the impact of the latter proposal that is of relevance for the forecast simulation, these two steps are followed because the initial proposal (unlike the latter) was attended by a sufficient level of public documentation of its consequences for prices and taxation receipts. Hence a practical way of modelling the actual GST policy is to first model the initial proposal, and then model the GST as finally implemented by making the appropriate changes to the shocks implicit in the initial GST proposal.

5.3.2 The original GST proposal

As Harding et al. (2000) note, the original taxation reform package proposed by the Government was complex - involving fundamental changes to the national indirect taxation system, large cuts in income tax, and significant changes to social security programs. As a modelling exercise, this complexity presents a significant challenge, and it is necessary to summarise some of the policy changes in order to render the modelling task tractable. As a first step in this direction, it is useful to quote Harding et al. (2000) who provided the following convenient summary of the original GST proposal (hereafter "ANTS(I)"):

i. The implementation of a 10 per cent GST on a broad base, with health and medical care, education, childcare, charitable activities, and religious services GST-free, and residential rents and financial services input taxed.
ii. Abolition of the current wholesale sales tax.
iii. Abolition of a range of state government taxes including FID; debits tax; stamp duty on marketable securities; conveyancing duties on business property; stamp duties on credit arrangements, instalment purchase arrangements and rental agreements; stamp duties on leases; stamp duties on mortgages bonds, debentures and other loan securities; stamp duties on cheques, bills of exchange and promissory notes; and accommodation taxes.
iv. Introduction of taxes on wine and luxury cars to maintain the current effective consumption tax rates.

v. Adjustments to excise duties following the imposition of a GST, including the introduction of a "per-stick" excise on tobacco.

vi. Large reductions in income tax rates.

vii. Social welfare reforms involving restructured and increased payments to families, increases in pensions and benefits, rationalised child care benefits, and savings bonuses for aged persons and self-funded retirees (Harding et al. 18-20).

By considering Table O.2 and the complete table on p. 33 of Treasurer of the Commonwealth of Australia (1998), it is possible to begin to summarise the revenue and expenditure components of this package in a manner that begins to make clear both the magnitude and direction of the policies subsumed by ANTS(I). To this end, the information in these two tables is amalgamated and summarised in Table 5.2 below.

The information in Table 5.2 can then be more conveniently summarised by both consolidating the accounts of the Commonwealth, State, and Local governments, and presenting them in a "sources and applications of funds" framework. This has been done in Table 5.3 below. Note that the values in Table 5.3 have also been deflated to 1999/00 values using the forecasts for real GDP and the CPI contained in Treasurer of the Commonwealth of Australia (1999).

Table 5.3 makes clear the essence of the original ANTS package. Approximately $17b. was to be raised from changes in the Commonwealth's indirect tax system; $4b. was to be raised from various company and business tax measures, approximately $1b. was to be raised from miscellaneous other sources, and a further $5 b. was to be raised by reducing the Commonwealth's net asset position. Broadly, these funds were to be applied to reducing personal income tax receipts by $11b.; increasing welfare payments by approximately S4b.; funding approximately $2b. worth of diesel fuel measures; and compensating the states for reducing their taxes by approximately $10b. (including the franchise fee replacement taxes).

Table 5.2
ANTS(I) Commonwealth, State, Territory and Local Government Impacts ($b)

Commonwealth Budget Impacts			
Commonwealth Revenue	**2000-01**	**2001-02**	**2002-03**
Personal income tax cuts	-11.7	-11.9	-12.78
Company and business tax measures	3.4	5.0	3.5
WST and other indirect tax changes	-9.4	-11.5	-12.4
Other revenue (incl. "growth dividend")	1.1	0.9	1.0
Total	**-16.6**	**-17.5**	**-20.7**
Commonwealth Outlays			
Reduction in Commonwealth's state and local govt. responsibilities	19.5	20.2	20.89
Social welfare payments and policies	-5.7	-4.4	-4.6
Diesel fuel related	-2.0	-2.2	-2.3
Miscellaneous	0.0	-0.9	-0.6
Total	**11.9**	**12.7**	**13.5**
Impact on Commonwealth Budget	**-4.75**	**-4.80**	**-7.2**
State, Territory and Local Government Impacts			
Revenue			
GST revenue	27.2	32.0	32.8
Reduction in FAG's and local govt responsibilities	-19.5	-20.2	-20.9
Reduced gambling taxes and accommodation taxes	-0.6	-0.6	-0.7
Abolition of FID/debits tax/business stamp duties	-1.0	-4.7	-4.9
Abolition of business franchise fee replacement taxes	-6.7	-7.0	-7.2
Miscellaneous	0.2	1.2	0.7
Total revenue measures	**-0.3**	**0.6**	**-0.1**
Remainder of outlays	**-0.4**	**0.1**	**0.0**
Impact on State, Territory and Local Government Budgets	**-0.7**	**0.7**	**-0.1**
Impact on Australian Government sector	**-5.4**	**-4.1**	**-7.3**

Source: Derived from Treasurer of the Commonwealth of Australia (1998) p.30, pp. 33-35.

Table 5.3
Sources and Applications of Funds - Consolidated Australian Government - 1999/00 values ($b)

Sources of funds	**2000-01**	**2001-02**	**2002-03**
Commonwealth indirect tax measures	16.8	18.2	17.1
Commonwealth business tax collections	3.2	4.4	2.9
Miscellaneous net receipts and outlays: Comm'th, State, Local	0.8	1.1	1.0
Commonwealth budget deficit	4.5	4.3	6.1
State and local budget deficit	0.6	n.a	0.1
Australian Government Sources of funds	**26.0**	**28.0**	**27.2**
Applications of funds			
Personal income tax cuts	-11.0	-10.6	-10.7
Welfare payments	-5.3	-3.9	-3.8
Diesel fuel related	-1.9	-1.9	-1.9
Reduced gambling taxes and accommodation taxes	-0.5	-0.6	-0.5
Abolition of FID/debits tax/business stamp duties	-0.9	-4.2	-4.1
Abolition of business franchise fee replacement taxes	-6.3	-6.3	-6.1
State and local budget surplus	n.a	-0.6	n.a
Australian Government Application of funds	**-26.0**	**-28.0**	**-27.2**

Source: Compiled from data in Table 5.2 above.

5.3.3 Modelling the original GST proposal

The original ANTS document (Treasurer of the Commonwealth of Australia 1998) used a price input-output model (PRISMOD) to measure the impact of the package on costs by industry and the purchaser's prices of commodities faced by households. These impacts are reproduced in the report at a fine level of industrial and commodity classification. In addition to the budget impacts summarised in Table 5.2, the document also summarised the impact of the measures on various final demand deflators. In particular, the private final consumption deflator was projected to rise by 2.2 per cent, and the private investment deflator was projected to rise by 6.9 per cent. Industry costs in aggregate were projected to fall by 3.2 per cent. Furthermore, in running PRISMOD, the Treasury assumed that declines in Australian costs will be approximately matched by exchange rate appreciation (Dixon and Rimmer 1999b). Treasury assumed a nominal exchange rate appreciation of 3.5 per cent.

The ANTS document therefore contains a large amount of information on the outputs of the Treasury's modelling exercise, in addition to a detailed discussion of the nature of the policies that are modelled. However, it contains no information of a quantitative nature on the underlying changes in tax rates. Nevertheless, following Dixon and Rimmer (1999b) it is possible to deduce these tax shocks from the numbers that are published in Treasurer of the Commonwealth of Australia (1998).

First, it was necessary to aggregate the PRISMOD cost results, which are presented for 107 industries, to FEDERAL-F's 37 industries. The table containing these 107 cost results in Treasurer of the Commonwealth of Australia (1998: 167-169) contains both the percentage change and absolute value of the cost savings by industry. Hence it was possible to derive the cost base in PRISMOD for each of these industries. With these base costs, the cost impacts for the 107 industries could then be appropriately weighted to calculate the cost impacts on each of the 37 FEDERAL-F industries (Column 1 Table 5.4). The table containing results for 107 household consumption commodities in Treasurer of the Commonwealth of Australia (1998: 170 - 172) contains results for the percentage change in the purchaser's price of each commodity, and the weighted percentage change in the purchaser's price of each commodity (the sum of which is the CPI impact of 2.2 percent).

Again, from this information it was possible to derive the base share of each commodity in household consumption, and thus form a 37 sector aggregation of the 107 sector PRISMOD price impacts (Column 2 Table 5.4).

Next, following Dixon and Rimmer (1999b), I implemented a database and closure for FEDERAL-F that effectively configured it as a price input-output model in the style of PRISMOD. I set equal to zero across all users the coefficients governing commodity substitution possibilities across sources. Similarly, substitution possibilities between primary factors and between labour of different occupational types were set equal to zero. The closure of the model was modified from the standard short run closure given in Appendix B in the following ways: rates of return ($crates_{j,r}$) were determined exogenously, with current capital stocks ($cap\_at\_t_{j,r}$) determined endogenously. The pre-tax nominal wage ($prewage_{q,j,r}$) was determined exogenously, thus switching off the indexing link with the CPI. Aggregate regional household consumption (crr_r) was determined exogenously, with the regional average propensity (f_apc_r) to consume determined endogenously. The quantities of individual commodity exports were determined exogenously, with the positions of their respective export demand schedules determined endogenously. Finally, household demands for non-source specific commodities ($x\_hous_{i,r}$) were determined exogenously, with the relevant taste shift variables ($f\_a3\_kr_{i,r}$) determined endogenously. These changes to the model's database and closure were sufficient to configure the model as a price input-output model - thus ensuring that shocks to the model would be reflected in price changes only, leaving the values of all real variables unchanged.

Small differences between PRISMOD and FEDERAL-F in the relative sizes of both industries and of household consumption by commodity meant that if the percentage changes in costs and household prices in FEDERAL-F were set equal to those in Table 3, then the impact of these on the relevant aggregate price deflators would not exactly equal those in ANTS. To

Table 5.4

PRISMOD Price Impacts Translated to FEDERAL-F Sectors

FEDERAL-F Industry	Basic Price	Household Price
1 Rural	-2.7	6.7
2 ForestLog	-2.0	na
3 FishHunt	-3.6	6.0
4 Mining	-4.4	na
5 MtSmgdsPltry	-3.1	6.6
6 MilkProd	-3.4	3.7
7 FruitVeg	-4.0	5.7
8 ProcSeafds	-3.4	2.1
9 ConfyCoc	-3.4	1.7
10 CerealProds	-3.5	4.8
11 BevMalts	-3.0	3.1
12 Tobacco	-3.6	13.3
13 TexClothFtwr	-3.1	6.4
14 LogSawChip	-3.1	na
15 Joineryetc	-3.0	-0.5
16 Paper	-3.9	-3.0
17 Printing	-3.5	3.1
18 Chemicals	-3.6	-1.7
19 Petroleum	-4.3	0.0
20 NonMetMin	-4.4	4.6
21 IrnOrBasMet	-4.2	na
22 StrcMetPrd	-3.3	3.9
23 MotVhShips	-3.6	-8.3
24 MachEqpMisc	-2.7	-2.8
25 Elect	-3.1	6.6
26 OthUtil	-5.7	3.9
27 ResBuild	-4.9	na
28 OthConst	-4.6	na
29 TradeInsM	-3.6	3.6
30 TranStorM	-4.8	1.6
31 RestHotM	-2.8	6.7
32 Commun	-4.9	4.7
33 Finance	-3.2	-2.4
34 Dwellings	2.3	2.3
35 PubAdmin	-2.1	7.9
36 CommServ	-1.4	-1.2
37 EntRecrn	-3.6	2.6
Total	**-3.2**	**2.2**

overcome this problem I added Equations *E_rel_p_ants* and *E_rel_p3r* to the model (Appendix A, Section 17). These provide for both general and specific shocks to basic and household prices, allowing the model to accommodate PRISMOD's output on both relative price changes and aggregate price changes. I also added Equation *E_sum_p_ants* to the model. This equation calculates *sum_p_ants*, the economy-wide sales share weighted sum of the percentage changes in p_ants_i. The variable *sum_p_ants* corresponds to the "total business costs" of the ANTS document, which the latter predicts will decline by 3.2 per cent following the implementation of ANTS(I). The variable p_ants_i measures the percentage change in the economy-wide price of i in a manner that is equivalent to the

ANTS definition of such. For all commodities other than Dwellings, p_ants_i is simply the sales share weighted sum of the percentage changes in the basic price of commodity i from each region (See Equations *E_tp_basic*, *E_p_antsA*). The basic price of Dwellings in ANTS is defined as the household price of housing. This is reflected in Equation *E_p_antsB*, which sets $p\_ants_{\text{"Dwellings"}}$ equal to the share-weighted sum of the percentage rates of change in the purchasers' price of Dwellings. A number of equations were then added to the model, which measure impacts on elements of the Commonwealth and regional government finances. Equations *E_Ch_CWr_comt*, *E_Ch_CWr_prodt*, *E_CWr_paye*, and *E_Ch_CW_btax* measure the changes in the Commonwealth's commodity, production, PAYE, and business income tax receipts. Equation *E_Ch_CWo_pbp* measures the change in the Commonwealth's outlays on personal benefit payments. Equation *E_Ch_RGr_bft* measures the change in individual regional government receipts from business finance taxes.

To begin the simulation, I set exogenous those aggregate price indices for which the ANTS document provides outputs: the household consumption deflator (*p3nat*); the investment price deflator (*p2nat*); and the ANTS index of business costs (*sum_p_ants*). The household consumption deflator is determined exogenously by setting endogenous the general shifter on household prices (*gen_p3*) in Equations *E_rel_p3_dwell* and *E_rel_p3r*. The index of business costs is set exogenous by setting endogenous the general shift variable (*gen_pants*) in Equation *E_rel_p_ants*. Finally, the investment price deflator (*p2nat*) is determined exogenously by determining endogenously the general shift variable on Commonwealth indirect taxes on investment inputs ($ftc0\_indk_{\text{"kap"}}$).

Next Equation *E_rel_p3r* was brought into operation by setting exogenous $rel\_p3r_{n,s,r}$ ($n \in$ NONDWELL), and setting endogenous the corresponding elements of the Commonwealth consumption tax shift variables $fswitch\_hous_{n,s,r}$. Equation *E_rel_p3_dwell* was brought into operation by setting exogenous $rel\_p3\_dwell_r$ and setting endogenous $fir\_tc\_hous_{\text{"Dwellings"},r}$. Equation *E_rel_p_ants* for $n \in$ NONDWELL was then brought into operation by determining $rel\_p\_ants_{n,r}$ exogenously, and determining endogenously the corresponding elements of the regional industry specific Commonwealth production tax rate shift variable ($cfprodjr_{n,r}$). Finally, as is clear from Table 5.3 above, the impact of the package on state and local government budgets is effectively neutralised by net Commonwealth grants (in this case, reflected in the allocation of GST revenue to the states). This is modelled by setting the nominal borrowing requirement of each regional government (*cb1r*) exogenous and determining endogenously the shift variable on the real value of Commonwealth grants to the regional governments (*f64r*).

The following shocks were then administered to the model. First, the nominal exchange rate (*x_rate*) was shocked equal to -3.5 per cent. The shift variable on the real value of personal benefit payments (*f_pbp*) was shocked by + 4.4 per cent (this shock being sufficient to generate an increase in personal benefit payments of approximately $4b.). Three price deflators for which the ANTS document provides results (*sum_p_ants*, *p3nat*, *p2nat*) were shocked equal to -3.2, +2.2, and -6.9 respectively. Wholesale sales tax on intermediate and capital inputs were then eliminated by shocking most elements of *fswitch_tind* equal to -99 per cent. The two exceptions were Mining (Commonwealth sales taxes on this commodity do not represent WST) and Petroleum. The Commonwealth commodity tax rate on Petroleum was shocked by -44 per cent. This shock reflects the cost of the diesel fuel concessions ($2b.) relative to the 1999/00 FEDERAL-F database value for Commonwealth sales taxes on the commodity Petroleum ($4.5b.) collected from users of intermediate inputs and capital creators. Next, regional government finance taxes were reduced by -32 per cent. This shock reflected the value of finance related taxes to be abolished by the states ($4.1b.) relative to the database value ($12.9b.) of regional government finance taxes (represented by the total of production taxes on the output of the Finance industry and commodity taxes collected on purchases of the Finance commodity). Hence the following shocks were administered to the model, reflecting regional government reductions in finance taxes: $fts0\_ind_{"Finance",s,r,k} = -32$; $fts\_hous_{"Finance",s,r} = -32$; $fprodrj_{"Finance",r} = -32$. The Treasurer (1998) also foreshadows the states abolishing approximately $0.5b. in gambling and accommodation taxes. This is reflected in a -0.37 per cent shock to regional government production tax rates ($fprodrj_{j,r}$) on the Entertainment and Recreation industry. As is clear from Table 5.3, approximately $6b. in business franchise fee replacement taxes were also to be abolished in ANTS(I). This reflects all business franchise fee taxes, and hence this is reflected in the model by shocking $fts0\_ind_{BFT,s,r,p}$ and $fts\_hous_{BFT,s,r,p}$ equal to -99 per cent. Next, the exogenous components of *rel_p3r* and *rel_p_ants* were shocked equal to their values as given in Table 5.4 above.

The final shocks administered to the model related to the rates of PAYE tax paid by residents in each region. In calculating these shocks, I thought it important that they reflect the higher proportion of low income earners in Tasmania relative to the nation (since the proposed changes in tax scales implied relatively greater falls in average tax rates for lower income earners). Hence I calculated these shock values in two steps. First, Table 2 of Australian Taxation Office (2000) contains, by state, data on the number of tax payers, tax paid, total income, and assessable income, cross classified by fine grades of taxable income. I used these data to calculate the average tax rate faced by both Tasmanian residents (23 per cent) and Mainland residents (25 per cent) under the existing system. I then applied the proposed income tax rates of ANTS(I), and found that the average Tasmanian PAYE tax rate fell by 13 per cent and the average Mainland PAYE tax rate fell by 12 per cent. However, I found that the economy-wide fall in the average income tax rate required to disburse $11b. of PAYE tax receipts was 14.5 per cent, by solving for this variable endogenously within the model. This is broadly consistent with the findings of Dixon and Rimmer (1999b), who find that a 14 per cent reduction in this rate is required in MONASH. Hence, I shocked $fpayer_2$ equal to -14.5 per cent, but then retained a 1 per cent gap between Tasmanian and Mainland PAYE tax rate reductions by shocking $fpayer_1$ equal to -15.5 per cent.

Taken together, these shocks deliver both the desired price and fiscal outcomes. Clearly, the desired price outcomes are achieved because they are determined exogenously. Similarly, the desired aggregate fiscal outcome at the regional government level (zero impact on borrowing requirements) is determined exogenously, with Commonwealth grants determined endogenously. This closure reflects the commitment in the Intergovernment Agreement on the Reform of Commonwealth - State Financial Relations (IGA), that in the transitional years following the introduction of national tax reform, the budgetary position of no State or Territory would be worse than it would have been had the reforms not been implemented. Both the bottom-line impact on the Commonwealth's borrowing requirement, and the values of the individual receipts and outlays of the Commonwealth, are determined endogenously. Hence it is important to determine whether these values coincide with the projections of Treasurer (1998). Overall, the Commonwealth borrowing requirement increases by approximately $9b. Given that the above shocks do not include the business tax measures (designed to raise $4b.)[118], this is the correct fiscal outcome for the Commonwealth. Personal benefit payments increase by approximately $4b., and net indirect tax revenue raised by the Commonwealth increases by $15b. The latter figure represents the net tax revenue raised by the introduction of the GST, the abolition of the WST, and the diesel fuel measures. These figures are broadly consistent with the annual average values of those in Table 5.3, confirming that the underlying tax and fiscal shocks implicit in Treasurer (1998) have been reproduced by this simulation under the PRISMOD-style closure of FEDERAL-F.

5.3.4 The modified GST proposal

In May 1999 the Commonwealth Government negotiated an agreement with the Australian Democrats to guarantee the passage of the (now modified) GST package before 30 June 1999 (Warren et al. 1999). The distinguishing features of this compromise package were:

- the removal of basic food items from the GST base;
- an increase in compensation to pensioners and miscellaneous other welfare beneficiaries;
- changes to the taxation of petroleum products;
- reductions to the planned cuts at the top of the income tax scale; and
- the deferred abolition of a number of state finance taxes (Warren 1999).

If the Treasury undertook simulations of the price impacts of this revised package using PRISMOD, they were not made publicly available. The only publicly available official information of a quantitative nature is the impact of the revised policy on Commonwealth and State revenues and outlays (Prime Minister of Australia 1999a). These costings, converted to 1999/00 values, are presented in Table 5.5 below.

[118] Under the PRISMOD closure of FEDERAL-F, an increase in taxes on capital income is passed through to primary factor prices and hence basic prices. Since these shocks were not included in Treasurer (1998), they are excluded in the simulation used to derive the tax and other fiscal shocks implicit in the price impacts reported in Treasurer (1998). A shock to the average rate of tax on capital and land income is however later added to the tax and fiscal shocks so derived, thus forming the total set of shocks that comprise ANTS (I).

