

**Essays on the Australian Economy -  
A Neoclassical Perspective**

by

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# Abstract

This thesis brings together three research papers or chapters. The key similarity among the chapters is that they are all based on neoclassical economics. Each chapter explains important episodes of the Australian economy. Starting from identifying government expenditure shocks from 1980 onwards, I explain the productivity miracle in Australia in the 1990s and the causes of the Great Depression in Australia in the 1920s and 1930s.

In Chapter 2, I identify government expenditure shocks for the Australian economy from 1980 onwards using VAR. In this identification, the timing of the announcement of government expenditure is taken into account rather than actual stream of government expenditure. The motivation of this is that, rational agents should start to react from the timing of the announcement of the change in government spending. This follows directly from observing the lifetime budget constraint of the agent. This research is closely related to Ramey (2011). My results show that government expenditure shocks based on newspaper sources has a significantly negative impact on GDP, hours worked, investment and the durable consumption variable, i.e. the impact of government expenditure shocks has been contractionary for Australia in recent times (1984-2009). I also run a VAR using the news variable of Ramey (2011) based on newspaper sources on the US and again, obtain a contractionary impact on the economy.

Chapter 3 focuses on the high productivity growth of Australia in the 1990s. From 1993 onwards Australia experienced an above average growth rate of the output per working-age person. During 1993-2004, the average annual growth rate of output per working-age person in the Australian economy was higher than the United States' (2.63 percent versus 1.98 percent). In various studies including the reports/publications of the Productivity Commission of Australia, it is suggested that high productivity growth

underpinned the high growth of output for nearly a decade. The average yearly growth rate of total factor productivity (TFP) was 2.95 percent during 1993-2004 compared to the slowdown period of 1988-92 (0.05 percent). I undertake the analysis with several versions of the neoclassical model. The basic model with only TFP shocks shows the importance of productivity in economic growth. The model predicts a boom in the economy as also reflected in the data. The correlation of the output per working-age person between the model and data is very high (0.99). However, the model predicts a noticeably larger growth of the output per working-age person, compared to the data (average growth 3.09 versus 2.63 percent). I extend the analysis including tax and government expenditure shocks in the model. The inclusion of extra shocks increases the model's ability to track the output per working-age person.

Chapter 4 focuses on the role of productivity during the Great Depression in Australia. In 1925 Australia's output per working-age person started to drop. The peak-to-trough (1925 to 1932) decline of detrended output per working-age person was around 35 percent. My analysis suggests that declining productivity was the major cause of the Depression. The basic model can account for 96 percent of the drop of output per working-age person. The research is carried out also within an open economy environment where the model can account for 88 percent of the drop. This result differs from the recent research by Payne and Uren (2011).



# Statement of Originality

I, Mohammad Altaf-Ul-Alam, certify that 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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Mohammad Altaf-Ul-Alam



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# Abbreviations

Australian Bureau of Statistics (ABS)

Australian System of National Accounts (ASNA)

Bureau of Economic Analysis (BEA)

Dynamic Stochastic General Equilibrium (DSGE)

First Order Conditions (FOCs)

Gross Domestic Product (GDP)

Gross National Expenditure (GNE)

Hodrick and Prescott (HP)

Information and Communication Technology (ICT)

Organisation of Economic Cooperation and Development (OECD)

Present Discounted Value (PDV)

Reserve Bank of Australia (RBA)

Structural Vector Autoregression (SVAR)

Total Factor Productivity (TFP)

Vector Autoregression (VAR)





# Chapter 1

## Introduction

This thesis is an exploration into the sources of aggregate fluctuations and economic growth of the Australian economy. In this regard, impact of fiscal and technology shocks on the Australian economy are investigated. The research is carried out both empirically and theoretically. The thesis consists of three distinct research papers or chapters. The basic similarity among the chapters is that they are all based on neoclassical economics. Each chapter explains several important episodes in the Australian economy. Starting from identifying government expenditure shocks from 1980 onwards, I explain the productivity miracle in Australia in the 1990s and the causes of the Great Depression in Australia in the 1920s and 1930s.

Chapter 2 addresses issues including: How does the Australian economy respond to the news of a rise in government spending? Do consumption and hours worked rise or fall? What happens to other macro variables? Are the responses similar to those that have been identified for the US economy? Focusing on government expenditure shocks is important in light of the ongoing and unresolved debate on the effectiveness of the Australian Labor Government's 2008 stimulus package and also on the effectiveness of any government expenditure plan in general. This chapter identifies government expenditure shocks for the Australian economy from 1980 onwards. I undertake this empirical research with an event study approach or narrative approach to identify government expenditure shocks. In this identification, timing of the announcement of government expenditure is accounted for rather than the actual stream of government expenditure. The motivation of this is that rational agents start to react from the tim-

ing of the announcement of the change in government spending. This is simply done by acknowledging the lifetime budget constraint of the agent. This research is closely related to Ramey (2011). She finds an expansionary impact on GDP and a negative impact on consumption for government expenditure shocks using data from 1939-2008 on the US. She also finds a contractionary impact on the economy during the period 1981-2008, which excludes the major shocks such as the Second World War and the Korean War, with her news variable based on professional forecasts.