To facilitate the modelling of ANTS (II), I have incorporated the information in Table 5.5 with the information in Table 5.3, to produce a sources and applications of funds statement for ANTS (II).

Table 5.5

Costing of Commonwealth and State Measures - 1999/00 values - $b

Expenditure measures	**2000-01**	**2001-02**	**2002-03**
Additional compensation package	0.7	0.5	0.7
Environmental expenditure	0.2	0.2	0.2
Other expenditure	0.1	0.1	0.1
Total	1.0	0.8	1.0
Revenue measures			
Exemption of basic food from GST	-2.9	-3.2	-3.2
Other GST related	-0.1	-0.1	-0.1
Environmental package - revenue items	0.0	0.0	0.0
Total revenue impact	-3.1	-3.4	-3.4
Total cost to government	-4.1	-4.2	-4.4
Funding measures			
Reduced income tax cuts	1.0	1.0	1.1
Diesel fuel related	0.6	0.6	0.6
Deferred abolition of FID	0.5	0.1	0.0
Deferred abolition - other state taxes	0.5	2.0	2.0
Total funding measures	2.7	3.7	3.7
Budget deficit	-1.4	-0.5	-0.7

Source: Derived from Prime Minister of Australia (1999a).

Table 5.6

ANTS(II) - Sources and Applications of Funds - Consolidated Australian Government - 1999/00 values ($b)

Sources of funds	**2000-01**	**2001-02**	**2002-03**
Commonwealth indirect tax measures	13.8	14.8	13.7
Commonwealth business tax collections	3.2	4.4	2.9
Miscellaneous net receipts and outlays: Comm'th, State, Local	0.5	0.7	0.7
Commonwealth budget deficit	5.8	4.7	6.7
State and local budget deficit	0.6	n.a	0.1
Australian Government Sources of funds	**23.9**	**24.7**	**24.2**
Applications of funds			
Personal income tax cuts	-10.0	-9.5	-9.6
Welfare payments	-6.0	-4.4	-4.6
Diesel fuel related	-1.2	-1.3	-1.3
Reduced gambling taxes and accommodation taxes	-0.5	-0.6	-0.5
Abolition of FID/debits tax/business stamp duties	0.1	-2.1	-2.1
Abolition of business franchise fee replacement taxes	-6.3	-6.3	-6.1
State and local budget surplus	n.a	-0.6	n.a
Australian Government Application of funds	**-23.9**	**-24.7**	**-24.2**

Source: Compiled from data in Table 5.3 and Table 5.5.

From these two tables, and the associated discussion in Prime Minister of Australia (1999b), the magnitude of the key departures of ANTS(II) from ANTS(I) can be summarised as follows:

i The exemption of basic food reduces net indirect tax revenue by approximately \$3.1b. per annum;
ii The Commonwealth budget deficit is higher by approximately \$0.8b. per annum;
iii Personal income tax cuts are lower by approximately \$1.1b. per annum;
iv Welfare payments are higher by approximately \$ 0.6b. per annum;
v Diesel fuel related measures are lower by approximately \$0.6b. per annum;
vi The abolition of certain state government finance taxes is deferred, saving \$1b. of revenue in 2000/01, and approximately \$2.1b. each year thereafter; and
vii The expenditure of approximately \$0.3b. on miscellaneous environmental programs, additional GST administration costs, and other items.

The first step in modelling ANTS(II) then was to eliminate the shocks to household taxes on food items. I deemed basic food to be "Meat, smallgoods and poultry", "Milk products", "Fruit and vegetables", "Processed seafoods", and "Cereal products". Hence, in modelling ANTS(II), I eliminated, for these commodities, the shocks to *fswitch_hous* which I had previously derived in modelling ANTS(I). Implementing these (now modified) GST shocks under the PRISMOD closure of FEDERAL-F reduced Commonwealth commodity tax receipts by approximately \$3.2b. - the desired outcome. Next, the original reductions in average PAYE tax rates had to be reduced to decrease the Commonwealth's loss of such PAYE revenue by \$1.1b. Reducing the mainland average PAYE tax rate reduction to 13 per cent, and the Tasmanian to 14 per cent, was sufficient to achieve this. Note that I maintained the one per cent gap between the average PAYE tax rate reductions in each region. Even under the new rate structure, I found (by again applying this rate structure to ATO data on the distribution of taxpayers by fine grades of taxable income) that the reduction in the average rate faced by Tasmanian households was one per cent higher than that faced by Mainland households. Again, this reflects the higher proportion in Tasmania of households in lower income brackets.

The increase in Commonwealth Government welfare payments of \$0.6b. is achieved by lifting the real increase in Commonwealth personal benefit payments, *f_pbp*, by one per cent, to 5.4 per cent. With the cost of diesel fuel measures now lower by S0.6b., the shock to the Commonwealth commodity tax rate on Petroleum products is reduced from the -44 per cent shock administered when modellings ANTS(I), to -31.11 per cent. Under ANTS(II), the reduction in regional government finance taxes is reduced from $4.1b. per annum starting in 2001/02 to $2.1b per annum. To reflect this, I reduce the shocks to the regional government finance tax variables ($fts0_ind_{\text{"Finance},s,r,k}$, $fts\_hous_{\text{"Finance"},s,r}$, $fprodrj_{\text{"Finance"},r}$) from their values of -32 per cent under ANTS(I) to -16 per cent. With the deferred abolition of these taxes at the regional government level, I also reduce the Commonwealth's grants to regional governments by $2.1 b in aggregate.

The extra expenditure of approximately $0.3b. on miscellaneous environmental programs, additional GST administration costs, and other items is modelled as an increase in Commonwealth Government general consumption expenditure. The increase in business tax collections of $4b. is modelled as an increase in the average rate of other income taxes (f_o_it) of 12 per cent.

5.4 Simulation for the 2000/01 financial year

5.4.1 Introduction

The simulation for 2000/01 can be thought of as being comprised of two elements. The first of these is comprised of the many shocks calculated and described in Section 5.3 to model the introduction of the GST. These shocks form part of the 2000/01 simulation. The second element is represented by the closure and shocks that form the more standard components of the forecasting closure: namely, the exogenous determination of macroeconomic variables, and the shocks to the model's structural variables. This second element is described in detail below.

5.4.2 Model closure for the 2000/01 simulation

The description of 2000/01 closure commences with Column (3) of Table 5.1. Starting with the closure described by this column, the volumes of traditional exports ($xr\_exp_{\text{TRAD},r}$) are determined exogenously. This requires that the positions of the foreign demand schedules ($f\_eq24T\_ir_{\text{TRAD},r}$) be determined endogenously. The foreign currency export prices of individual traditional exports from each region ($p\_rexp_{TRAD,r}$) are also determined exogenously, requiring that the non-spreading phantom tax shift variable ($tax\_nsph_{TRAD,r}$) be determined endogenously.

The CPI-X pricing rule for utilities industries is brought into operation by setting exogenous the shift variable *fp_utility* on Equation *E_fp_utility*. Movements in the basic prices for utilities, which are now determined by Equation *E_fp_utility*, are accommodated by movements in the (now endogenous) regional government production taxes levied on the output of these industries (*fprodrj*).

For the Tasmanian government, forward estimates are available from the Treasurer of Tasmania (1999) for current and capital outlays, and net financing requirements, to 2002/03. For each of these periods then, the Tasmanian government accounts are closed in the following way. Real current outlays (*f_x_cg*) and real capital outlays (*f_sg_invest*) are exogenous and shocked equal to their percentage rate of change as calculated from Treasurer of Tasmania (1999). The Tasmanian government's borrowing requirement (*cb1r*) is determined exogenously, and the general shifter on state taxes (tax_shiftr_1) is determined endogenously. The standard comparative-static indexing relationship determines transfers to households, and residual receipts, outlays, and foreign interest payments are exogenous. For the present year's simulation (2000/01), Commonwealth grants to Tasmania are determined exogenously, as calculated in the GST simulations (see Section 5.3).

A different approach to that above was used to close the Mainland government accounts. It was not practical to obtain forward estimates relating to expenditures, revenues and borrowing requirements for each of the jurisdictions comprising the state / local government sector of the Mainland. Hence I used a simpler approach to close the Mainland regional government accounts. I shocked real current ($f\_x\_sg_2$) and real capital ($f\_sg\_invest_2$) outlays equal to Access Economics' (2000) forecasts for national all-of-government real current and capital outlays. I then set the debt to GSP ratio for the Mainland government exogenous, and set endogenous the general shift variable (tax_shiftr_2) on the Mainland's taxation rates.

For the 2000/01 simulation, most elements of the revenue side of the Commonwealth's accounts are determined exogenously, as discussed in the GST simulations outlined in Section 5.3. Commonwealth real current (*f_x_cg*) and capital outlays (*f_fed_capr*) were shocked equal to their forecast values from Access Economics (2000).

Finally, a number of variables that are exogenous in the short-run comparative static closure remain exogenous, and are shocked equal to the annual average of the values with which they were shocked under the decomposition closure of the historical period. These variables are *d_f_eeqror_j*, *d_f_eeqror_jr*, *f_a_facjr*, *ai*, *a_in1*, *a_in2*, *f_a3_kr*, selected elements of *ais*, *f_pmp_i*, and *fpostjr*. Both the general shift variable on foreign currency import prices (*f_pmp*) and the economy-wide real wage (*fpre*) also remained exogenous, and were shocked equal to their forecast values in Access Economics (2000). Finally, the following homotopy variables are shocked equal to 1: *del_unity*, *del_unityr*, *del_unityr2*, *del_unitryr3*, *del_unityr4*, *del_unity_m1*, *del_unity_m2*, *del_own_H*, and *del_X*.

5.4.3 Data for the 2000/01 simulation

The inputs for the 2000/01 shocks come from a number of sources. The values for the ANTS(II) shocks were calculated in Section 5.3. The values for the shocks to national macroeconomic variables were sourced from Access Economics (2000). The values for the shocks to real consumption and real investment expenditures of both the Commonwealth and Mainland governments were also obtained from Access Economics (2000). Both the borrowing requirement and the real values of capital and current outlays by the Tasmanian government were obtained from Treasurer of Tasmania (1999). ABARE (2000) was used as the basis for volume and price forecasts for Tasmanian and Mainland traditional exports. For Tasmania, this publication formed the basis for volume forecasts for 3. *Fishing and Hunting*, 4. *Mining*, 13. *Textiles Clothing and Footwear*, and 21. *Iron Ore and Basic Metal Products*. The publication was also used for calculating foreign currency export price forecasts for all Tasmanian traditional export commodities other than 1. *Rural*, 5. *Meat Small Goods and Poultry*, and 8. *Processed Seafoods*. For the Mainland, this publication formed the basis for the volume forecasts for all traditional exports other than 8. *Processed Seafoods*. The publication was also used for calculating foreign currency export price forecasts for all Mainland traditional export commodities other than 8. *Processed Seafoods*. For those traditional export commodities from either region for which it was not possible to calculate either volume or price forecasts from ABARE (2000), their values were set equal to the trend annual percentage change over the historical period 1992/93 to 1998/99. Finally, the variables *d_f_eeqror_jr*, *d_f_eeqror_j*, *f_a_facjr*, *ai*, *a_in1*, *a_in2*, *f_a3_kr*, selected elements of *ais*, *f_pmp_i*, and *fpprejr*, were shocked equal to their average annual values from the historical simulations covering the period 1992/92-1998/99.

5.5 Simulations for the 2001/02 and 2002/03 financial years

5.5.1 Model closure for the 2001/02 and 2002/03 simulations

The closure for the simulations for the 2001/02 and 2002/03 financial years differs from that used for 2000/01 in two ways. First, the percentage change in Commonwealth grants to the states is now indexed to the percentage change in Commonwealth GST collections. This requires that Equation *E_ft61* be brought into operation. Equation *E_t61*, which determines Commonwealth grants to the states via an indexing relationship with the national CPI, is rendered inoperative via the endogenous determination of $f64r_r$. In its stead, Equation *E_ft61* determines grants to the states via an indexing relationship with aggregate Commonwealth consumption tax collections. This requires that the shift variable *ft61* on Equation *E_ft61* be determined exogenously.

The second difference is that the Commonwealth's borrowing requirement is now determined exogenously and shocked equal to the forward estimate values from Treasurer of the Commonwealth of Australia (1999). A general shift variable on all Commonwealth taxes other than household consumption taxes (*f_ngst*) is determined endogenously. This shift variable does not appear in Equation *E_thous*, reflecting the commitment in the IGA that the GST rate can only be changed with the agreement of all states and territories, endorsement by the Commonwealth Government of the day, and passage through both Houses of Commonwealth Parliament. Commonwealth real capital and current outlays continue to be shocked equal to their forecast values for government real capital and current outlays from Access Economics (2000).

5.5.2 Data for the 2001/02 and 2002/03 simulations

The values for the shocks to national macroeconomic variables were sourced from Access Economics (2000). The values for the shocks to real consumption and real investment expenditures of both the Commonwealth and Mainland governments were also obtained from Access Economics (2000). Both the borrowing requirement and the real values of capital and current outlays by the Tasmanian government were obtained from Treasurer of Tasmania (1999). As for the simulations undertaken in previous years, ABARE (2000) was used as the basis for volume and price forecasts for Tasmanian and Mainland traditional exports. Finally, the variables *d_f_eeqror_jr*, *d_f_eeqror_j*, *f_a_facjr*, *ai*, *a_in1*, *a_in2*, *f_a3_kr*, selected elements of *ais*, *f_pmp_i*, and *fpostjr*, were shocked equal to their average annual values from the historical simulations covering the period 1992/93-1998/99.

5.6 SIMULATION FOR THE 2003/04 FINANCIAL YEAR

5.6.1 Model closure for the 2003/04

The closure of the model for the 2003/04 simulation is the same as that used in the 2001/02 - 2002/03 simulations with two exceptions relating to the Tasmanian and Commonwealth government accounts. First, forward estimates were not available for either the Tasmanian government's borrowing requirement or its real outlays for 2003/04. Hence the regional government accounts were closed in the following way. First, the Tasmanian government debt to GSP ratio ($debt\_gsp\_t1_l$) was set exogenous, and the general shift variable on Tasmanian government taxes (tax_shiftr_l) was determined endogenously. Second, real Tasmanian government consumption expenditure was indexed to real Tasmanian household consumption expenditure by setting $fx5reg_l$ exogenously and determining the general shift variable on Tasmanian government consumption ($f\_x\_sg_l$) endogenously. Finally, real Tasmanian government capital outlays were indexed to real Tasmanian private investment expenditure by determining fr_sginv_l exogenously and determining the general shift variable on state government capital outlays ($f\_sg\_invest_l$) endogenously.

Forward estimates of the Commonwealth Government's borrowing requirement were not available for 2003/04. To close the Commonwealth Government's accounts, the Commonwealth's debt to GDP ratio (*debt_gdp_t1*) was determined exogenously, and the general shift variable on all taxes other than consumption taxes (*f_ngst*) was determined endogenously.

5.6.2 Data for the 2003/04

The values for the shocks to national macroeconomic variables were sourced from Access Economics (2000). The values for the shocks to real consumption and real investment expenditures of both the Commonwealth and Mainland governments were also obtained from Access Economics (2000). Both the borrowing requirement and the real values of capital and current outlays by the Tasmanian government were obtained from Treasurer of Tasmania (1999). As was the case for the forecasting simulations of the preceding years, ABARE (2000) was again used as the basis for volume and price forecasts for Tasmanian and Mainland traditional exports. Finally, the variables *d_f_eeqror_jr*, *d_f_eeqror_j*, *f_a_facjr*, *ai*, *a_in1*, *a_in2*, *f_a3_kr*, selected elements of *ais*, *f_pmp_i*, and *fpostjr*, were shocked equal to their average annual values from the historical simulations covering the period 1992/92-1998/99.

5.7 RESULTS OF THE FORECASTING SIMULATION

Table 5.7 presents the results for the forecasting simulation. Results are presented for a selection of Tasmanian and Mainland macroeconomic variables, and a selection of Tasmanian sectoral variables. It would be possible to decompose the forecast results into the individual contributions of all the exogenous shocks administered to the model over the forecast period. However, because this decomposition would be analytically identical to the method employed in Chapter 4 of this thesis, I have chosen not to repeat this here. I do however provide an overview of the results below, before moving on in Chapter 6 to use these results as the base case for a number of policy simulations.

The results show the Tasmanian economy continuing to grow at a slower rate than the Mainland economy. The annual average growth rate in Tasmania's real gross regional product at factor cost is projected to be 2.86 per cent. This can be compared with a forecast Mainland growth rate of 4.23 per cent - a difference of 1.37 percentage points per annum. Hence the forecasts show a continuation of the historical trend of a declining

Tasmanian share in national GDP (Graph 5.1), with only a slight reversal in the final year of the simulation.

Figure 5.1
Tasmanian GRP as a share of national GDP

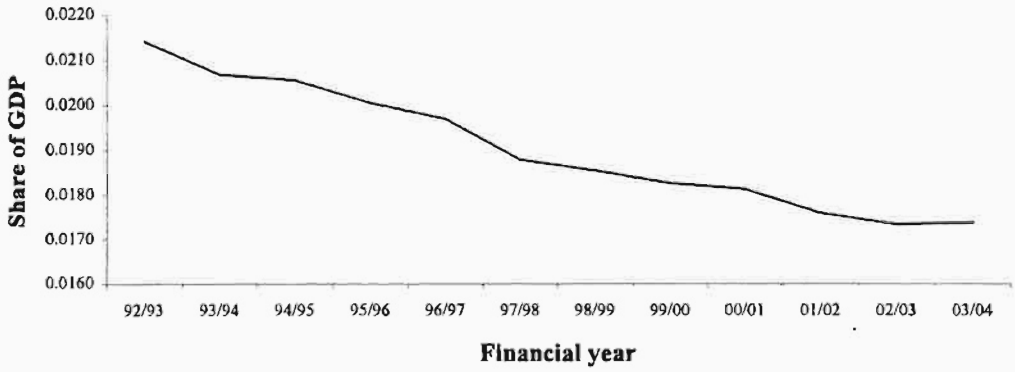


Table 5.7: Results of the forecast simulations
(percentage change on previous year)

Variable	Region	1999/00	2000/01	2001/02	2002/03	2003/04	Average
Macroeconomic results							
Real GDP (factor cost)	Tasmania	3.73	3.40	1.17	2.15	3.88	2.86
	Mainland	5.37	4.20	4.28	3.63	3.69	4.23
Real investment	Tasmania	-1.31	12.46	7.91	12.73	11.26	8.48
	Mainland	8.51	-2.71	2.98	2.43	-0.90	1.99
Real consumption	Tasmania	3.71	2.25	-1.92	0.74	2.30	1.40
	Mainland	4.81	3.35	2.16	3.87	2.62	3.36
Real foreign exports	Tasmania	3.83	7.86	3.35	1.66	0.98	3.51
	Mainland	10.28	11.40	9.94	4.97	2.71	7.80
Real foreign imports	Tasmania	10.03	5.84	4.10	8.04	2.33	6.03
	Mainland	13.30	4.82	6.11	9.20	1.63	6.94
Real regional government consumption expenditure	Tasmania	2.12	-0.52	0.72	1.04	2.30	1.13
	Mainland	3.80	3.04	3.47	4.02	1.77	3.22
Real Commonwealth government consumption expenditure	Tasmania	3.80	3.04	3.47	4.02	1.77	3.22
	Mainland	3.80	3.04	3.47	4.02	1.77	3.22
Real interstate exports	Tasmania	4.86	0.81	0.49	-2.18	2.98	1.36
	Mainland	3.03	5.83	1.74	3.46	5.89	3.98
Real interstate imports	Tasmania	3.03	5.83	1.74	3.46	5.89	3.98
	Mainland	4.86	0.81	0.49	-2.18	2.98	1.36
GSP deflator	Tasmania	1.92	6.47	1.59	2.44	4.69	3.40
	Mainland	3.28	3.77	2.57	1.05	2.46	2.62
Employment	Tasmania	2.06	4.15	0.09	0.86	2.24	1.87
	Mainland	2.89	2.93	2.11	0.76	0.17	1.76
Capital stock (rental weights)	Tasmania	-0.61	-0.81	-0.41	-0.64	-0.41	-0.58
	Mainland	3.27	3.79	2.93	2.90	2.74	3.12
Consumer price index	Tasmania	1.80	7.06	3.14	3.08	3.48	3.70
	Mainland	2.31	5.77	2.08	2.08	3.60	3.16
Population	Tasmania	-0.76	-0.44	-0.28	-0.18	-0.10	-0.35
	Mainland	1.41	1.37	1.26	1.21	1.18	1.29

Table 5.7: Results of the forecast simulations (continued)

Variable	1999/00	2000/01	2001/02	2002/03	2003/04	Average
Real output by Tasmanian sector						
1. Agriculture	5.30	4.81	5.13	4.26	6.99	5.29
2. Mining	7.80	3.64	0.02	-2.40	-0.31	1.69
3. Manufacturing	2.55	3.34	0.36	-0.86	2.21	1.51
4. Utilities	5.12	3.59	1.57	1.39	2.64	2.86
5. Construction	-0.36	12.02	8.20	12.36	11.43	8.62
6. Margin industries	5.16	3.84	-0.21	2.28	3.74	2.95
7. Communications	11.06	7.76	4.85	7.85	9.25	8.13
8. Finance	5.30	5.41	1.54	3.31	5.39	4.18
9. Dwellings	0.77	-1.12	0.42	0.25	1.02	0.27
10. Public administration	2.53	0.36	1.39	1.79	2.18	1.65
11. Community services	3.91	2.34	0.30	1.91	3.07	2.30
12. Entertainment and recreation	3.30	0.68	-3.27	-0.87	1.55	0.25
Per unit costs by Tasmanian sector						
1. Agriculture	-0.47	2.36	6.10	4.03	3.75	3.13
2. Mining	-2.66	-2.20	1.62	1.08	2.02	-0.05
3. Manufacturing	0.67	2.65	5.08	4.05	4.97	3.47
4. Utilities	1.49	6.74	2.84	2.77	3.18	3.39
5. Construction	0.05	-0.59	3.98	3.11	3.01	1.90
6. Margin industries	-2.56	-1.62	3.03	1.22	0.14	0.02
7. Communications	-1.61	-3.81	0.77	-0.51	0.46	-0.95
8. Finance	-1.18	0.71	4.82	3.41	2.90	2.11
9. Dwellings	7.34	0.14	-1.25	3.38	5.32	2.94
10. Public administration	-0.90	0.50	2.46	1.89	1.70	1.12
11. Community services	0.45	2.52	3.86	2.85	2.10	2.35
12. Entertainment and recreation	1.22	1.63	7.41	5.47	3.95	3.91
Employment by Tasmanian sector						
1. Agriculture	4.83	7.08	5.91	3.84	7.02	5.73
2. Mining	-2.05	-3.95	-8.38	-11.07	-9.41	-7.03
3. Manufacturing	2.04	5.01	0.20	-1.65	1.12	1.32
4. Utilities	-1.71	-0.86	-5.80	-6.88	-5.81	-4.25
5. Construction	-3.20	11.66	6.59	10.37	8.77	6.70
6. Margin industries	2.96	3.75	-2.39	-0.04	1.07	1.05
7. Communications	-0.51	-1.70	-5.31	-2.97	-2.21	-2.55
8. Finance	6.26	8.94	3.37	4.79	6.48	5.95
9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00
10. Public administration	-2.13	-2.22	-2.15	-2.17	-2.32	-2.20
11. Community services	1.99	2.51	-0.53	0.66	1.28	1.17
12. Entertainment and recreation	4.99	4.22	-1.73	0.50	2.59	2.08
Exports by Tasmanian sector						
1. Agriculture	2.30	-6.18	-1.67	-1.55	-1.43	-1.74
2. Mining	14.43	9.04	1.83	0.71	0.66	5.19
3. Manufacturing	2.17	9.81	4.33	2.30	1.38	3.95
4. Utilities	-27.76	18.52	13.95	7.03	3.09	1.49
5. Construction	0.00	0.00	0.00	0.00	0.00	0.00
6. Margin industries	-27.76	18.52	13.95	7.03	3.09	1.49
7. Communications	-27.76	18.52	13.95	7.03	3.09	1.49
8. Finance	-27.76	18.52	13.95	7.03	3.09	1.49
9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00
10. Public administration	-27.76	18.52	13.95	7.03	3.09	1.49
11. Community services	-27.76	18.52	13.95	7.03	3.09	1.49
12. Entertainment and recreation	-27.76	18.52	13.95	7.03	3.09	1.49

Tasmania's slower growth rate can be traced to two immediate causes; namely, lower forecast rates of growth in capital, and primary factor productivity. Tasmania's employment growth rate is forecast to exceed that of the Mainland, by approximately 0.11 percentage points per annum. *Ceterus paribus*, this causes Tasmania to grow marginally faster than the Mainland. The share of labour in Tasmanian gross regional product at factor cost is approximately 70 per cent over the forecast period. Hence, if forecast Tasmanian employment were to have grown at the same rate as Mainland employment, the forecast annual average growth rate in real Tasmanian output would have been 0.08 percentage points lower[119]. The two major immediate factors accounting for Tasmania's slower growth rate are a negative capital growth rate, and a relatively slow rate of primary factor productivity growth. The share of capital rentals in Tasmanian gross regional product is approximately 18 per cent over the forecast period. If Tasmania's capital stock had grown at the same rate as the Mainland's capital stock, then Tasmania's forecast output growth rate would have been 0.67 percentage points per annum higher on average[120]. However, differences in factor growth rates can only account for approximately 0.74 percentage points of the difference in annual average growth rates[121]. Another 0.56[122] percentage points are due to a lower rate of productivity growth in Tasmania. Given the approximate average factor shares in GRP over the forecast period, we can write the percentage change in gross regional output in the Tasmanian and Mainland economics as:

$$
\begin{aligned}
2.86 &= (0.01\times 0)+(0.70\times 1.87)+(0.18\times -0.58)+(0.11\times 2.86)+a_{Tas}\\
4.23 &= (0.01\times 0)+(0.67\times 1.76)+(0.22\times 3.12)+(0.11\times 4.23)+a_{Mainland}
\end{aligned}
$$

(real GRP) (land) (labour) (capital) (other costs) (technical change)

where the first term in each bracket is the share of the relevant factor in GRP at factor cost, the second term is the average annual percentage change in usage of that factor, and a_r is the region-wide percentage improvement in primary factor productivity. From the above

119 $(0.70\times 1.76)-(0.70\times 1.87)$

120 $(0.18\times 3.12)-(0.18\times -0.58)$

121 Differences in growth rates of inputs of other costs account for approximately 0.15 percentage points of the difference in annual average growth rates.

122 The remaining 0.07 percentage points are due to differences between the regions in factor shares in GRP at factor cost.

two equations it is clear that the value for a_{Tas} was 1.3 per cent per annum, while the value for $a_{Mainland}$ was 1.9 per cent per annum. The lower growth rate in Tasmanian productivity is largely an extrapolation of the productivity trends derived in the historical simulations. Recall that in each period of the forecast simulation, other than 1999/00 when *f_a_facr* is determined endogenously, the shifts in both Tasmanian and Mainland productivity variables are determined exogenously and shocked equal to the annual average of their values as derived in the historical simulations.

Turning now to the Tasmanian macroeconomic aggregates, we can see that real investment expenditure is projected to grow strongly over the forecast period (8.48 per cent per annum). This causes the share of real investment expenditure in Tasmanian real GRP to increase over the forecast period from approximately 14 per cent to 22 per cent. In the 1999/00 simulation, Tasmanian real investment expenditure is determined exogenously, however in subsequent years it is determined endogenously. The significant increase in real investment in these periods reflects both the growing scarcity of capital in Tasmania (which causes expected rates of return to rise), and the operation of Equation *E_d_diseq*. Expected rates of return on Tasmanian capital stocks over the forecast period are higher than the equilibrium rates of return (given Tasmania's low capital growth rates). Equation *E_d_diseq* operates to give a boost to Tasmanian capital growth rates (and hence investment) to bring the expected rates of return on Tasmanian capital towards their equilibrium rates of return. However despite the increase in Tasmanian investment, the aggregate level of Tasmanian gross investment is insufficient to cover depreciation on the aggregate Tasmanian capital stock, which is projected to decline at an annual average rate of 0.58 per cent over the forecast period.

Real consumption expenditure is projected to grow more slowly than gross regional product, rising at an annual average rate of only 1.4 per cent. This causes the share of real consumption expenditure in gross regional product at market prices to decline from approximately 69 per cent at the beginning of the forecast period to approximately 68 per cent by the end of the period. The declining share of real consumption is in large part due to a sharp fall in real consumption spending in 2001/02, followed by relatively low growth in 2002/03. These changes in real consumption largely arise from subdued growth in nominal consumption in each of these years occurring against a background of consumer price inflation of approximately 3 per cent per annum. From the results of the decomposition equations discussed in Section 2.12.12[123] the most important contributors to the subdued growth in nominal disposable income are a decline in receipts by Tasmanian households of capital rentals and particularly phantom taxes in each of these two years, and also rising payments of Commonwealth direct taxes in the second year.

Real regional government consumption expenditure is projected to increase at an annual average rate of 1.13 per cent per annum. This is slightly slower than the forecast rate of growth in gross regional product at market prices[124]. Real Commonwealth consumption expenditure is forecast to increase at 3.22 per cent per annum. Overall, the share of total government expenditure in Tasmanian gross regional product at market prices is projected to increase from approximately 24 per cent at the beginning of the forecast period to 25 per cent by the end of the period.

The forecast decline in real consumption expenditure as a share of gross regional product at market prices is not sufficient to offset the rising shares of both real investment and real government consumption expenditure. Hence Tasmania's trade deficit as a share of gross regional product must increase. This is expressed as a rise in the interstate balance of trade deficit as a share of gross state product. Tasmania has a large international balance of trade surplus over the forecast period. Hence, even though foreign import volumes rise faster than foreign export volumes (6.03 per cent per annum as compared to 3.51 per cent per annum, respectively), the foreign balance of trade surplus as a proportion of gross state product is steady, at about 13 per cent. However the interstate balance of trade deficit is forecast to increase from 20 to 26 per cent of gross regional product over the period. This is manifested by rising interstate imports (3.98 per cent per annum), and reflected in a faster growth rate in the overall Tasmanian price level (3.40 per cent per annum) relative to the Mainland price level (2.62 per cent per annum).

Turning to the sectoral results, the fastest growing Tasmanian sector is projected to be Construction (8.62 per cent per annum). This reflects the strong growth in Tasmanian investment expenditure over the period. Employment in the sector does not increase as quickly as output, because of the relatively strong (2.7 per cent per annum) improvement in

[123] Results not reported in Table 5.7.
[124] 1.47 per cent per annum.

primary factor technical efficiency to which the sector is assumed to be subject over the period. This productivity improvement is an extrapolation into the forecast period of the technical change found to have been experienced by this sector in the historical simulations.

Communications is forecast to be the second fastest growing sector in Tasmania (activity is projected to increase by 8.13 per cent per annum). During the historical simulations, this sector was found to be the beneficiary of both strong improvements in primary factor productivity (9.1 per cent per annum) and all-input using technical change (1.0 per cent per annum). On the demand side, there was an increase in per-unit requirements of Communication in current production and capital formation (+6.0 per cent per annum), as well as a shift in household preferences towards the commodity (+4.8 per cent per annum). These technical and taste changes are extrapolated into the forecast period. Here, both the rising input requirements for the commodity, and the shift in household preferences towards the commodity, are reflected in strong output growth. The rising productivity in the production of Communications is reflected in falling per unit production costs and falling employment in the sector. The basic price of Tasmanian Communications is projected to fall by 0.95 per cent per annum, and employment in the sector is projected to fall by 2.55 per cent per annum.

The third fastest growing sector is projected to be Agriculture (5.29 per cent per annum). The expansion in Tasmanian Agriculture is due almost entirely to rising intermediate input sales to Tasmanian and Mainland firms. The growth in sales to these firms is assisted by two factors. First, over the historical period, I found a strong shift (+3.9 per cent per annum) in commodity using technical change towards the usage of 1.*Rural*. This industry accounts for approximately sixty per cent of value added in the Tasmanian Agriculture sector. Hence, *ceterus paribus*, when extrapolated to the forecast period, this increase in input requirements for *1.Rural* added approximately 2.3 per cent to Agriculture's output growth rate. However this was offset somewhat by commodity saving technical change experienced by the remaining two commodities subsumed within Agriculture (2. *Forestry and logging* and 3. *Fishing and Hunting*). These commodities experienced commodity saving technical change over the historical period of -0.3 and -1.7 per cent respectively. Over the forecast period, the average shares of these two industries in the value added of Agriculture are approximately 21 per cent and 18 per cent respectively. Hence, *ceterus* *paribus*, the commodity saving technical change experienced by these two commodities would have reduced Agriculture's growth rate by approximately 0.4 percentage points per annum. The second and less important factor contributing to Agriculture's relatively rapid growth rate was the growth experienced by the Tasmanian industry 5. *Meat Small Goods and Poultry*. This industry is projected to grow slightly faster than real gross regional product at factor cost. Over the forecast period, approximately one third of the output of 1. *Rural* is sold to this industry.

Real activity in the Tasmanian Finance sector is forecast to grow somewhat faster than real GRP, with output forecast to expand by 4.18 per cent per annum. Examining the results of the output decomposition equations[125], the forecast growth in this sector is due in the main to rising intermediate sales to Tasmanian current producers. The historical simulations found a rising Finance requirement per unit output (of 2.3 per cent) across both intermediate input users and capital creators. When this technical change is applied to the forecast period, it leads to the Finance sector growing at a faster rate than real gross regional product at factor cost.

Output of the Margins sector is forecast to grow at an annual average rate of 2.95 per cent per annum, about the same rate as the Tasmanian economy as a whole. The bulk of the output of this sector (approximately seventy per cent) is used as margin services, so changes in the sector's output tend to follow those of real gross regional product at factor cost. However the sector's output growth rate is not reflected in its forecast employment growth rate. Employment in Margins is forecast to increase by only 1.05 per cent per annum. Again, this reflects the assumed continuation into the forecast period of the historical technical changes in production efficiency for the industries within the Margins sector. Over the historical period, the industries subsumed within the Margins sector (29. *Trade and Insurance Margins*, 30. *Transport and Storage Margins*, and 31. *Restaurant and Hotel Margins*) were found to have experienced improvements in primary factor technical efficiency of 1.9, 0.9, and 0.6 per cent per annum respectively. They were also found to have experienced improvements in all input using technical efficiency of 0.4, 0.3 and 0.2 per cent respectively. When weighted by each industry's share in the value added of the Margins sector, these numbers are equivalent to an improvement in primary factor

[125] Not separately reported.

productivity of approximately 1.9 per cent per annum for the Margins sector. Hence, when applied to the forecast period, these technology shocks are associated with relatively slow rates of both employment growth and cost increase for this sector.

Output of the Utilities sector is forecast to grow at an annual average rate equal to that of real gross regional product. Despite the forecast output growth for this sector of 2.86 per cent per annum, employment in the sector is forecast to decline sharply (at an annual average rate of 4.25 per cent). This reflects the extrapolation into the forecast period of the strong primary factor saving technical change (7.5 per cent per annum) that this sector was found to experience in the historical simulations. This is not reflected in the basic price for this sector's output. The basic price of Utilities is projected to increase at an annual average rate of 3.39 per cent. This is 0.30 percentage points lower than the annual average rate of increase in the Tasmanian consumer price index over the period. This reflects the operation of Equation *E_fp_utility* over the forecast period, which continues to be implemented with its historical value for XUTE_1 of 0.3.

Output in the Community services sector is forecast to increase by 2.30 per cent per annum. The output of this sector is sold largely to Tasmanian households, the Tasmanian regional government, and the Commonwealth Government. Over the forecast period, Tasmanian consumers and government account for approximately 30 percent and 50 per cent respectively, of the output of the sector. Hence, with household real consumption rising by only 0.60 per cent per annum, and regional government consumption rising by only 0.92 per cent per annum, the growth prospects for this sector are forecast to be quite subdued. However the sector's output rises faster than what would otherwise be implied by these figures for two reasons. First, household demand for the commodity rises faster than overall real consumption expenditure, because of the imposition of a 1.4 per cent per annum shift in the preferences of Tasmanian consumers towards Community Services in each year of the forecast simulations. Second, demand for the output of the sector by the Commonwealth Government increases by 3.22 per cent per annum. Sales to the Commonwealth account for a little less than 20 per cent of the sector's output. Hence overall the sector is able to manage an average annual growth rate of 2.30 per cent despite the relatively slow rate of growth in the real consumption expenditure of both the Tasmanian government and Tasmanian households. Employment in the Community Services sector is forecast to grow at an annual average rate of only 1.17 per cent per annum. Approximately ninety-five per cent of the payments to primary factor inputs in Community Services are accounted for by payments to labour. Hence, with forecasts for both all input saving technical change of 0.4 per cent per annum, and primary factor saving technical change of 0.7 per cent per annum[126], the growth rate in the sector's employment must be approximately 1.1 per cent per annum less than its output growth rate.

Activity in the Tasmanian Mining sector is projected to increase at an annual average rate of 1.69 per cent per annum. Most of this growth is due to rising export sales, which are forecast to rise at an annual average rate of 5.19 per cent per annum. This reflects strong growth in ABARE forecasts for zinc exports in the early years of the forecast simulation. Sales to domestic users are projected to remain relatively static. Employment in the Tasmanian Mining sector is projected to decline by 7.03 per cent per annum. This reflects the strong improvement in primary factor technical efficiency to which the Mining sector is subject (7.4 per cent per annum) over the forecast period[127].

Activity in the Public Administration sector is forecast to increase at an annual average rate of 1.65 per cent per annum. The growth in this sector is simply a reflection of the weighted average growth in both Tasmanian government and Commonwealth government consumption expenditure over the period. Despite the growth in output, employment is projected to contract by 2.20 per cent per annum. This reflects the implementation of primary factor and all input using technical change shocks to this sector of -3.0 and -0.8 per cent per annum respectively.

Activity in the Manufacturing sector is forecast to increase at an annual average rate of 1.51 per cent. This sector summarises the activity of twenty individual industries, making it difficult to generalise about the causes for the forecast changes in variables related to this sector. However, examining the results of the decomposition equations[128], it is possible to say that most of the increase in the sector's activity is attributable to rising export sales, the real value of which is forecast to increase by 3.95 per cent per annum. Had real Manufacturing export volumes not expanded, then the forecast output for this sector would

[126] Both of which were derived during the historical simulations.
[127] Over the forecast period, almost 90 per cent of primary factor payments in the Tasmanian Mining sector are to labour. Hence the forecast improvement in primary factor productivity translates into an almost identical reduction in employment.
[128] Results not separately reported.

have grown at only about 0.2 per cent per annum. Examining the results for the output decomposition equations, it is apparent that while rising intermediate input sales to Tasmanian and Mainland firms contributed approximately 0.6 percentage points per year to the Manufacturing sector's growth, this was almost entirely offset by the effect of falling purchases of Tasmanian Manufacturing by Tasmanian and Mainland households. The latter reduced the sector's growth rate by 0.4 percentage points per annum. The growth rate in the sector's primary factor productivity is forecast to be just under half that of the average for the state as a whole. Employment in the sector is forecast to increase by approximately 1.32 per cent per annum. The sector's capital stock is forecast to decline at an annual average rate of approximately 2.0[129] per cent per annum. With the average factor shares in total value added for this sector over the forecast period being approximately 75, 10 and 15 per cent for labour, capital, and other costs respectively, this implies an average improvement in total factor productivity for this sector of only 0.5 per cent per annum.

The slowest growing sector is forecast to be Entertainment and Recreation, activity in which is projected to increase at an annual average rate of only 0.25 per cent. Approximately seventy percent of the output of Entertainment and Recreation is sold to Tasmanian consumers, who source approximately eighty percent of their Entertainment and Recreation consumption from Tasmania. Over the forecast period both the basic price and the consumer price of Entertainment and Recreation are forecast to rise faster than the Tasmanian consumer price index. The basic price of the sector's output is forecast to increase by 3.91 per cent per annum and the consumer price by 5.23 per cent per annum[130]. The relatively rapid rise in the basic price is due to two factors. First, the nominal wage in this sector is forecast to rise by approximately 6.2[131] per cent per annum, and payments to labour account for approximately seventy percent of total factor payments in this sector. Approximately 4.1 percentage points per annum of this wage rise is due to a continuation into the forecast period of the shocks to relative wage differentials which were applied in the historical simulations. The second factor explaining the sharp increase in the sector's basic price is primary factor using technical change of 2.1 per cent per annum. Again, this is a continuation into the forecast period of the technical change derived for this sector

[129] Result not separately reported.
[130] The latter result is not separately reported in Table 5.7.
[131] This result is not separately reported in Table 5.7.

during the historical simulations. With the value of Tasmanian sourced Entertainment and Recreation representing such a large share in total purchases by Tasmanian households of Entertainment and Recreation, the rise in the price of the Tasmanian sourced component causes Tasmanian households to substitute away from Entertainment and Recreation in general. Furthermore, the consumer price of Tasmanian sourced Entertainment and Recreation is forecast to rise relative to the prices for the commodity from the Mainland and overseas. This causes households to substitute away from Tasmanian sourced Entertainment and Recreation and towards Mainland and foreign sources for the commodity. Together, these two factors act to cause activity in this sector to grow quite slowly over the forecast period.

6. ILLUSTRATIVE APPLICATIONS III: POLICY SIMULATIONS

6.1 MICROECONOMIC REFORM IN THE UTILITIES SECTOR

6.1.1 Introduction

Since the 1980's an extensive program of microeconomic reform has been introduced in Australia (Productivity Commission 1999a). A significant impetus to reform was the agreement by the Council of Australian Governments (COAG) on the introduction of National Competition Policy (NCP) in 1995.

Prior to the COAG agreement on NCP, there were a number of studies released, which gave support to the concept of NCP. For the most part these studies were focussed on the long-run benefits that microeconomic reform would bring. The most comprehensive study was that by Industry Commission (1995), published shortly before the COAG agreement on NCP. The Industry Commission (IC) modelled all of the NCP reforms as advanced by Hilmer et al. (1993) and certain related reforms.

The IC used a model of the national economy (HILORANI) and did not provide any regional decomposition of results. Estimates of the regional effects of NCP were made at the time by Madden (1995a and 1995b) using the MMRF model. However, like the IC, Madden focussed entirely on the long run.

Both the IC and Madden projected significant long run increases in real GDP. The IC study estimated a long run increase in real GDP of 5.5 per cent. Madden found a long run increase in real GDP of 3.4 per cent. The lower impacts found by Madden were due largely to the narrower scope of his study, rather than differences in shocks, model structure, or closure (Madden 2000). Despite the Commission's estimate of the long-run GDP impact being much smaller than some previous studies (e.g Ralph 1994), it was criticised by Quiggin (1996 and 1997) as an overestimate.

The main points of Quiggin's (1997) detailed critique of the IC study can be summarised under three points. The first was that the IC's assumption that all jobs lost through NCP would be matched by job expansion elsewhere in the economy was contrary to the IC's own evidence on the experience of workers made redundant by labour-shedding. Quiggin cited the IC as suggesting that "about 50 per cent of workers made redundant by microeconomic reform were still unemployed or not in the labour force after three years".

The second of Quiggin's arguments was directed at the method employed by the IC to estimate the direct effect of NCP. The IC assumed that exposure to competition would force Australian government business enterprises to achieve 'world best practice' through internal restructuring. The long run benefits of microeconomic reform were therefore measured by the IC as the gap between current productivity performance and world best practice. World best practice was determined by examining the productivity performances of the top ranked enterprises within each industry. The best practice benchmark was then set between the productivity performance of the top-ranked and second-ranked enterprise within each industry (Quiggin 1997). The productivity improvement to be delivered by NCP was then set equal to the gap between the current productivity performance of the Australian enterprise and the best practice benchmark.

Quiggin argued that the IC's approach set the productivity benchmark at the maximal or near maximal observation, while failing to take account of the fact that any sample of productivity measures for selected enterprises will be subject to errors, measurement biases and enterprise-specific factors. Quiggin suggested that one way of overcoming these problems would be the use of the stochastic frontier production (SPF) method. Whiteman (1999) considered this claim. Whiteman estimated technical efficiency for Australian and international electricity suppliers using SPF and data envelopment analysis (DEA), the latter being one of the methods criticised by Quiggin. However contrary to Quiggin's concerns, Whiteman showed that, on average, the DEA estimates of the productivity gaps were approximately half those of the SPF estimates.

The third element of Quiggin's critique of the IC's study related to the latter's choice of counter-factual when calculating the productivity effects of NCP. The productivity effect of NCP should be set equal to the difference between the productivity levels expected to be achieved in the presence of NCP, and the productivity levels expected to be achieved under the counter-factual. The IC's calculations effectively assumed that the level of productivity growth under the counter-factual would be zero. This allowed all of the difference between current productivity and benchmark productivity to be attributed to NCP. No account was taken of the fact that most of the Australian enterprises had experienced steady growth in total factor productivity in the past.

6.1.2 Current study

One of the many outputs of the historical simulations reported in Chapter 4 are year-by-year changes in primary factor productivity in the Tasmanian and Mainland Utilities industries for the years 1993/94 to 1998/99 inclusive. In the current study, the consideration of what might have been the productivity consequences of NCP is taken up by examining the productivity changes derived during the historical simulations for both the Tasmanian and Mainland Utilities sectors. The question to be considered initially is whether productivity growth in Utilities increased in the period subsequent to the COAG agreement.

The six years of the historical simulation period were divided in two, the first three years being considered as approximating the pre-NCP period. The average productivity improvements for the two phases were compared, and the differences were assumed to be the impact of NCP as agreed by the Council of Australian Governments in 1995. By using an estimate of the actual increase in Utilities annual productivity improvement, the problem in estimating the degree and speed with which NCP will remove efficiency gaps is reduced. An obvious limitation of this approach is that only one explanatory variable (NCP) is posited to account for the observed difference in average productivity between the two periods. The method does however allow for ongoing productivity improvement in the counterfactual, thereby avoiding the third of Quiggin's criticisms of the IC's study.

Figures 6.1 and 6.2 summarise the percentage changes in primary factor productivity for the Tasmanian and Mainland Utilities sectors over both the historical and forecast periods. The Figures also contain the assumed percentage changes in primary factor productivity in the deviation simulation undertaken below. For Tasmanian Utilities, the average annual additional productivity improvement estimated to be brought out by NCP was 3.0 per cent (an average value for annual primary factor saving technical change of 6.0 per cent for

Figure 6.1: Tasmanian Utilities: primary factor saving technical change

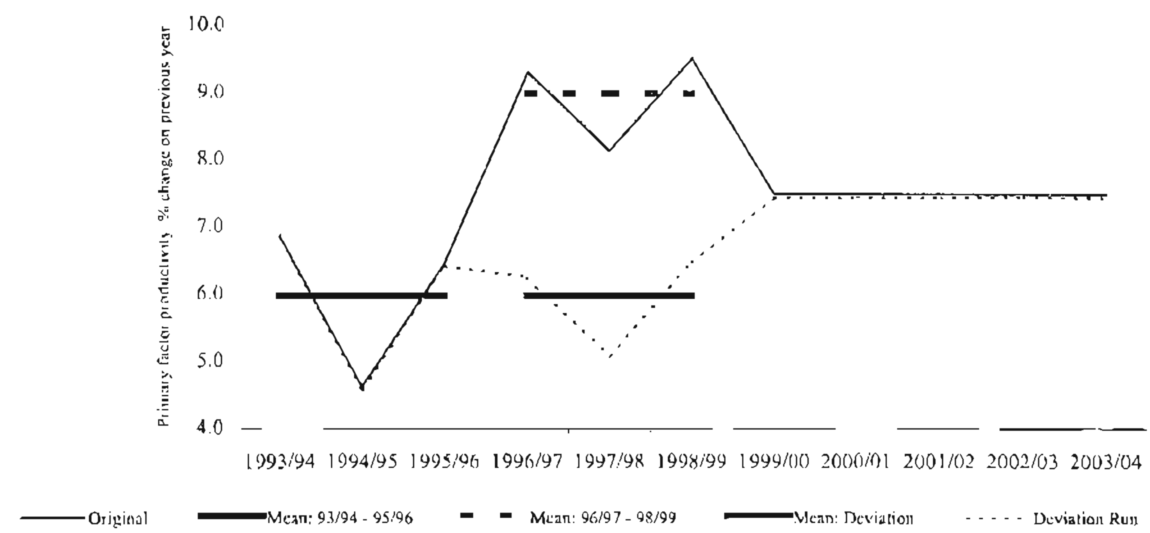
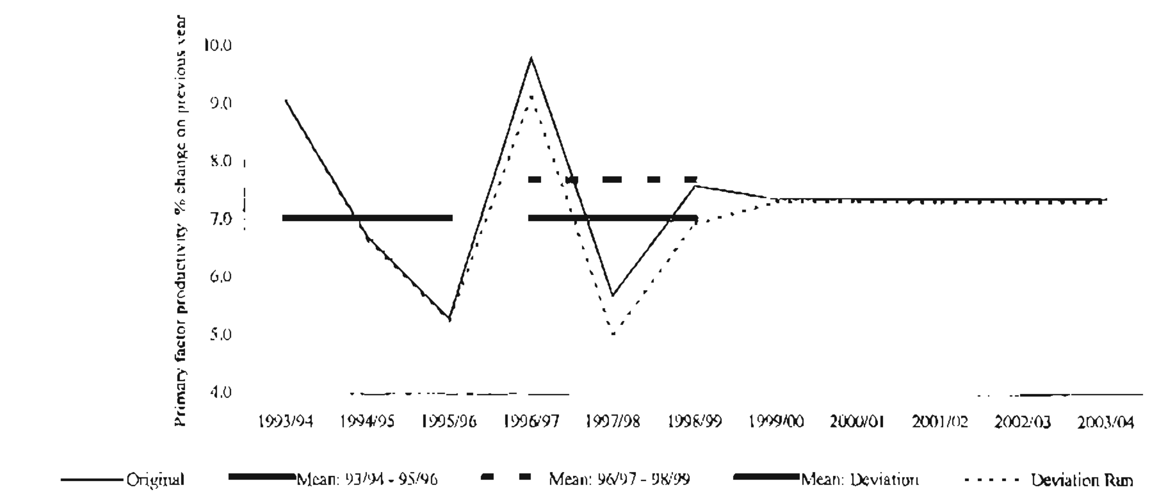


Figure 6.2: Mainland Utilities: primary factor saving technical change



1993/94 to 1995/96, compared with 9.0 per cent for 1996/97 to 1998/99). The estimated NCP-induced productivity improvement for the Australian Mainland Utilities sector was considerably less. The average value for annual primary factor saving technical change for the Mainland Utilities was 7.0 per cent in the first three years and 7.7 per cent in the second three-year phase. This appears consistent with the substantial microeconomic reform that occurred in Mainland Utilities prior to the introduction of NCP. It is worth noting that over the full six years of the historical period, the annual average productivity improvements for this sector in each of the two regions are almost identical, with Tasmania's at 7.5 per cent and the Mainland's at 7.4 per cent.

In the deviation simulation, the rate of change in primary factor productivity in both the Tasmanian and Mainland Utilities sector is assumed to be the same as in the historical simulation for the period 1993/94 to 1995/96 inclusive. Then, over the second half of the historical period, primary factor productivity growth in this sector is assumed to be 3.0 and 0.7 percentage points per annum lower in Tasmania and the Mainland respectively. Over the forecast period, 1999/00-2003/04, total factor productivity growth is then assumed to return to its assumed rate of growth under the forecast simulations.

6.1.3 Closure

For that part of the simulations which relate to the period 1992/93 - 1998/99, the closure of the model is identical to that used in the decomposition simulations reported in Section 4.5, with the exception only of the CPI-X pricing rule (see below) and the labour market adjustment mechanism. In the deviation simulations, the labour market adjustment mechanism is rendered operational by swapping the endogenous / exogenous status of *del_f_wage_c* and *fpre*, and then shocking *real_wage_c_o* and *emp_w_wgts_o* exogenously equal to the values in the base case of *r_prewage* and *l_emp* respectively. For a discussion of the operation of the labour market adjustment mechanism, see Section 2.12.14. Otherwise, for the period 1999/00 to 2003/04, a closure of the model that is analogous to the decomposition closure described in Section 4.2.2 is employed. I do not provide a detailed description of this closure here, because its content is readily apparent from the discussion of the forecasting closure in Chapter 5, and an understanding of the construction of the decomposition closure discussed in Section 4.2.2. As was discussed in Chapter 5, certain structural, policy, and external variables were endogenous in the forecasting closure to allow for the exogenous determination of certain variables for which extraneous forecasts were available. These variables are returned to their exogenous status in the policy simulations (with the exception only of those variables relating to the CPI-X rule and the labour market adjustment rule), and shocked equal to the values that they attained under the forecasting simulations. All other exogenous variables are shocked by the same values with which they were shocked in the forecasting simulation.

The same CPI-X rule that was assumed to be operational under the historical closure and forecasting closures is also assumed to remain operational under the deviation closure. This means that the deviations in primary factor productivity will be reflected in lower profits to the regional governments owning the capital in the Utilities sector, while Utility output prices continue to track changes in the regional CPI. The question of how accurate a reflection of reality this represents should be considered, given that there were some sales by regional governments of their assets in these industries over the period. Not only will this have reduced their control over output prices, but it will have also reduced the sensitivity of their net revenues to the fortunes of the firms subsumed within the Utilities sector. Recall that two industries (25.*Electricity*, and 26.*Other utilities*) are subsumed within the Utilities sector. Beginning with Tasmania, effectively all the enterprises within these industries have remained government owned for the entire historical period, and are likely to remain so over the forecast period. The situation for the Mainland is less clear-cut. Starting with industry 25.*Electricity*, effectively all of Victoria's electricity assets have been privately owned since 1996/97[132], the first year of the deviation simulation. South Australia has started privatising its generation and transmission assets only in the past year. These two states account for approximately 24 per cent and 6 per cent respectively of value added in the Mainland electricity industry (ABS 1999d). State government's continue to own effectively all of the generation and transmission assets in the remaining states, suggesting that roughly 70 per cent of the activity in the Mainland electricity market is still accounted for by state owned enterprises. Hence, in the present study, the assumption that the Mainland regional governments can set prices for 25.*Electricity*, with their profits from this industry determined endogenously, is a useful working rule although clearly only an approximation of reality. In future work, the problem of government ownership in this industry could be addressed by identifying two separate Mainland electricity industries - one essentially privately owned (and operating in South Australia and Victoria), with the remainder primarily publicly owned.

Effectively all gas industry assets are privately owned in each state, and effectively all water and sewerage assets remain government owned. Gas accounted for one-third of the

[132] Although the Victorian government continued to collect significant franchise fees (approximately $350m) from retailers under a five year arrangement expiring in December 2000.

value added of FEDERAL-F industry 26.*Other utilities* in 1998/99, with water and sewerage accounting for the remaining two-thirds (ABS 1999d). Since there is essentially no gas industry in Tasmania, both the application of the CPI-X rule and the allocation of GBE rentals from this industry to the Tasmanian government, are not unreasonable assumptions. The situation for the Mainland however is similar to that for the industry 25.*Electricity*. A sufficiently high proportion of the activity in *26. Other utilities* (that is, approximately one third) is accounted for by private enterprise. This suggests that for this industry, we can only cautiously proceed with the use of the CPI-X pricing rule and the allocation of GBE rentals to government. Again, in future work, this limitation could be overcome by dividing industry 26.*Other utilities* into its two sub-components (gas, and water and sewerage).

6.1.4 Broad Approach

The study period for the simulations undertaken in Section 6.1.5 is 1996/97 through to 2003/04. The base case, or counter-factual for these simulations is comprised of the results of the historical simulations for the period 1996/97 - 1998/99, and the results of the forecast simulations for the period 1999/00 through to 2003/04. The policy or "deviation" simulations then commence with the 1995/96 database generated during the historical simulations as the initial solution for the 1996/97 simulation. However thereafter, it is the updated policy-inclusive databases that form the initial solutions for each subsequent year's simulation. In any given year of the simulation period, the deviation in the result for percentage change variable k from its value in the base case ($d_t^{(k)}$) is then given by:

$$\left[\left(\prod_{h=1}^{t}\left(1+r_h^{(k)D}\right)\Big/\prod_{h=1}^{t}\left(1+r_h^{(k)B}\right)\right)-1\right]\times 100 \qquad (t\le 8),$$

where $r_t^{(k)D}$ is the percentage change in variable k in the deviation simulation for year t relative to its value in the deviation simulation for year t-1, and $r_t^{(k)B}$ is the percentage change in variable k in the base case simulation for year t relative to its value in the base case simulation for year t-1. It is the values for $d_t^{(k)}$ that are reported in Tables 6.1 and 6.2 in Section 6.1.5.

Table 6.1 Results of Deviation Simulation (Endogenous PSBR's)

Variables		1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
		Macroeconomic results							
Real GDP (factor cost)	Tasmania	0.11	0.20	0.28	0.24	0.23	0.23	0.22	0.18
	Mainland	-0.01	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	-0.02
Real GDP (market prices)	Tasmania	0.11	0.18	0.23	0.19	0.18	0.19	0.18	0.16
	Mainland	-0.01	-0.01	-0.02	-0.02	0.00	-0.01	-0.01	0.01
Real investment	Tasmania	0.71	1.11	1.51	1.03	0.85	0.72	0.60	0.39
	Mainland	0.05	0.08	0.15	0.12	0.07	0.07	0.06	0.05
Real consumption	Tasmania	0.20	0.39	0.57	0.48	0.40	0.43	0.41	0.32
	Mainland	0.03	0.04	0.05	0.04	0.02	0.01	0.01	0.01
Real foreign exports	Tasmania	-0.31	-0.48	-0.72	-0.60	-0.41	-0.37	-0.33	-0.22
	Mainland	-0.17	-0.26	-0.40	-0.34	-0.19	-0.19	-0.17	-0.09
Real foreign imports	Tasmania	0.07	0.11	0.14	0.10	0.11	0.12	0.12	0.10
	Mainland	0.01	0.01	0.02	0.01	0.00	0.00	-0.01	0.00
Real regional government consumption expenditure	Tasmania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mainland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Commonwealth government consumption expenditure	Tasmania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mainland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real interstate exports	Tasmania	-0.03	-0.04	-0.08	-0.06	-0.04	-0.04	-0.04	-0.02
	Mainland	0.23	0.40	0.52	0.39	0.33	0.32	0.30	0.22
Real interstate imports	Tasmania	0.23	0.40	0.52	0.39	0.33	0.32	0.30	0.22
	Mainland	-0.03	-0.04	-0.08	-0.06	-0.04	-0.04	-0.04	-0.02
GSP deflator	Tasmania	0.10	0.17	0.21	0.13	0.08	0.09	0.08	0.03
	Mainland	0.00	-0.01	-0.01	-0.01	-0.03	-0.02	-0.02	-0.03
Employment	Tasmania	0.27	0.50	0.72	0.63	0.59	0.56	0.52	0.44
	Mainland	0.01	0.01	0.01	0.00	-0.01	-0.01	-0.01	-0.01
Capital stock (rental weights)	Tasmania	-0.02	-0.06	-0.14	-0.22	-0.31	-0.41	-0.50	-0.59
	Mainland	0.00	-0.01	-0.02	-0.03	-0.03	-0.04	-0.05	-0.05
Capital stock (asset value weights)	Tasmania	0.00	0.04	0.10	0.17	0.22	0.25	0.28	0.30
	Mainland	0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.03
Consumer price index	Tasmania	0.12	0.21	0.27	0.20	0.14	0.13	0.11	0.06
	Mainland	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
Population	Tasmania	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Mainland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.1 Results of Deviation Simulation (Endogenous PSBR's) (continued)

Variables		1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
Regional government borrowing requirements ($m.)	Tasmania	16	17	22	-1	5	3	1	3
	Mainland	98	79	95	17	8	8	6	16
Payroll tax rate	Tasmania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mainland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Federal borrowing requirement ($m.)		-46	-42	-63	25	12	15	8	-18
Average PAYE tax rate		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tasmanian sectoral output volumes									
1. Agriculture		-0.05	-0.09	-0.13	-0.10	-0.06	-0.06	-0.05	-0.03
2. Mining		-0.23	-0.49	-0.68	-0.67	-0.53	-0.51	-0.50	-0.38
3. Manufacturing		-0.02	-0.06	-0.09	-0.07	-0.03	-0.02	-0.02	0.01
4. Utilities		0.00	0.03	0.00	0.06	0.17	0.21	0.20	0.21
5. Construction		0.68	1.05	1.47	0.99	0.82	0.70	0.58	0.38
6. Margin industries		0.18	0.32	0.44	0.36	0.30	0.30	0.28	0.21
7. Communications		0.26	0.47	0.66	0.54	0.43	0.45	0.41	0.30
8. Finance		0.15	0.27	0.37	0.30	0.27	0.27	0.26	0.20
9. Dwellings		0.00	0.05	0.13	0.17	0.20	0.24	0.26	0.29
10. Public administration		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Community services		0.12	0.21	0.29	0.24	0.20	0.20	0.19	0.14
12. Entertainment and recreation		0.21	0.41	0.59	0.49	0.39	0.40	0.37	0.27
Tasmanian sectoral basic prices									
1. Agriculture		-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
2. Mining		-0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01
3. Manufacturing		0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
4. Utilities		0.12	0.21	0.27	0.20	0.14	0.13	0.11	0.06
5. Construction		0.08	0.11	0.12	0.08	0.07	0.07	0.07	0.05
6. Margin industries		0.10	0.17	0.21	0.14	0.10	0.10	0.09	0.07
7. Communications		0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01
8. Finance		0.07	0.11	0.14	0.10	0.08	0.08	0.07	0.05
9. Dwellings		0.51	0.87	1.15	0.82	0.55	0.55	0.45	0.21
10. Public administration		0.02	0.04	0.05	0.05	0.04	0.04	0.03	0.03
11. Community services		0.02	0.04	0.05	0.04	0.04	0.04	0.04	0.03
12. Entertainment and recreation		0.12	0.21	0.25	0.18	0.14	0.13	0.12	0.09

Table 6.1 Results of Deviation Simulation (Endogenous PSBR's) (continued)

Variables	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
Tasmanian sectoral employments								
1. Agriculture	-0.08	-0.15	-0.21	-0.18	-0.13	-0.13	-0.12	-0.09
2. Mining	-0.28	-0.56	-0.77	-0.79	-0.63	-0.61	-0.59	-0.47
3. Manufacturing	-0.03	-0.08	-0.13	-0.12	-0.07	-0.06	-0.06	-0.03
4. Utilities	7.38	15.25	24.05	24.07	24.67	24.61	24.33	24.22
5. Construction	0.75	1.14	1.57	1.06	0.88	0.76	0.64	0.43
6. Margin industries	0.25	0.45	0.61	0.48	0.39	0.40	0.37	0.28
7. Communications	0.26	0.48	0.68	0.55	0.44	0.45	0.42	0.31
8. Finance	0.19	0.33	0.45	0.36	0.31	0.31	0.29	0.23
9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10. Public administration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Community services	0.12	0.22	0.30	0.24	0.20	0.21	0.19	0.14
12. Entertainment and recreation	0.29	0.54	0.76	0.62	0.50	0.50	0.46	0.35
Tasmanian sectoral export volumes								
1. Agriculture	-0.15	-0.23	-0.32	-0.23	-0.18	-0.17	-0.15	-0.11
2. Mining	-0.48	-1.04	-1.59	-1.64	-1.32	-1.29	-1.24	-1.00
3. Manufacturing	-0.31	-0.42	-0.64	-0.46	-0.27	-0.22	-0.19	-0.08
4. Utilities	-0.40	-0.50	-0.84	-0.82	-0.54	-0.50	-0.44	-0.32
5. Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Margin industries	-0.40	-0.50	-0.84	-0.82	-0.54	-0.50	-0.44	-0.32
7. Communications	-0.40	-0.50	-0.84	-0.82	-0.54	-0.50	-0.44	-0.32
8. Finance	-0.40	-0.50	-0.84	-0.82	-0.54	-0.50	-0.44	-0.32
9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10. Public administration	-0.40	-0.50	-0.84	-0.82	-0.54	-0.50	-0.44	-0.32
11. Community services	-0.40	-0.50	-0.84	-0.82	-0.54	-0.50	-0.44	-0.32
12. Entertainment and recreation	-0.40	-0.50	-0.84	-0.82	-0.54	-0.50	-0.44	-0.32

6.1.5 Results

Two sets of simulations are undertaken. In the first set, the borrowing requirements of both the Commonwealth (*cb2*) and regional governments (*cb1r*) are allowed to deviate from their levels in the base case. In the second set of simulations, it is assumed that the Commonwealth and regional governments take action to ensure that these variables do not deviate from their base case values. To ensure that government borrowing requirements do not deviate from their base levels, regional governments are assumed to vary their average payroll tax rates (*frollr* is determined endogenously), and the Commonwealth government is assumed to vary its average PAYE income tax rate (*fpaye* is determined endogenously).

In each simulation, the regional governments are assumed to continue to fix the price of the output of Utilities equal to the regional CPI less some fixed amount[133]. The rate of productivity improvement in Utilities in each year of the period 1996/97-1998/99 is then reduced, as discussed in Section 6.1.2. With the potential for changes in the price of Utilities constrained by the operation of the CPI-X rule, demand for the output of the sector is essentially unchanged. Hence a slower rate of efficiency growth is manifested in rising employment in Utilities relative to the base case, and a rising government borrowing requirement (as the regional governments sacrifice lower profit in the face of lower productivity growth in order to maintain the CPI-X pricing rule).

Table 6.1 reports the results of the first simulation. Macroeconomic results are reported for the Tasmanian and Mainland economies, and sectoral level results are reported for Tasmania only. The deviations in the basic price of Utilities output away from it base values track the deviations in the regional consumer price index because of the operation of the CPI-X rule. In the first year of lower productivity growth (1996/97) both the Tasmanian consumer price and basic price of Utilities rises by 0.12 percentage points, relative to their historical values for that year. By the final year of lower productivity growth (1998/99), both price indices peak at 0.27 per cent higher than their historical values for that year. Thereafter, the two price indices decline until they are only marginally higher (0.06 per cent) than their forecast values for 2003/04. The initial rise in

[133] that is, the "X" component of the CPI-X pricing rule. As is the case in the base simulations, this continues to be 0.3 for Tasmania, and 1.3 for the Mainland in each year of the simulation period.

the Tasmanian CPI reflects the rise in Tasmanian consumption expenditure. Real Tasmanian consumption expenditure is projected to be 0.57 percentage points higher than it would otherwise have been by the final year of lower productivity growth (1998/99). This seems a somewhat counter-intuitive result, given that the underlying shock is one of deteriorating productivity growth. The key to this result is the assumption that regional governments in the deviation simulation continue to set the price of Utilities output using the CPI-X pricing rule. This ensures that none of the cost consequences of the slower rate of productivity growth are reflected in the price paid by users of Utilities output. Rather, regional governments in this simulation operate to effectively subsidise Utilities (via lower production tax rates), thereby incurring higher borrowing requirements.

With the price of Utilities output essentially unchanged, the output of the Tasmanian Utilities industry is also projected to be largely unaffected in the deviation run. With primary factor productivity declining in the presence of (essentially) fixed capital stocks, this implies a significant increase in employment in Utilities. In the first year of the deviation simulation, just under forty percent of payments to primary factors in the Tasmanian Utilities sector is accounted for by payments to labour. With output initially unchanged and capital stocks fixed, this translates the decline in primary factor productivity of 3 per cent into an increase in employment of approximately 7.5 per cent in each of the shock years. Hence by the final shock year (1998/99) employment in Tasmanian Utilities is 24.0 per cent higher than what it would otherwise have been. In the initial year of the deviation simulations, the wage bill in the Tasmanian Utilities sector is approximately 1.8 per cent of that for Tasmania as a whole. Hence the increase in Utilities employment alone in the initial year lifts Tasmanian employment by 0.13 percentage points - approximately one half of the total increase in Tasmanian employment in that year (0.27 per cent). The remaining employment gain is due to the regional multiplier effects of both higher real regional consumption and real regional investment expenditure. The rise in real investment reflects the rise in the regional labour / capital ratio, which is associated with an increase in expected rates of return on capital.

Clearly however, the results in Table 6.1 do not provide a full picture of the consequences of a slower rate of growth in productivity in the Utilities sector. A reasonable assumption is that regional governments will act to neutralise the impact of declining profits from Utilities on their net financing requirements. By the end of 1998/99, the Tasmanian government has accumulated deficits of $55 m. and the Mainland government has accumulated deficits of $272 m. Table 6.2 presents results for simulations in which both regional governments and the Commonwealth Government maintain borrowing requirements in the deviation run that are identical to those they achieved in the base run. For regional governments, it is assumed that this is achieved through variations in their average rate of payroll tax. This assumption is justified on the basis of receipts of payroll tax representing the largest share of own-source revenue for regional governments. The Commonwealth Government is assumed to vary its average rate of PAYE income tax to neutralise the impact of the scenario on its borrowing requirement.

In the first year of the simulation, the Tasmanian government must recover approximately $16 m. in revenue through higher payroll tax rates. This represents just over 10 per cent of total payroll tax collections in that year. However the required increase in the average rate of payroll tax turns out to be slightly higher than this, at approximately 13 per cent in the first shock year. This is due in part to the fact that employment falls when the payroll tax rate is lifted. However a more important factor is that there is a change in the industrial composition of employment towards those industries subject to relatively low payroll tax rates and away from those industries subject to relatively high payroll tax rates[134]. While in absolute terms the amount of revenue that must be collected by the Mainland government is significantly higher than that for Tasmania, this represents a much smaller proportion of total payroll tax collections. In the first year, the Mainland regional government is only required to lift its average payroll tax rate by 1.4 per cent. As a result, by the end of the three years of the shock period, the Tasmanian government's average payroll tax rate is projected to be 42.8 per cent higher than its historical value for that year. In comparison, that of the Mainland government is projected to be only 3.1 per cent higher than its historical value. The difference reflects the smaller reduction in productivity shocks to which the Mainland is subject in the deviation simulations, and the greater importance of receipts from GBE's in the total revenues of the Tasmanian regional government.

[134] For example, in 1996/97, employment in Utilities expands by 6.57 per cent, however this industry is subject to a zero rate of payroll tax. Employment in Mining contracts by 1.4 per cent, and this industry is subject to a 5.25 per cent payroll tax.

Table 6.2 Results of Deviation Simulation (Exogenous PSBR's)

Variables		1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
Macroeconomic results									
Real GDP (factor cost)	Tasmania	-0.17	-0.40	-0.63	-0.60	-0.60	-0.56	-0.54	-0.54
	Mainland	-0.03	-0.03	-0.04	-0.03	-0.01	-0.01	-0.01	0.00
Real GDP (market prices)	Tasmania	-0.17	-0.41	-0.69	-0.65	-0.63	-0.62	-0.59	-0.57
	Mainland	-0.02	-0.01	-0.02	0.00	0.05	0.04	0.05	0.07
Real investment	Tasmania	0.14	0.13	0.43	0.10	-0.13	-0.05	-0.12	-0.28
	Mainland	-0.01	0.05	0.11	0.08	0.09	0.09	0.07	0.07
Real consumption	Tasmania	-0.05	-0.14	-0.23	-0.26	-0.31	-0.26	-0.26	-0.32
	Mainland	-0.02	-0.02	-0.03	-0.02	-0.01	0.00	-0.01	0.00
Real foreign exports	Tasmania	-1.18	-2.23	-3.82	-3.52	-3.23	-3.15	-3.00	-2.80
	Mainland	-0.09	-0.15	-0.25	-0.14	-0.03	-0.02	0.01	0.06
Real foreign imports	Tasmania	-0.31	-0.71	-1.17	-1.08	-1.04	-0.99	-0.94	-0.90
	Mainland	-0.03	-0.03	-0.02	-0.02	-0.01	0.00	0.00	0.00
Real regional government consumption expenditure	Tasmania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mainland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Commonwealth government consumption expenditure	Tasmania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mainland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real interstate exports	Tasmania	-0.22	-0.42	-0.67	-0.57	-0.49	-0.47	-0.43	-0.37
	Mainland	-0.14	-0.35	-0.53	-0.56	-0.59	-0.54	-0.51	-0.54
Real interstate imports	Tasmania	-0.14	-0.35	-0.53	-0.56	-0.59	-0.54	-0.51	-0.54
	Mainland	-0.22	-0.42	-0.67	-0.57	-0.49	-0.47	-0.43	-0.37
GSP deflator	Tasmania	0.15	0.27	0.41	0.26	0.15	0.25	0.27	0.19
	Mainland	-0.01	-0.03	-0.03	-0.05	-0.07	-0.07	-0.07	-0.08
Employment	Tasmania	-0.11	-0.27	-0.42	-0.43	-0.45	-0.42	-0.41	-0.43
	Mainland	-0.02	-0.02	-0.02	-0.01	0.02	0.02	0.01	0.02
Capital stock (rental weights)	Tasmania	-0.03	-0.10	-0.24	-0.36	-0.48	-0.64	-0.77	-0.89
	Mainland	-0.01	-0.02	-0.03	-0.04	-0.05	-0.05	-0.05	-0.05
Capital stock (asset value weights)	Tasmania	0.00	0.01	0.01	0.03	0.03	0.02	0.02	0.00
	Mainland	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03
Consumer price index	Tasmania	0.10	0.18	0.28	0.21	0.17	0.20	0.19	0.15
	Mainland	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
Population	Tasmania	0.00	0.00	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01
	Mainland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.2 Results of Deviation Simulation (Exogenous PSBR's) (continued)

Variables		1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
Regional government borrowing requirements ($m.)	Tasmania	0	0	0	0	0	0	0	0
	Mainland	0	0	0	0	0	0	0	0
Payroll tax rate	Tasmania	13.30	27.51	42.77	39.37	41.97	37.43	35.71	33.00
	Mainland	1.39	2.27	3.10	2.37	1.82	1.56	1.38	1.25
Federal borrowing requirement ($m.)		0	0	0	0	0	0	0	0
Average PAYE tax rate		0.07	0.06	0.05	-0.02	-0.10	-0.10	-0.09	-0.12
Tasmanian sectoral output volumes									
1. Agriculture		-0.19	-0.39	-0.60	-0.48	-0.42	-0.42	-0.39	-0.36
2. Mining		-1.14	-2.73	-4.01	-3.99	-3.93	-3.91	-3.82	-3.58
3. Manufacturing		-0.46	-1.03	-1.64	-1.43	-1.32	-1.28	-1.23	-1.14
4. Utilities		-0.32	-0.71	-1.23	-1.11	-1.00	-0.96	-0.93	-0.88
5. Construction		0.17	0.19	0.50	0.16	-0.06	0.01	-0.07	-0.24
6. Margin industries		-0.14	-0.33	-0.56	-0.57	-0.61	-0.57	-0.55	-0.58
7. Communications		-0.07	-0.19	-0.29	-0.30	-0.35	-0.29	-0.28	-0.33
8. Finance		-0.14	-0.34	-0.52	-0.51	-0.53	-0.50	-0.48	-0.49
9. Dwellings		0.00	-0.01	-0.05	-0.07	-0.09	-0.13	-0.15	-0.17
10. Public administration		0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
11. Community services		-0.01	-0.05	-0.08	-0.09	-0.12	-0.09	-0.09	-0.12
12. Entertainment and recreation		-0.10	-0.25	-0.40	-0.40	-0.44	-0.38	-0.36	-0.40
Tasmanian sectoral basic prices									
1. Agriculture		0.03	0.04	0.07	0.05	0.03	0.02	0.01	0.01
2. Mining		0.13	0.32	0.55	0.46	0.43	0.43	0.41	0.37
3. Manufacturing		0.14	0.27	0.43	0.36	0.33	0.33	0.32	0.30
4. Utilities		0.10	0.18	0.28	0.21	0.17	0.20	0.19	0.15
5. Construction		0.19	0.38	0.60	0.50	0.46	0.45	0.42	0.38
6. Margin industries		0.18	0.35	0.53	0.44	0.41	0.41	0.40	0.37
7. Communications		0.10	0.19	0.29	0.23	0.21	0.19	0.17	0.15
8. Finance		0.23	0.46	0.73	0.61	0.56	0.54	0.51	0.46
9. Dwellings		0.00	-0.06	-0.09	-0.15	-0.23	-0.09	-0.05	-0.15
10. Public administration		0.07	0.13	0.20	0.16	0.15	0.14	0.13	0.12
11. Community services		0.06	0.12	0.18	0.14	0.13	0.13	0.12	0.11
12. Entertainment and recreation		0.18	0.35	0.57	0.48	0.44	0.44	0.42	0.38

Table 6.2 Results of Deviation Simulation (Exogenous PSBR's) (continued)

Variables	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
Tasmanian sectoral employments								
1. Agriculture	-0.30	-0.62	-0.96	-0.83	-0.79	-0.77	-0.74	-0.70
2. Mining	-1.40	-3.19	-4.61	-4.66	-4.58	-4.52	-4.39	-4.12
3. Manufacturing	-0.61	-1.38	-2.18	-2.00	-1.91	-1.87	-1.80	-1.71
4. Utilities	6.57	13.40	20.68	20.67	21.11	21.08	20.94	20.90
5. Construction	0.18	0.21	0.53	0.17	-0.06	0.01	-0.07	-0.25
6. Margin industries	-0.20	-0.46	-0.77	-0.79	-0.84	-0.77	-0.74	-0.77
7. Communications	-0.07	-0.19	-0.29	-0.31	-0.36	-0.30	-0.28	-0.34
8. Finance	-0.18	-0.41	-0.63	-0.62	-0.65	-0.61	-0.58	-0.59
9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10. Public administration	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
11. Community services	-0.01	-0.05	-0.08	-0.09	-0.12	-0.10	-0.09	-0.12
12. Entertainment and recreation	-0.14	-0.33	-0.50	-0.51	-0.56	-0.49	-0.46	-0.51
Tasmanian sectoral export volumes								
1. Agriculture	0.03	0.11	0.09	0.19	0.21	0.18	0.14	0.12
2. Mining	-2.01	-4.84	-8.15	-8.51	-8.25	-8.18	-7.85	-7.34
3. Manufacturing	-1.23	-2.13	-3.64	-3.12	-2.72	-2.61	-2.47	-2.28
4. Utilities	-1.09	-1.75	-3.42	-3.59	-3.12	-2.96	-2.73	-2.50
5. Construction	-0.06	-0.04	-0.10	-0.04	-0.02	-0.01	-0.01	-0.01
6. Margin industries	-1.09	-1.75	-3.42	-3.59	-3.12	-2.96	-2.73	-2.50
7. Communications	-1.09	-1.75	-3.42	-3.59	-3.12	-2.96	-2.73	-2.50
8. Finance	-1.09	-1.75	-3.42	-3.59	-3.12	-2.96	-2.73	-2.50
9. Dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10. Public administration	-1.09	-1.75	-3.42	-3.59	-3.12	-2.96	-2.73	-2.50
11. Community services	-1.09	-1.75	-3.42	-3.59	-3.12	-2.96	-2.73	-2.50
12. Entertainment and recreation	-1.09	-1.75	-3.42	-3.59	-3.12	-2.96	-2.73	-2.50

The increase in payroll tax rates in the two regions initially causes activity in both economies to contract. For example, in the first year of the deviation simulations, real gross regional product in Tasmania and the Mainland contract by 0.17 and 0.03 per cent respectively. By the end of the three years in which the productivity shocks are administered, the reductions in activity away from their historical values have increased to 0.63 and 0.04 per cent for Tasmania and the Mainland respectively. Moving into the forecast period, Tasmanian real GRP is left lower by approximately 0.55 percent per annum. In the long run, the impact of the shock on the Mainland is mitigated by a falling national real wage as the level of national employment returns to its base forecast value. In 1998/99, employment in both Tasmania (at -0.42 per cent) and the Mainland (at -0.02 per cent), and hence also national employment, are lower than their historical values. However by 2003/04, national employment has nearly returned to its base forecast value - that is the deviation in national employment is close to zero. With Tasmanian employment eventually contracting by just under half a per cent, this allows Mainland employment to rise by 0.02 per cent. Hence the contraction in Mainland real gross regional product peaks in 1998/99 at -0.04 per cent. Thereafter, as national employment returns to its long-run forecast value, there is a small rise in Mainland employment. This leaves Mainland real output unchanged by 2003/04 despite the small fall in Mainland Utilities productivity and a small fall in the rental-weighted value of the Mainland capital stock.

Real Tasmanian household consumption expenditure initially falls at approximately half the rate of the fall in Tasmanian employment. This reflects the fact that the non-wage income components of Tasmanian household disposable income (such as unemployment benefits, rental receipts from Mainland capital, and other government transfers) are relatively unaffected by the shock. There is a small rise in Tasmanian investment, during the first three years of the simulation period. This reflects the net effect of rising investment in Utilities, where rates of return are rising because of the increase in the sector's labour / capital ratio. After 1999/00, the effects of declining investment in other sectors dominates the aggregate Tasmanian investment result, leaving total Tasmanian investment 0.28 per cent lower than forecast by 2003/04. Real regional and Commonwealth government consumption expenditure is unchanged from its base forecast level. With Tasmanian real investment expenditure first rising and then later falling more slowly than real GRP, real government consumption expenditure unchanged, and real household consumption falling more slowly than real GRP, Tasmania's balance of trade deficit must increase. The interstate balance of trade deficit is relatively unaffected by the shock. Interstate import volumes fall at about the same rate as the fall in real GRP, and the fall in interstate export volumes is ultimately slightly slower than the fall in interstate import volumes. Hence the requirement for Tasmania's overall balance of trade deficit to increase is manifested in a decrease in the state's international balance of trade surplus. This reflects the much higher price elasticity of demand for foreign exports relative to interstate exports. Foreign import volumes into Tasmania contract at just under twice the rate of the contraction in real output, falling by 0.31 per cent in the first year, and finishing 0.90 per cent below their forecast value in 2003/04. Real Tasmanian foreign exports initially contract by 1.18 per cent. By the last year of the productivity shocks, the contraction in real Tasmanian foreign exports peaks at 3.82 per cent. Thereafter, as real investment expenditure begins to fall, the contraction in foreign export volumes declines, until by 2003/04 they are 2.80 per cent lower than their forecast value for that year.

The sharp contraction in total Tasmanian foreign exports is reflected in the declining exports of the more trade exposed sectors such as Mining and Manufacturing. By the final year of the simulation, foreign exports of Tasmanian Mining are projected to be approximately 7.3 per cent below their forecast value for that year. In the same year, foreign exports of Tasmanian Manufacturing are projected to be approximately 2.3 per cent below their forecast value. There is a small rise in Agricultural exports (0.03 per cent in the first year, rising to 0.12 per cent in the final year), despite a small rise in the basic price of the sector's output. This reflects a compositional matter. The exports of 3. *Fishing and Hunting* in 1995/96 represented just over half of the Agriculture sector's exports, while the industry's value added represented just under one third of the sector's value added. The basic price of this commodity falls slightly in the deviation simulation, causing a small rise in its exports, while the reverse is the case for the other industries subsumed within Agriculture. Hence, while the rise in 3. *Fishing and Hunting* exports is reflected in a small rise in export volumes for the Agriculture sector, the fall in the industry's basic price is too small, relative to its share in the sector's value added, to offset the effects of the rising basic prices of the remaining two sectors subsumed with Agriculture.

The contractions in Mining and Manufacturing exports leave the output of these two sectors the worst affected among the Tasmanian sectors. By the final year of the simulation period, the output of the Mining sector is 3.6 per cent below its forecast value, leaving employment in the sector 4.1 per cent below its forecast value. Approximately half of this contraction is attributable to the fall in the sector's export sales, with the bulk of the remainder of the fall being due to declining intermediate sales to the Tasmanian Manufacturing sector. By 2003/04, output in the latter sector is projected to decline by 1.1 per cent relative to its forecast value, leaving employment in the sector lower by 1.7 per cent. Approximately two-thirds of the contraction in this sector's output is due to the fall in its export volumes, with the remaining third being attributable, in approximately equal parts, to declining intermediate sales to Tasmanian and Mainland firms. The contractions in activity experienced by the Agriculture, Utilities, and Finance sectors are all largely explicable in terms of declining intermediate input sales to Tasmanian firms. The contraction in the Margins sector tracks relatively closely the decline in aggregate activity, and reflects declining sales to both current producers and users of margin services. The decline in activity in the Entertainment sector is due largely to declining sales to consumers, in addition to a smaller effect from declining sales to Tasmanian producers. Outputs of Public Administration and Community Services are largely unaffected, reflecting the fact that real government expenditure in the deviation simulation does not change from its level in the base historical and forecast simulations. At first the output of the Construction sector rises, tracking the increase in Tasmanian investment expenditure, until it is 0.50 per cent higher than its historical value for 1998/99. However from 2000/01 to 2003/04, the sector's output is below its forecast values, reflecting the decline in Tasmanian real investment expenditure over this period.

6.1.6 Conclusions

The modelling in Section 6.1.5 has introduced three new features to the CGE modelling of NCP. First, the calculation of the NCP related shocks was informed by a comparison of the pre- and post-NCP productivity performances of the Utilities industries. Previous studies have based these shocks on estimates of the gaps between actual and best-practice productivity, raising questions about the reasonableness of attributing the closure in this productivity gap to NCP, and the proper specification of the counter-factual. The second novel feature of this study is the use of a multi-regional dynamic model. Previous studies of the regional consequences of NCP have used comparative static models. Finally, the modelling has been informed by a greater attention to the fiscal dimension of microeconomic reform than has been paid in previous studies. In particular, both the role of regional governments in setting the price of Utilities output, and the impact of changing GBE profitability on the fiscal positions of regional governments, were explicit elements of the modelling.

Madden (2000) noted that that one of the factors blamed for the widely perceived increase in the economic divide between capital cities and regional Australia has been NCP. The Productivity Commission (1999c) also stated that "NCP is widely perceived as being responsible for the withdrawal of government services, the demise of local businesses, the closure of country bank branches and is regarded by some as a major factor behind the population decline in parts of country Australia". In some respects Tasmania can serve as one case example in the consequences of microeconomic reform for an ailing regional economy. For example, the state accounts for only approximately two per cent of national activity, and was considered sufficiently small by the Taskforce on Regional Development (1994) to be defined as a region in its own right. The region's growth rate has lagged that of the nation as a whole, so that its share of total activity has declined from 2.1 per cent in 1992/93 to 1.9 per cent in 1999/00. In Chapter 5 this share was forecast to decline even further, to 1.7 per cent by 2003/04. Inter-regional and international trade accounts for a relatively high proportion of gross regional product. Throughout the 1990's the region has been subject to high rates of unemployment relative to the nation, and high and persistent emigration to the Mainland. Overall, Tasmania conforms to the popular image of regional economic and social disadvantage, as outlined for example by Sorensen (2000).

The results in Table 6.2 do not lend any clear support to the proposition that a higher pace of productivity growth in the Utilities sector has added to either the economic or social disadvantage of Tasmania. On the contrary, by reversing the signs in the table, it is apparent that the increase in productivity growth between 1996/97 and 1998/99 improved the major indicators of economic advantage. The state's population is projected to be approximately 0.01 per cent higher than forecast. Real consumption per capita is projected to be approximately 0.3 per cent higher. Employment and real gross regional product are projected to be, respectively, approximately 0.4 and 0.5 per cent higher than forecast.

Overall, the benefits of NCP appear to outweigh the costs for an economy like Tasmania. However, NCP is clearly associated with adjustment costs, as is borne out by the employment results for the Utilities sector. However adjustment costs are mitigated in other sectors, where employment is projected to be higher in the presence of faster productivity growth. For example, 2003/04 employment in Mining is approximately 4.1 per cent higher than forecast. This is in a sector in which the base forecast has employment contracting at an annual average rate of 7.03 per cent. Some way of evaluating, aggregating and comparing these adjustment costs is required before more definite statements can be made about the relative sizes of the costs and benefits of NCP in general. This question is taken up further in Chapter 7. It could also be argued that Tasmania, while a small region, is still too large to serve as a reasonable proxy or representative case example of the regional consequences of NCP. Furthermore, the region is encompassed by a single government, which in these simulations manipulates a region-wide tax (the payroll tax) with significant employment consequences. To better investigate the regional consequences of NCP for Tasmania, a top-down decomposition of the Tasmanian results to sub-state regions using an ORES (Dixon et al. 1982) style regional extension, such as that employed in Giesecke (1999a) could be added to the model. This would allow better modelling of the effects on sub-state regions of microeconomic reform, which could be important for regions in which the industries subject to the direct effects of reform account for a relatively large share of sub-regional activity. For example, the Productivity Commission (1999b), using an ORES-style decomposition of national results, found that NCP increased gross regional product in all statistical divisions other than Gippsland in Victoria. A large share of activity in the latter region is accounted for by electricity generation, a sector directly affected by the simulations they undertook.

6.2 A REGIONAL GOVERNMENT MACROECONOMIC RECOVERY PACKAGE.

6.2.1 Introduction

As discussed in Section 5.7, the forecast simulations show Tasmania's GSP growth rate lagging that of the Mainland by an annual average of approximately 1.4 percentage points per annum. An interesting question to investigate is whether it is within the power of the Tasmanian government to influence materially this forecast outcome. To this end, two policy packages are examined. In the first, the question asked is whether, over the forecast period, there exists a feasible re-arrangement of the revenue raising effort of the Tasmania government, which maintains Tasmania's share of national GDP at its 1998/99 level? The judgement of feasibility is made on an informal, plausibility basis: are the changes in policy instruments required to maintain a constant share of national GDP excessively large, relative to the original tax bases upon which they operate? This is indeed found to be the case. Hence a second and (comparatively) less ambitious policy change is considered. This involves the gradual but complete elimination of payroll tax over the forecast period, and its replacement with a direct tax on households. Even when such a dramatic tax change as this is considered, the impact on the forecast for Tasmania's share of national activity is not large.

The starting point for the simulations are the results of Giesecke and Madden's (1997) ranking of the impacts on Tasmanian gross regional product of changes in selected regional government taxes. They found that real gross regional product was most sensitive to changes in the average payroll tax rate, falling as it does directly on the producer cost of labour. The taxes that had least effect on real gross regional product were those that directly reduced household income, such as motor vehicle taxes and fees and fines.

Payroll tax collections in 1997/98 were the largest source of Tasmanian government own-source revenue, at approximately $144 m (ABS 1998b). In the same year, fees and fines raised approximately $47 m. On the face of it, the relative sizes of these two tax bases suggest that the scope for changing the revenue raising effort away from payroll taxes and towards direct taxes may be limited. However there are a number of state government indirect taxes, (and which are currently modelled as such in FEDERAL-F) some components or proportions of which could nevertheless be plausibly modelled as changes in direct taxes. For example, an increase in vehicle registration fees and taxes ($64 m. in 1997/98) and stamp duties on existing vehicle registrations ($27 m.) would likely largely act as a direct tax in the short run, since the stock of privately owned cars in the short-run is essentially fixed. More importantly perhaps, since 1978 the states have had the capacity to levy surcharges on Commonwealth income tax, although no state has as yet taken up this option. Hence, there is potentially more scope to switch the state's revenue raising effort away from payroll taxes and towards direct taxes on households than is perhaps indicated by a simple comparison of the relative amounts currently raised by these two instruments.

6.2.2 Maintenance of a constant share of national GDP

In this simulation, Tasmania's share of national GDP (*grp_sh_l*)[135] is determined exogenously, and the tax which has the most impact on real GRP - the payroll tax (*$froll r_l$*) - is determined endogenously. Under this closure, the average Tasmanian payroll tax will adjust in each period to ensure that Tasmania's share of national GDP is equal to the exogenously determined value of *grp_sh_l*. The latter variable is shocked equal to 0, thereby imposing maintenance of a constant share of national GDP on the part of Tasmania. The Tasmanian government's borrowing requirement is then not allowed to deviate away from its forecast value. This requires that *$cblr_l$* be determined exogenously, and the shift variable on state government income reducing taxes (*f_ytax_l*) be determined endogenously.

The results of the simulation, for selected Tasmanian and Mainland regional variables, are contained in Table 6.3. This shows Tasmanian real GSP at factor cost rising from 1.79 per cent higher than forecast in 1999/00, to 7.00 per cent higher than forecast in 2003/04. Relative to the 2002/03 deviation result, the deviation in real GDP in 2003/04 is slightly lower, because in the base forecast there is a small rise in Tasmania's share of national GDP in the final year (see Section 5.7). Real GSP at market prices rises slightly faster than real GSP at factor cost, indicating that the simulation has stimulated activity in areas attracting indirect taxes. Relative to the growth in employment, the growth in real consumption expenditure is quite subdued. This reflects the increase in Tasmanian government taxation of household income as the average rate of payroll tax falls. Hence, while in the underlying forecast Tasmanian consumption expenditure accounts for approximately 70 per cent of Tasmanian GSP by 2003/04, this falls to 65 per cent in the deviation simulation. While there is some growth in investment (3.01 per cent higher than forecast in the final year), this too is subdued. While investment increases strongly in the traded goods sectors, there is little change in investment in those sectors producing output primarily for household consumption and government, and this depresses the real investment result relative to the real GSP result. With aggregate investment rising more slowly than real GSP, by 2003/04 its share of GSP also falls relative to its forecast level, from 16 per cent to 15 per cent. Interstate export and import volumes are higher in the deviation simulation by approximately the same percentage amount as real GSP. This

[135] See Section 2.12.15.

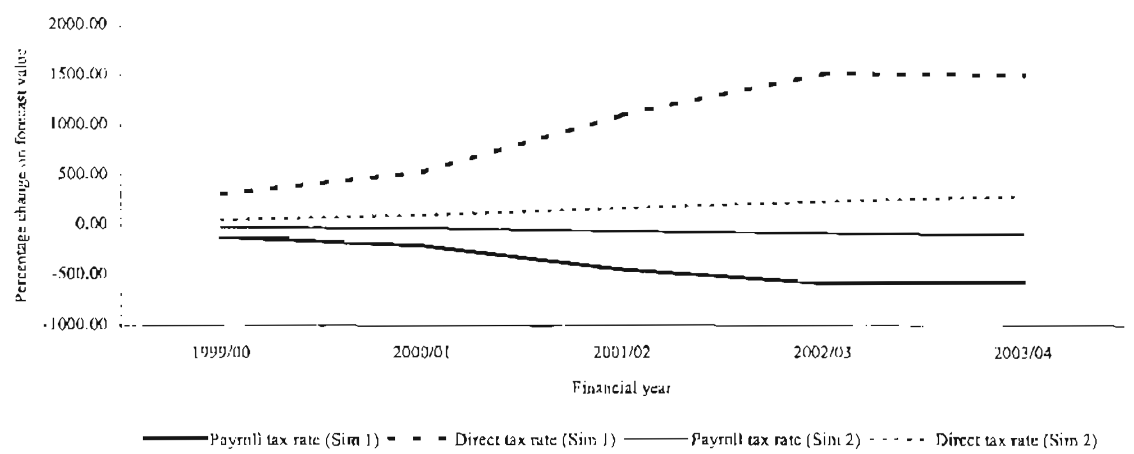
leaves the interstate balance of trade deficit as a share of GSP approximately equal to its level in the base forecast. Ultimately, the growth in output is reflected largely in higher foreign export volumes (44.51 per cent higher than forecast by the final year) reflecting the high price elasticity of demand for these commodities. By the final year, this lifts the share of exports in GSP from its value of 27 per cent in the forecast simulation to 35 per cent in the deviation simulation.

Table 6.3: Simulation 1: Maintenance of constant share of national GDP
(Deviations from forecast values)

Variable	Region	1999/00	2000/01	2001/02	2002/03	2003/04
Real GDP (factor cost)	Tasmania	1.79	2.58	5.68	7.20	7.00
	Mainland	-0.01	-0.01	-0.02	-0.05	-0.08
Real GDP (market prices)	Tasmania	1.99	3.00	6.89	8.83	8.54
	Mainland	0.00	0.01	-0.02	-0.06	-0.08
Real investment	Tasmania	1.66	2.08	4.03	4.17	3.01
	Mainland	0.00	0.03	0.04	0.01	-0.01
Real consumption	Tasmania	0.39	0.70	1.31	1.11	0.94
	Mainland	0.03	0.04	0.07	0.07	0.03
Real foreign exports	Tasmania	10.36	14.31	32.10	43.82	44.51
	Mainland	-0.15	-0.20	-0.41	-0.56	-0.58
Real foreign imports	Tasmania	3.11	4.22	9.02	11.51	11.17
	Mainland	0.00	-0.01	-0.02	-0.05	-0.08
Real regional government consumption expenditure	Tasmania	0.00	0.00	0.00	0.00	0.00
	Mainland	0.00	0.00	0.00	0.00	0.00
Real Commonwealth consumption expenditure	Tasmania	0.00	0.00	0.00	0.00	0.00
	Mainland	0.00	0.00	0.00	0.00	0.00
Real interstate exports	Tasmania	1.74	2.55	5.69	7.20	6.88
	Mainland	1.78	2.56	5.47	6.67	6.33
Real interstate imports	Tasmania	1.78	2.56	5.47	6.67	6.33
	Mainland	1.74	2.55	5.69	7.21	6.88
GSP deflator	Tasmania	-1.19	-1.60	-4.23	-5.88	-5.42
	Mainland	0.01	0.00	0.06	0.10	0.08
Employment	Tasmania	2.30	3.30	7.11	8.89	8.56
	Mainland	0.00	-0.01	-0.03	-0.08	-0.11
Capital stock (rental weights)	Tasmania	-0.03	0.00	0.03	0.15	0.27
	Mainland	0.00	0.01	0.02	0.03	0.04
Capital stock (asset value weights)	Tasmania	0.00	0.08	0.20	0.43	0.69
	Mainland	0.00	0.00	0.00	0.01	0.01
Consumer price index	Tasmania	-0.78	-1.09	-2.59	-3.57	-3.50
	Mainland	0.02	0.02	0.05	0.07	0.07
Regional government borrowing requirement	Tasmania	0	0	0	0	0
	Mainland	0	0	0	0	0
Payroll tax rate	Tasmania	-120.4	-208.6	-445.6	-581.5	-562.2
	Mainland	-0.14	-0.10	0.03	0.37	0.71
Federal borrowing requirement		0	0	0	0	0
Average PAYE tax rate		-0.22	-0.35	-0.61	-0.59	-0.46
State direct tax	Tasmania	313.5	526.5	1103	1510	1498
	Mainland	0.00	0.00	0.00	0.00	0.00

While the results indicate that a combination of direct taxation and payroll taxation exists which maintains Tasmania's share of national GDP, this combination is in no sense feasible. The results for the two Tasmanian government policy variables, f_ytax_t and $frollr_t$, are also included in Table 6.3, and are also graphed in Figure 6.3. In the first year, the average Tasmanian payroll tax rate falls by 120 per cent - that is, it becomes a per-unit labour subsidy. In 1998/99 (the initial solution to the 1999/00 year), the database value for Tasmanian government payroll tax collections was just under $150 m., representing approximately 2.3 per cent of the total Tasmanian gross labour bill. Hence, in the first year of the simulation, a labour subsidy of $30m., or approximately 0.5 per cent of the total Tasmanian labour bill, is required to maintain Tasmania's share of national GDP. At the same time, an increase in state government direct taxation of 313 per cent is required. This lifts collections of direct taxes from approximately $45 m. to $190 m. The difference between what is disbursed via the reduction in payroll taxes (approximately $180 m.) and what is received from the increase in direct taxes (approximately $145 m.) is recouped in higher tax receipts from other sources as the Tasmanian economy expands.

Figure 6.3. Time paths for Tasmanian Government tax instruments



Thereafter, continuous reductions in the payroll tax rate, and continuous increases in the direct tax rate are required to maintain the state's share of GDP, until the final year of the simulation period. Recall that in the underlying forecast, there is a small rise in Tasmania's share of the national GDP in the final year. This allows in that year a small increase in the payroll tax, and a small fall in the direct tax, relative to the deviation result for the previous year. If the infeasibility of the package were not apparent from an inspection of the first year's results, it can be in no doubt from the final year's results. In the penultimate year, when the deviations in the tax rates peak, the payroll tax is forecast to be 581 per cent below its forecast level, and the direct tax rate is forecast to be 1510 per cent above its forecast value. In dollar terms, these are equivalent in current (2003/04) dollars to $-700 m. and $787 m. respectively. The former figure is equivalent to a per unit labour subsidy of approximately nine per cent of the gross wage bill.

These results are broadly consistent with the findings of Giesecke and Madden (1997), who undertook a comparative-static analysis with a 1992/93 Tasmania / Mainland implementation of FEDERAL. One of the features provided by the dynamic modelling is the provision of an interesting target (maintenance of national GDP) against which to model the scope for regional government policy action. Giesecke and Madden found that the short run impact on real GSP at factor cost from raising $10 m. in net revenue from an increase in either payroll tax or direct tax, were -0.22 and -0.05 per cent respectively. In Table 6.3, the required deviation in the Tasmanian growth rate in real GSP at factor cost is approximately 1.8 percentage points in the first year of the simulation. On the basis of Giesecke and Madden's results, we would expect that to close this gap we would need to transfer approximately $105 m.[136] (in 1992/93 terms) in revenue raising effort from the payroll tax base to the direct tax base. This is equivalent to almost $140 m. in 1999/00 terms[137], which is comparable to the result from FEDERAL-F in the initial year of the deviation simulation. In the final year of the deviation simulation, an increase in Tasmanian real GSP at factor cost of 7.00 per cent is required. Again, using the Giesecke and Madden (1997) results, this requires approximately $410 m. (in 1992/93 terms) in revenue raising effort to be shifted from the payroll tax base to the direct tax base. In 2003/04[138] terms, this equivalent to approximately $700 m., which is again broadly in line with the results obtained with FEDERAL-F for that year.

[136] (1.8 / (0.22-0.05)) x 10

[137] The nominal size of the Tasmanian economy increased by approximately 30 per cent between 1992/93 and 1999/00.

[138] The nominal size of the Tasmanian economy is forecast to grow by a little under 30 per cent between 1999/00 and 2003/04. See Table 5.7.

6.2.3 A run-down in payroll tax collections to zero

In this simulation, payroll tax collections are steadily reduced over the forecast period until they are zero in 2003/04. Such a policy is likely to be at the very outer bounds of what would ever be considered politically feasible by a state government. Despite the likely impracticality of the proposal, its extreme nature makes the results of the simulation more interesting rather than less so, since the results will illustrate the limits of the practical influence that a state government can hope to have on aggregate economic activity within its jurisdiction. That is, the outer bounds of the influence of state government macroeconomic policy will have been illuminated.

To simulate this policy, the same closure is used as that in the simulation in Section 6.2.2, with one exception. Instead of determining grp_sh_l exogenously, Tasmanian government total payroll tax collections ($sgptr_l$) are determined exogenously. In the new simulation, aggregate Tasmanian payroll tax collections are reduced by approximately the same absolute amount in each period. Hence, $sgptr_l$ is shocked by -20, -25, -33.33, -50, and -99[139] per cent in each of five years between 1999/00 and 2003/04 respectively.

Table 6.4 contains selected results from this simulation. As one would expect, the directions and relative sizes of the impacts are the same as those in the previous simulation, although of a smaller magnitude. Again, the growth in real consumption and real investment is subdued relative to the growth in real GSP. With interstate exports and imports rising at approximately the same rate as real GSP, the increase in real output is reflected in rising foreign exports, which is facilitated by a decrease in the Tasmanian price level. The percentage changes in the two policy variables away from their forecast values are contained in Table 6.4 and also graphed in Figure 6.4. These show the average rate of payroll tax falling steadily over the simulation period, so that by 2003/04 it is less than 1% of its forecast value. Over the same period, the revenue that was raised from the payroll tax is instead raised from a higher rate of direct taxation. This sees the direct tax rate increase by 53 per cent of its forecast value in the first year, and then rise further in each year thereafter until by 2003/04 it is 288 per cent above its forecast value.

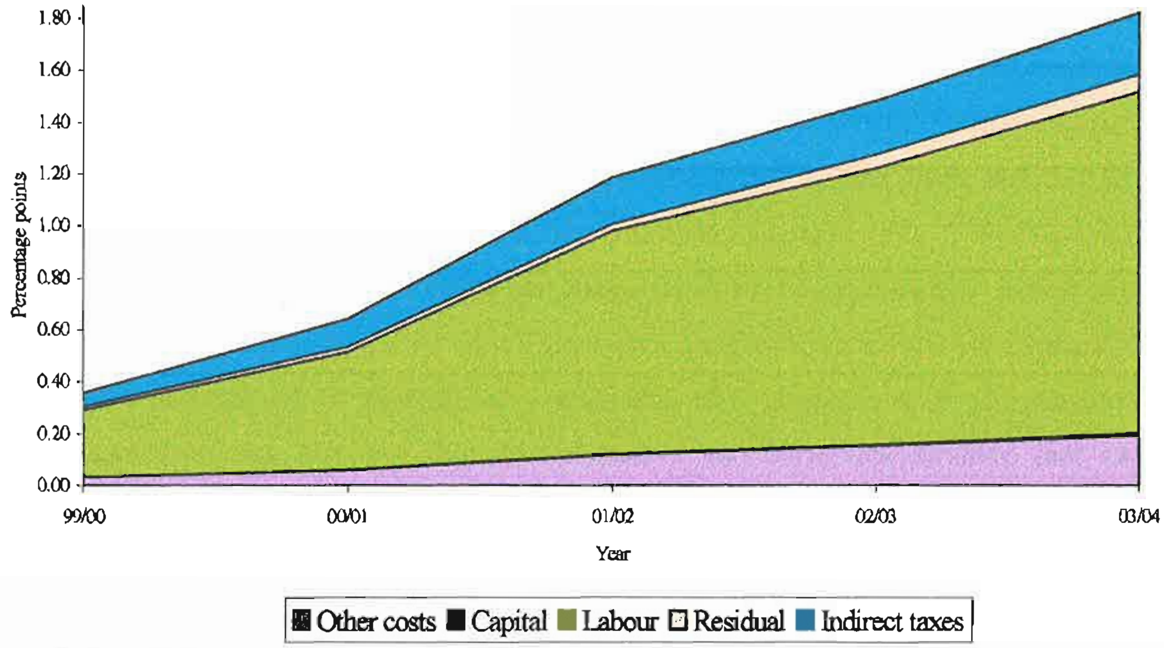
[139] In the final simulation $sgptr_l$ is shocked by -99 per cent to prevent the values for any payroll tax collections passing through zero.

The processes generating the time paths for the policy variables in Figure 6.4 can be seen by considering further the results of the first year's simulation. In that year aggregate payroll tax receipts are reduced by 20 per cent, which is associated with a reduction in the average rate of payroll tax of 20.6 per cent. *Ceterus paribus*, this is associated with a rise

Table 6.4: Simulation 2: Elimination of payroll tax
(Deviations from forecast values)

Variable	Region	1999/00	2000/01	2001/02	2002/03	2003/04
Real GDP (factor cost)	Tasmania	0.30	0.54	1.01	1.28	1.58
	Mainland	-0.01	0.01	0.00	-0.01	-0.01
Real GDP (market prices)	Tasmania	0.36	0.64	1.19	1.48	1.82
	Mainland	0.01	0.03	0.01	0.01	0.02
Real investment	Tasmania	0.25	0.41	0.69	0.75	0.70
	Mainland	-0.02	0.02	0.02	0.01	0.02
Real consumption	Tasmania	0.08	0.18	0.28	0.25	0.30
	Mainland	0.00	0.02	0.02	0.02	0.03
Real foreign exports	Tasmania	1.73	2.91	5.59	7.46	9.63
	Mainland	-0.01	-0.03	-0.07	-0.10	-0.12
Real foreign imports	Tasmania	0.57	0.96	1.80	2.31	2.84
	Mainland	-0.01	0.00	0.00	-0.01	-0.01
Real regional government	Tasmania	0.00	0.00	0.00	0.00	0.00
consumption expenditure	Mainland	0.00	0.00	0.00	0.00	0.00
Real Commonwealth	Tasmania	0.00	0.00	0.00	0.00	0.00
consumption expenditure	Mainland	0.00	0.00	0.00	0.00	0.00
Real interstate exports	Tasmania	0.34	0.53	0.92	1.15	1.39
	Mainland	0.31	0.55	1.01	1.22	1.48
Real interstate imports	Tasmania	0.31	0.55	1.01	1.22	1.48
	Mainland	0.34	0.53	0.92	1.15	1.39
GSP deflator	Tasmania	-0.24	-0.34	-0.70	-0.98	-1.11
	Mainland	-0.01	-0.02	-0.01	0.00	-0.01
Employment	Tasmania	0.38	0.67	1.24	1.54	1.90
	Mainland	0.00	0.00	-0.01	-0.02	-0.02
Capital stock (rental weights)	Tasmania	0.00	0.01	0.02	0.04	0.06
	Mainland	0.00	0.01	0.01	0.02	0.02
Capital stock (asset value	Tasmania	0.00	0.01	0.03	0.07	0.12
weights)	Mainland	0.00	0.00	0.00	0.00	0.00
Consumer price index	Tasmania	-0.14	-0.19	-0.37	-0.52	-0.64
	Mainland	0.00	0.00	0.01	0.01	0.01
Regional government borrowing	Tasmania	0	0	0	0	0
requirement	Mainland	0	0	0	0	0
Payroll tax rate	Tasmania	-20.60	-37.01	-63.35	-82.21	-99.69
	Mainland	-0.07	-0.20	-0.14	-0.06	-0.05
Federal borrowing requirement		0	0	0	0	0
Average PAYE tax rate		-0.06	-0.16	-0.17	-0.16	-0.20
State direct tax	Tasmania	53.01	97.11	169.0	231.8	288.4
	Mainland	0.00	0.00	0.00	0.00	0.00

Figure 6.4
Contributions to deviation in real GSP (at market prices)



in employment of approximately 0.5[140] per cent as the producer cost of labour falls. In the 1998/99 database, Tasmania collected approximately $150 m. in payroll tax. Hence a 20 per cent reduction in these collections is equivalent to a fall in payroll tax receipts of $30m. However the expansion in economic activity that is induced by the payroll tax reduction causes the Tasmanian government's borrowing requirement to fall by approximately $5 m.[141] less than the amount of payroll tax revenue foregone. To maintain an unchanged budget position relative to the forecast budget position, the government must raise the remaining $25 m. from higher direct taxes. The base value for these taxes in the 1998/99 database is $46m., hence an increase in the direct tax rate of approximately 53 per cent is required. This causes real Tasmanian household consumption to fall by approximately 0.3 per cent. While this is associated with a small rise in foreign and interstate exports, total activity and hence employment in Tasmania falls. The increase in the direct tax rate reduces Tasmanian employment by approximately 0.1 per cent. When this is netted against the rise in employment induced by the payroll tax reduction (0.5 per cent), the net

[140] This result is not separately reported.
[141] This result is not separately reported.

employment effect is the expansion in employment of approximately 0.4 per cent reported in Table 6.4.

Returns to labour account for approximately 68 per cent of Tasmanian GSP at factor cost in 1998/99. Hence in the first year of the simulation period the increase in Tasmanian employment adds approximately 0.26 percentage points to real gross regional product. Aggregate inputs of "other costs" move at the same rate as real GSP at factor cost (0.30 per cent in the first year), and so add another 0.03 percentage points to the deviation in real Tasmanian GSP[142]. The aggregate capital stock cannot deviate from its forecast level in the first period. Hence increases in factor inputs add approximately 0.29 percentage points to Tasmanian real GSP in the first year. However Table 6.4 reports that real GSP at factor cost increases by 0.30 per cent. The difference is attributable to the fact that the many shocks that underlie and drive the forecast simulations are also administered in the deviation simulation. Since the structure of the economy is changing (relative to the forecast simulation) in the deviation simulation, these background shocks exert a slightly different impact on the economy in the deviation simulation relative to the forecast simulation. This adds approximately 0.01 percentage points to Tasmanian real GSP in the first year of the simulation, leaving Tasmanian real GSP at factor cost 0.30 percentage points higher than its forecast value in 1999/00. The simulation also causes an increase in activity in areas of the Tasmanian economy attracting indirect taxes. This adds approximately 0.06 percentage points to the deviation in real GSP, leaving real GSP at market prices 0.36 percentage points higher than its deviation level.

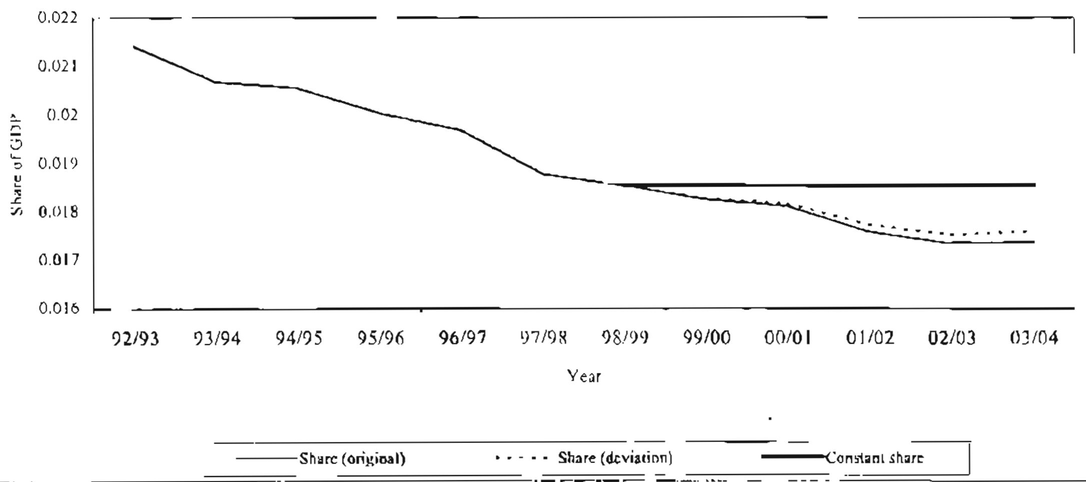
The various contributions to the deviation in real Tasmanian GSP are graphed in Figure 6.4. This figure indicates that the bulk of the increase in real GSP arises from increasing employment. Inputs of "other costs" rise in line with the increase in real GSP at factor cost. There is a small increase in real output (rising to 0.07 percentage points in the final year) arising from the change in the structure of the Tasmanian economy in the deviation simulation relative to the forecast simulation (labelled "Residual" in Figure 6.4). The simulation induces a rise in indirect taxes, which account for a relatively constant share (approximately 14 per cent) of the total deviation in real GSP at market prices. There is a small rise in the Tasmanian capital stock over the simulation period, reflecting the rise in

[142] Inputs of other costs account for about 11 per cent of Tasmanian GSP at factor cost in 1998/99.

investment in the deviation simulation. However even by the final year, this extra investment has only been sufficient to raise the capital stock 0.06 per cent higher than its forecast value. This contributes only about 0.01 percentage points to the deviation in real GSP in the final year.

For such a significant re-alignment of the Tasmanian government's taxation effort, it is instructive to now consider what impact this has on Tasmania's forecast share of national GDP. Figure 6.5 graphs both the historical and forecast values for Tasmania's share of national GDP at factor cost. In 1998/99, Tasmania accounted for 2.1 per cent of national GDP. In Chapter 5, this was forecast to decline to 1.7 per cent by 2003/04. In the deviation simulation, Tasmania's share of national GDP is forecast to be 1.8 per cent by 2003/04. In Figure 6.5, the path of Tasmania's share of GDP in the deviation simulation is given by the dotted line. This diagram portrays starkly the conclusion that the capacity of state governments to influence their economy's growth path is extremely limited. Even when a very large policy package is considered - one at the very limits of what might be politically feasible - the deviation in real GSP is relatively small. In Tasmania's case, it is unable to make a significant impact on the continued decline forecast for the state's share of national economic activity.

Figure 6.5
Tasmanian GSP as a share of national GDP



7 OVERVIEW AND FUTURE DIRECTIONS

7.1 INTRODUCTION

This thesis has involved the construction and testing of a two-region dynamic fiscal CGE model of the Australian economy, FEDERAL-F. The theoretical structure of the model, and its development from its parent model FEDERAL, were described in detail. The implementation of the model for this thesis featured Tasmania as the region of focus, with the second region being the remainder of Australia. An existing database for the comparative-static FEDERAL model was the starting point for the development of the database for the present implementation of FEDERAL-F, and so the modifications and additions to the existing database were also described in some detail.

Five sets of illustrative applications were undertaken with the new model. The first involved an investigation of the period 1992/93 - 1998/99. This uncovered the values for the structural, policy, and external shocks, which together explained (within the confines of the theory and data of the model) the observed economic outcomes for the two regional economies over this period. Over the period investigated, the growth rate of the Tasmanian economy consistently lagged that of the rest of Australia. This was found to be due to the net effect of a large number of exogenous shocks. No single factor, or set of factors, was found to account for Tasmania's relatively slow growth rate.

The second application was a forecast of the prospects for the two regional economics out to 2003/04. The key inputs to this forecast were an exogenously determined macroeconomic environment for the Australian economy, and an assumption of a continuation of the structural changes observed during the historical simulations. The forecast simulations projected a continuation of Tasmania's relatively slow economic growth rate, and hence a continuation of its historical trend of accounting for a decreasing share of national economic activity.

The final three applications were policy simulations. The first of these investigated the impact of changes in the rates of growth in primary factor productivity in the Tasmanian and the Mainland utilities sectors. Faster rates of technological improvement in the Tasmanian utilities sector in the second half of the historical period were associated with higher rates of Tasmanian output, employment and per capita consumption growth over both the historical and forecast periods. The second set of policy simulations investigated the feasibility of the Tasmanian government re-arranging its revenue raising effort in such a way that it could halt the forecast decline in its share of national economic activity. This was not found to be feasible. The required reductions in the employment-generating instrument (the payroll tax rate) and the required increases in the revenue-raising instrument (the household direct tax rate) were found to be very high, and so not plausible. The final simulation investigated a less ambitious version of the same policy; one in which aggregate payroll tax receipts were steadily replaced by direct tax receipts over the forecast period. The results of this simulation supported the proposition that even when very large policy packages (in terms of the required changes in revenue raising effort relative to their starting values) are considered, the scope for effective state government macroeconomic policy is very limited.

The major contributions of this thesis relate to both the development of a dynamic bottom-up multi-regional CGE model with a high level of fiscal detail, and the applications to which this model has then been put. FEDERAL-F can be used to elucidate both the regional and sectoral effects of changes over time in government policy, technology, tastes, resource availability, and conditions in foreign markets. The model is detailed and large scale, and hence can be readily applied to the dynamic analysis of a wide range of state and national economic issues. In this thesis, four issues were examined that have hitherto not been investigated in Australia at the state level using a bottom-up dynamic CGE model. First, a very detailed analysis was undertaken of the determinants of Tasmania's relative economic performance through the middle of the 1990's. Second, these determinants were used as input to a forecast for the prospects for the state economy. Third, the potential impacts of certain national competition policy reforms on the Tasmanian economy within a dynamic context were investigated. Finally, two simulations were undertaken to investigate the extent to which it is within the power of a state government to materially influence its projected economic growth rate.

A model that can elucidate the regional, sectoral, and fiscal aspects of both policy and other shocks, and of general economic growth and decline, should see interest from users of CGE models outside of Tasmania, and possibly outside of Australia. A number of implementations of the FEDERAL model already exist for Australian jurisdictions other than Tasmania, and two of these are operated by users within those jurisdictions. This increases the likelihood that there will be future implementations of FEDERAL-F which focus on other Australian jurisdictions.

The remainder of this chapter considers in more detail the main contributions of the thesis, some of the limitations of the work, directions in which the model can be developed in the future, and further applications of the model. These issues orientate naturally around the theoretical structure of the model, the model's database, and model applications, and so are discussed under each of these headings.

7.2 THEORETICAL STRUCTURE

7.2.1 Contributions of FEDERAL-F

FEDERAL-F delivers a working two-region dynamic CGE model of the Australian economy, featuring detailed industry, commodity, and fiscal disaggregation. It fills a significant gap between the comparative-static bottom-up regional analysis that could be undertaken with FEDERAL and MMRF, and the dynamic tops-down regional analysis that could be undertaken with MONASH. Prior to the development of FEDERAL-F, this gap was only filled by MMRF, which features more limited dynamics and a less detailed fiscal dimension than FEDERAL-F. This leaves FEDERAL-F as the most detailed bottom-up multi-regional dynamic CGE model in Australia. It is a significant improvement on the regional CGE models represented in the international literature, which are predominantly comparative-static, small scale, and generally have limited fiscal detail.

The starting points for the development of FEDERAL-F were the FEDERAL and MONASH models. The general approach was to add to FEDERAL those broad features of the MONASH model that allowed it to be used in the dynamic analysis of a wide range of issues under a variety of closures. In each instance, the particular feature had to be adapted to the multi-regional character of FEDERAL-F. In some instances, the multi-regional dimension of the model, the presence of its detailed fiscal modelling, or simply a desire to attempt to improve on the MONASH approach, led to a number of departures from the MONASH theory. These departures are briefly revisited below.

Both MONASH and FEDERAL-F contain a large number of equations that allow for the exogenous determination of sectoral outputs, employments, and investments. In MONASH, when results for variables relating to a given sector are determined exogenously, the results for the corresponding variables for the individual commodities/industries within that sector are forced to equal the exogenously given value for the sector as a whole. While this approach has also been implemented in FEDERAL-F, the option of an alternative approach has also been introduced. This allows the industrial/commodity composition of a given sector's activity to change, while still allowing the weighted average of that sector's activity to be determined exogenously. This allows the model to determine the composition of the sector's activity (whether that activity be employment, output or investment) among its component parts, on the basis of differences between industries in real producer wages, demand conditions, or expected rates of return. It was this approach that was implemented in the simulations undertaken in Chapter 4.

Providing for the exogenous determination of regional sectoral outputs in FEDERAL-F introduced a number of difficulties that were not present in MONASH. In MONASH, commodity outputs are determined exogenously by determining commodity-using technical change shift variables endogenously. Hence, one option in FEDERAL-F for determining regional sectoral outputs exogenously is to determine source-specific commodity-using technical change shift variables endogenously. This approach is acceptable for commodities that are either used as margins, or are not traded inter-regionally. However, the approach may not be appropriate for goods that are traded inter-regionally. As outlined in Section 4.4.4, whether this is so depends on the differences between Region 1 and Region 2 agents in the relative shares of Region 1-sourced goods in the construction of an effective unit of a given commodity. To overcome this problem, inter-regional sourcing twists were introduced to the model, which allow for cost-neutral changes in the ratio of the usages of domestically sourced goods.

In MONASH, sourcing twist terms were introduced to allow for the exogenous determination of international import volumes. The same approach has also been followed in FEDERAL-F. A complication in FEDERAL-F is the existence of three sources of supply (rather than the two in MONASH). Substitution possibilities between these three sources of supply are modelled by CRESH functions. The import twist terms in FEDERAL-F are derived with these CRESH functions in mind, which leads to a more complex expression for these terms than that present in MONASH, which uses CES functions to govern substitution possibilities between only two sources.

The MONASH model includes "phantom tax" terms to allow for the exogenous determination of various purchasers' prices in historical and forecasting simulations. Phantom taxes have also been introduced into FEDERAL-F for the same purpose. However the modelling of these taxes in the two models is quite different. In MONASH, explicit account is not taken of who is the final recipient of the phantom taxes. Furthermore, phantom taxes only accumulate in the MONASH database within any given simulation period - at the beginning of each simulation year, the phantom taxes which accrued in the previous period are added back to the basic flow data, with balancing adjustments then being made to the other cost matrices. In FEDERAL-F, the more intuitively plausible approach is taken of treating phantom tax receipts as windfall profits. These are retained in the database, and distributed to capital owners on the basis of their shares in the capital in the industries producing the goods upon which the phantom taxes accrue.

The tracking of regional industry capital ownership forms an important role in the FEDERAL-F theory, a role which does not have a clear analogue in the MONASH model. Six types of owner (two households, two regional governments, the Commonwealth, and foreigners) are modelled in FEDERAL-F, and the claims of each on the capital and land rentals of each regional industry are recognised. In year-on-year simulations, a link is established between changes in the savings behaviour of these agents, and changes in their ownership shares in regional industry capital rentals. This ensures a consistency in the modelling of savings and capital ownership over time. It also ensures that in policy simulations any deviation from the base-case in regional household capital receipts can only arise from deviations in rental rates and from deviations in capital ownership arising from deviations in household savings.

Another innovative feature of the FEDERAL-F theory relating to capital ownership is the account that is kept of ownership claims on capital and land rentals by inter-regional migrants. Hence, unlike other bottom-up multi-regional models such as FEDERAL and

MMRF, which also allow for inter-regional migration, households in FEDERAL-F retain their pre-simulation capital ownership claims even as they move between regions. This avoids a shortcoming of the latter two models, which effectively fix regional capital receipts to a specific region, and then allow all the residents of that region to share in those receipts.

The modelling of the determinants of inter-regional migration in FEDERAL-F is more detailed than that of either FEDERAL or MMRF, with a more plausible basis in assumed household behaviour. In the latter two models, households are typically assumed to move between regions in order to either maintain the number of regional unemployed (in the case of FEDERAL) or equalise unemployment rates (in MMRF) in the (long run) solution year. In FEDERAL-F, inter-regional migration is motivated by changes in the differential between regional per-capita household incomes (inclusive of net fiscal benefits). The relevant income measure distinguishes between those components of income that are specific to the region in which a household resides (such as wage income, and regional government transfers) and those that are independent of the region in which a household resides (such as capital income).

7.2.2 Limitations and future work

The FEDERAL-F model currently does not feature model-consistent expectations for variables such as expected rates of return or expected post-migration income. This may be an issue for some simulations that feature large shocks to specific sectors (such as the microeconomic reform shocks in Chapter 6) or where the shocks generate significant and sustained changes in the price level. In the MONASH model, there is an option for the imposition of forward-looking expectations, despite the use of a year-on-year solution method, through an iterative algorithm. In the first iteration, guesses of outcomes for the year following each of the solution periods (t+1) are made, in order to solve the model for each of the solution years (t). After completing a sequence of trial solutions, these guesses are revised, and a new sequence of trial solutions is computed. Dixon and Rimmer (1999a) report that by using simple rules for revising the model's guesses for outcomes in t+1, they have encountered little difficulty in obtaining a converged sequence of solutions with only a few iterations. There would be no practical impediments to the implementation of a similar technique in the FEDERAL-F model. However, before incurring the associated developmental and on-going computational costs, it will be worthwhile first investigating what difference alternative assumptions about the formation of expectations actually make to the simulation results for a given scenario. In the first instance, this could be done relatively simply by simulating the scenario of interest within the national MONASH model, and comparing the results under closures imposing alternatively static and model-consistent expectations.

The present FEDERAL-F treatment of non-traditional export demands under the historical closure, like the MONASH approach upon which it is based, does not allow changes in relative cost conditions among industries producing non-traditional export commodities to be reflected in the commodity composition of aggregate non-traditional exports. In essence, under an historical closure, both the FEDERAL-F and MONASH models operate as if there is a single aggregate non-traditional export commodity (albeit with a regional dimension in FEDERAL-F) sold on world markets, with this aggregate being a Leontief combination of the individual non-traditional export commodities. One future development would be to recognise this explicitly, and introduce into each region a production function (i.e. one that allowed substitution possibilities between non-traditional export commodities) for the aggregate regional non-traditional export commodity. This would allow changes in the relative prices of the individual non-traditional export industries to have some impact on the commodity composition of aggregate non-traditional exports, while still facilitating the dampening of the responsiveness of individual non-traditional commodity export volumes to changes in their own cost conditions. However this approach would still suffer from the limitation that the export sales of an industry producing non-traditional exports could still be affected by the cost conditions of other non-traditional export firms, even when its own cost conditions were unchanged. An alternative approach then might be to investigate the introduction of transformation functions for each non-traditional industry, with these functions governing the capacity of the industry to switch a given output level between production for the domestic market and production for the export market.

In the historical simulations, certain elements of the government accounts, both on the revenue and expenditure sides, were determined exogenously, and shocked equal to their observed values over the period. There is not however a clear and distinct correspondence between the government accounts categories represented in FEDERAL-F, and those recognised by the ABS. This required the allocation and apportioning of the ABS data among the FEDERAL-F categories. None of this was undertaken within the model. This can be contrasted, for example, with the approach taken with household consumption. Here the ABS consumption categories themselves are determined exogenously, with the mapping between these categories and those recognised by the CGE core of FEDERAL-F being internal to the model. A similar approach could be considered in future for the government finances. This would have three advantages. First, it would reduce the possibility of error, since the alternative to undertaking these mappings and allocations within the model is to do them manually outside of it, using for example spreadsheets. Second, it would make more transparent the relationship between the ABS and FEDERAL-F government accounts categories. Finally, in simulations of the model under a structural closure, it would produce output for the regional and Commonwealth accounts that were in the same format as the ABS government accounts.

A module that provides an index of labour market adjustment costs similar to that developed by Dixon and Rimmer (1999c) (the "labour input loss index" or LILI) could be added to the model. When combined with an ORES-style top-down decomposition of Tasmanian results to the sub-regional level, this would elucidate the regional dimension of the costs of labour market adjustment, both at the state and sub-state level. The LILI method assigns a cost to gross labour market movements on the basis of their likely impact on the amount of time withdrawn from employment. Differing time losses are attributed to movements between labour force status (employed, unemployed, or not in the labour force), remaining unemployed, and moving between occupations and regions. These time losses are valued using national accounts estimates of average annual earnings per employed person (Dixon, Parmenter and Rimmer 1997). The net adjustment costs of a policy change are then measured by the difference between adjustment costs in the base case compared with adjustment costs in the policy simulation.

One possible limitation of the present treatment of phantom taxes in FEDERAL-F is that they are distributed to capital owners in proportion to capital ownership shares, but without being subject to income tax. While not an important limitation in terms of its likely impact on simulation results, there is no reason why the phantom tax receipts (which it will be recalled are treated like super-normal profits) should not be subject to some form of income taxation, and in future development work this could also be considered.

7.3 DATABASE AND PARAMETER ESTIMATES

7.3.1 Contributions of FEDERAL-F

The focus in this thesis has been on the development of the theoretical structure of FEDERAL-F, the implementation of the resulting model for Tasmania / rest of Australia, and a number of illustrative applications of the new model. Improvements in database estimation and model parameterisation as such have not been a chief focus of the research. In part this was driven by the prior existence of a 1992/93 Tasmania / rest of Australia database for the comparative-static FEDERAL model. The existence of this database facilitated the establishment of the database for the version of FEDERAL-F used here. However a number of adjustments were made to the existing database, and estimates of many new coefficients and parameters were also required. The thesis' chief contribution in the area of database construction then was the writing of a set of computer routines that generate a database for the FEDERAL-F model using inputs from both the MONASH database and an existing two-region database in the FEDERAL model format. The procedures in this computer program are described in Chapter 3. This program will facilitate the task of developing working versions of FEDERAL-F for other jurisdictions for which FEDERAL databases already exist, such as South Australia, New South Wales, Western Australia, and Victoria.

7.3.2 Limitations and future work

The model currently contains a mixture of lagged and instantaneous responses on the part of agents to changes in relative prices and endowments. Lagged adjustment mechanisms are currently instituted for the movement of actual rates of return to their equilibrium levels, movements of inter-regional migrants to their equilibrium levels, and the movement of economy-wide employment in deviation simulations towards its base-case level. In each case, approximately half of the gap between actual and equilibrium levels for the variable are closed in each period, implying adjustment periods of between five and six years. Other parts of the model do not contain lags, such as consumer responses to changes in relative prices, export demands, primary factor substitution, and substitution on the part of the various agents between alternative sources of commodity supply. This raises an issue about the choice of parameters for these parts of the model, since these parameters are held fixed in year-on-year simulations of the model. If the parameter estimates relate to the short-run reactions of agents to their changed circumstances, then in year-on-year simulations of the model over extended periods, the model will underestimate these reactions. Similarly, if the substitution parameters relate to long-run elasticities, then the model will tend to over-estimate the reaction of agents to exogenous shocks in any given sub-period of a simulation over an extended period of time (Longva et al. 1985). FEDERAL-F is not alone among Australian CGE models in facing this problem - it is shared with MONASH, FEDERAL, and MMRF. For the latter two models, the problem is not as pressing, since the model-user always has the option (albeit an option not often taken up) of employing alternative substitution parameters for short-run and long-run simulations. However the problem is more apparent for year-on-year simulations, in which we might expect the capacity of agents to adjust to changes in relative prices will itself change over time. Future work on this could focus first on obtaining (from existing literature or possibly new econometric studies) new parameter estimates, carefully distinguishing long-run and short-run elasticities. Work could then be undertaken on incorporating new adjustment mechanisms into the model which allowed lagged adjustments towards the long-run solutions for export demands, consumer demands, and so on. However the effort required to estimate new parameter values would be significant, and the addition of many new lagged adjustment mechanisms would add considerably to the complexity of what is already a very large model. It might be worth experimenting first with such lags in a miniature FEDERAL-F model. The objective would be to determine such things as which elasticities exert the most influence on the model solution, and whether using, say, a simple average of long-run and short-run elasticities (without a lagged adjustment response) yields results not much different from a model with adjustment lags.

From the historical simulations, it was found that around one half a percentage point per annum of the gap between the growth rates of the two regions was attributable to shifts in the preferences of domestic agents away from Tasmanian goods and towards mainland goods. This was an important finding, since it suggests a number of questions about both the causes of the relative decline in the size of the Tasmanian economy, and the modelling methodology that has been employed. Taking the results for these variables at face value, one would conclude that there were changes in the tastes of households away from Tasmanian goods and towards equivalent mainland goods, and similarly, changes in production technology leading to a shift from Tasmanian goods towards mainland goods. However, a number of other possibilities should be explored. First, it could be that the inter-regional sourcing twists are picking up un-modelled changes in stocks of Tasmanian outputs. Alternatively, the issue might be one of aggregation in the database. That is, perhaps the Tasmanian commodity aggregates are comprised of a higher proportion (relative to the Mainland) of those (sub-) commodities experiencing declining national demand because of either technical or preference changes. If this were the case, then a finer level of commodity disaggregation would reduce the size of the Tasmanian-specific twist and technical changes, since they would be reflected in the national level variables for the same. A more interesting possibility from a regional modelling methodology perspective is that the parameters reflecting substitution possibilities between regions are inaccurate. The evaluation of these parameters is notoriously problematic in regional CGE modelling. An interesting avenue for future research is to examine alternative values for inter-regional substitution possibilities across commodities. The aim would be to adjust the values for these parameters such that changes in relative prices and activity levels can explain a greater proportion of the observed regional output responses, thereby reducing the need to resort to endogenously calculated inter-regional sourcing twists and source-specific technical changes. This same approach could be extended to other areas of the model, in an effort to provide better estimates of the model's parameters. The objective would be to adjust substitution parameters in directions that minimised the values of variables such as the import / domestic twist and the labour / capital twist. However one problem with this approach would be that it is possible that such twists may be picking-up un-modelled shocks. For example, Dixon, Rimmer and Menon (2000) suggest that the import / domestic twists may be picking up the effects of the removal of non-tariff barriers. As suggested above, in FEDERAL-F the inter-regional sourcing twists may be reflecting un-modelled changes in stocks. The possibility that such twists are reflecting either un-modelled shocks or too aggregated a database would need to be considered before proceeding with adjustments to substitution parameters to reduce the values of these twists.

The Tasmania / rest of Australia implementation of FEDERAL-F used in this thesis features 37 industries. This is a relatively high degree of aggregation relative to the MONASH model (which features 113 industries and 115 commodities), but a more disaggregated treatment than the MMRF model (which usually features 12 sectors[143]). The disaggregation in the present model is far greater than that present in the international regional CGE models, which typically feature around 10 sectors on average. There are of course costs and benefits to be traded off in implementing a more disaggregated model. A more disaggregated database expands the general-purpose nature of the model, widening the range of industry-specific shocks that can be modelled in deviation / policy simulations. Dixon and Parmenter (1994) also note that greater industrial / commodity disaggregation can greatly expand the utility of the disaggregated forecasts generated by dynamic CGE models, by more directly meeting the needs of public and private sector users of such forecasts. These groups are typically interested in forecasts for much more narrowly defined industries than those present even in a highly disaggregated model, such as one featuring over 100 industries. There are also some theoretical advantages in a more disaggregated model. For example, the present treatment in FEDERAL-F of uniform economy-wide tariff rates becomes a more accurate depiction of reality the greater is the level of commodity disaggregation (Madden 1990). However, further commodity disaggregation of the agricultural sector of the model in particular would likely require further theoretical development work on the model, particularly with respect to the addition of the original FEDERAL model's multi-product industries as discussed in Section 2.4.3. There are however also a number of important disadvantages to increasing the model's disaggregation. First, it is important to note that with two regions and 37 industries, the model effectively already has 74 industries. The addition of the regional dimension to the model already increases the effort required to develop and maintain the model's database. It can also add to the complexity of interpreting results. These costs must be considered against the benefits of greater disaggregation. It is easy to over-rate these benefits for a bottom-up multi-regional model. Experience with comparative-static applications of the FEDERAL model has been that users are primarily interested in results for national, state, and sub-state macroeconomic variables, government finance results, broad sectoral results, and results for the one or two specific industries that might be directly affected by the shock in question. In these applications, it is typical for the model-user to introduce to the model superior information on the industries that are directly affected by the shock. This is normally done by disaggregating such industries from the existing industries within which they were initially subsumed in the starting database. Even with a

[143] However Mark Horridge at the Centre of Policy Studies has recently compiled a 50 sector database for MMRF.

highly disaggregated model, users are still likely to continue to want to disaggregate further the industries directly affected by a shock. Finally, the number of model users interested in forecasts for highly disaggregated industries and commodities at the state level is unlikely to be sufficiently high to justify the costs of maintaining highly disaggregated multi-regional databases. In this environment, it is likely to be difficult to justify the costs of developing and maintaining highly disaggregated databases for FEDERAL-F.

7.4 APPLICATIONS

7.4.1 Contributions of FEDERAL-F

Five sets of illustrative applications were conducted for this thesis: an historical and decomposition simulation, a forecasting simulation, a policy simulation focussing on productivity improvement in the utilities sector, and two policy simulations focussing on regional government fiscal policy. The historical and decomposition simulations represented one of the most sophisticated and detailed analyses undertaken in Australia to identify the factors that influence economic performance at the state level, and the relative contributions of each of the factors so identified to the measured performance of a state economy. The forecast simulations represent the first use of a bottom-up multi-regional CGE model to generate forecasts for an Australian state. The national competition policy simulations attempted to make a number of improvements on previous studies. First, by examining the observed change in productivity in the utilities sector following the introduction of NCP, plausible bounds were placed on the productivity impact of NCP. This can be contrasted with the approach of earlier studies, which set the productivity consequences of NCP equal to the gap between measures of actual and "best-practice" productivity. Second, the high level of government ownership in the utilities sector was explicitly modelled, allowing a better modelling of the fiscal consequences of NCP than has hitherto been achieved. Finally, the use of the dynamic model then provided a state-level estimate of the time-paths of the economic impacts from the introduction of NCP. Two policy studies were undertaken to investigate the efficacy of state government fiscal policy. Both these studies represented an extension into a dynamic framework of earlier work undertaken with the comparative static FEDERAL model.

7.4.2 Limitations and future work

The historical / decomposition simulations, which covered a period of six years, were undertaken using a sequence of year-on-year simulations of the model. For a simulation period this long, a case might be put for running the model under a single annual-average run covering the whole simulation period, and in which certain stock variables (such as capital and regional populations) are determined exogenously in the historical simulation, and endogenously in the decomposition simulation. This might provide for a better attribution of the observed economic changes over the period to each exogenous shock under the decomposition run, since changes in the capital stock (for example) would be linked directly to the economic shocks that originally induced the change in capital demand. By way of contrast, economic shocks in any given year of the year-on-year decomposition simulations generate changes in rates of return and hence investment. These changes in investment then impact on the capital stock in future periods via the shocks to the capital accumulation homotopy variables. Hence, the causes of the changes in the capital stock in the decomposition simulation can be traced only as far as the momentum implicit in the previous period's data on net investment and initial capital stocks. The correct answer as to which technique to use depends on the time period of the analysis. For very long time periods, the better approach is probably to conduct single-step simulations in which capital stocks are determined exogenously in the historical simulation, and can fully adjust to exogenous shocks in the decomposition simulation. For very short time periods of only, say, a few years, the year-on-year approach, which only allows gradual adjustment of the capital stock in the decomposition simulations (and attributes that adjustment to the homotopy shocks) is preferable, since the alternative would be to overstate the extent of capital adjustment to each exogenous shock. For a period of six years, which is the length of the historical simulations in this thesis, the question of which is the better technique is moot. It is worth noting however that six years is approximately the length of the period imposed on the model, via the setting of the model's various adjustment parameters, for the (near complete) attainment of long-run values for aggregate employment, inter-regional migration, and equilibrium rates of return. By the end of the historical period 1992/93 - 1998/99, the economy has only had, on average, three years to adjust to the exogenous shocks to which it was exposed. Recall that in deviation simulations, the labour market adjustment mechanism returns the economy to its long-run solution after about five years, while the inter-regional migration theory takes about six years to fully adjust. Hence, over the historical period analysed in this thesis, the economy has on average only half the time available to fully adjust to an exogenous shock, relative to the time allowed for by the adjustment parameters operating during deviation simulations. It could be argued then that there would be some inconsistency in imposing full adjustment of capital stocks to exogenous shocks spread evenly over a six year period in the historical simulations, while only allowing near-complete adjustment of the model to its long-run solution after about six years from the original date of a single shock in a deviation simulation. Ultimately, for the simulations reported in Chapter 4, there may be little practical difference between the two approaches. It was found that the largest impact on investment, particularly for the Mainland, was from exogenous shifts in rate of return schedules. These are independent of the other shocks to which the economy was subject.

There is perhaps a more important caveat to be advanced with respect to the interpretation of the historical results than those just outlined. The interpretation of the structural and policy variables calculated endogenously in the historical simulations should be undertaken with some caution and care, since not only is it possible that the values attained by these variables will reflect any shortcomings of the model's data and parameter values, but they may also be picking up missing theoretical relationships and missing exogenous shocks. This caveat is relevant regardless of whether the historical period is solved as a sequence of year-on-year solutions, or as a single average-annual simulation.

With these caveats in mind, the forecasts and historical simulations in Chapters 4 and 5 are not advanced as being definitive studies, but rather, serious demonstrations of the capabilities of the model, within the practical constraints of the time available to undertake these studies. As has been emphasised in a number of places in this thesis, one of the strengths of the CGE modelling approach is the detail with which changes in the economic environment can be modelled. Hence, over time, the inputs to both the historical and forecast simulations should be developed with ever increasing detail, reflecting regional and industry specific factors, and more detailed policy modelling to provide greater institutional richness. For the historical simulations, this will also include obtaining better estimates for the values of those variables that are determined exogenously, particularly those variables defining industry and commodity level activities. For the forecasts, it will include more detailed modelling of government policy change, particularly at the regional level. It will also include giving further thought to the appropriate exogenous shock values for those structural variables in the forecasting simulations that are currently shocked equal to the average of their values as computed under the historical closure. Over time, these shocks could be refined with more industry-specific detail, particularly for the region of focus, as the entire set of shocks governing the historical and forecast periods are continually refined.

In the future, FEDERAL-F can be turned to the analysis of a wide range of issues, and these issues can be investigated with respect to their impacts on a large number of variables. In the present thesis, the focus of the discussion has been on impacts on relative regional growth rates. This was largely motivated by the fact that the relatively slow growth rate of the Tasmanian economy is one of the more stark of the various stylised facts relating to Tasmania's relative economic performance. This also makes it a common focal point for debate - both policy and popular - within Tasmania. From a welfare perspective however, there are more relevant variables to concentrate upon in future research. One immediate example would be an examination of the consequences for real consumption per capita of the various structural and policy shifts uncovered during the historical simulations. This will leave aside the current inquiry into the relative sizes of the two economies, and focus directly on the welfare of the individuals living within each. The model is already relatively well equipped to investigate this, given its attention to the modelling of inter-regional migration and accounting for household capital ownership. Further work though could be undertaken on the dynamic properties of the migration function, also informed by econometric studies of the responsiveness of inter-regional migration to various explanatory variables.

The addition of a LILI module to FEDERAL-F as discussed in Section 7.2.2 would also fruitfully expand the range of policy-relevant variables produced by the model. This module would provide information about the timing, magnitude, and location of job gains and losses. It would elucidate the net costs of workers having to retrain to change their employment between industries and occupations, the costs of retrenchments and periods of unemployment, and the costs of inter-regional migration. Until recently, the proper assessment of these costs and benefits had been neglected by policy modellers. This was one of the main critiques by Quiggin of the IC's work on NCP, and remains a limitation of the NCP simulations undertaken in Chapter 6. The addition of a LILI module to FEDERAL-F would provide a quantitative assessment of these important social and economic costs, and thus facilitate the calculation of the net benefits of policy change at the regional level. It would also, for example, allow the investigation of whether there are firmer economic grounds for state government macroeconomic policy (relative to the pessimistic conclusion reached in Chapter 6) when the costs of both the labour market adjustments and the inter-regional emigration experienced by an ailing regional economy are fully costed.