I use a VAR methodology similar to Ramey (2011) to derive the impulse responses of the government expenditure shocks. My results show that government expenditure shocks based on newspaper sources have a significantly negative impact on GDP, hours worked, investment and the durable consumption variable, i.e. the impact of government expenditure shocks has been contractionary for Australia in the post-1980 period. I also run a VAR using the news variable of Ramey (2011) based on newspaper sources on the US and again, obtain a contractionary impact on the economy.

Chapter 3 focuses on the above average productivity growth of Australia during 1993-2004. During this time period, the average annual growth rate of output per working-age person of the Australian economy was higher than the US (2.63 percent versus 1.98 percent). In various studies including the reports/publications of the Productivity Commission of Australia, it is stated that high productivity growth underpinned the high growth rate of output for nearly a decade.

In Australia productivity has been a buzzword of economic policy. A recent quote reminds us how important productivity is to the policy-makers of Australia and Australian society:

“Want to be a politician, policy wonk or media commentator and you want to deliver or analyse economic policy? Make sure you throw in a good helping of ‘productivity’.” (‘Productivity in a nutshell’ by Greg Jericho, The Drum on ABC News 24, 14 March 2012).

The concern about productivity in Australia emerges due to the slowdown of pro-

ductivity growth after the early 2000s. It has often been claimed that TFP growth was instrumental for economic growth in the 1990s. The research in Chapter 3 is undertaken concerning the issues of productivity: What was the role of productivity in economic growth in the 1990s and 2000s in Australia? What were the determinants of economic growth?

In this research, the growth accounting methodologies developed by Cole and Ohanian (2001) and Kehoe and Prescott (2002) are used. The methodology differs from Solow (1957) as his accounting procedures preceded the development of the dynamic general equilibrium growth model. In the growth accounting the average yearly growth rate of TFP is 2.95 percent during 1993-2004. I undertake the analysis with several versions of the neoclassical model. The basic model with only TFP shocks shows the importance of productivity in economic growth. The model also predicts a boom in the economy as reflected in the data. The correlation of the output per working-age person between the model and data is very high (0.99). However, the model predicts a noticeably larger growth of the output per working-age person, compared to the data (average growth 3.09 versus 2.63 percent). So I extend the research addressing the issue: Were there any impacts from taxes and government expenditure on business cycle fluctuations in Australia?

Including the tax and government consumption shocks, the model does an impressive job of tracking the output per working-age person. A model with taxes (marginal labour and capital taxes) and government consumption including the TFP shocks is able to significantly improve the performance of the model in accounting for the data, where the average growth rate is 2.52 percent during 1993-2004, compared to other versions of the model. The correlation between output per working-age person of the model and the data is around 0.98. In all the versions of the model TFP is the highest contributor of the above average growth compared to the contribution of capital and labour. The analysis also shows parallel findings of Prescott (2004) that taxes have a negative impact on hours worked. All the models that include tax shocks show a lower average yearly increase of hours worked compared to the model without taxes.

In Chapter 4, the focus is, on an important economic event in Australian economic

history that happened nearly 90 years ago - the Great Depression of the 1920s and 1930s. This chapter addresses issues such as: Why did output fall so much during the Great Depression in Australia? What caused the enormous drop in economic activity? Why did the output remain so low for a decade? In Chapter 4 I carry out the research to answer these questions. During 1925-32 Australia faced the highest fall in output per working-age person in the twentieth century. The peak-to-trough (1925 to 1932) decline of detrended output per working-age person was around 35 percent. While in 1925 the unemployment rate was 6.3 percent, it reached 19.7 percent in 1932.

In this research, growth accounting methodology is similar to Chapter 3. I find the cause of the Depression in the lense of the neoclassical growth theory. This chapter finds a significant impact from the fall in the productivity on output per working-age person. The analysis begins by abstracting from international factors. The artificial economy driven only by TFP shocks can account for 96 percent of the peak-to-trough output drop. Australia is an open economy and some authors, notably Valentine (1987a,b) and Siriwardana (1995) suggest a significant role of falling terms of trade (or falling export prices) as the cause of the Depression, I also test the impact of productivity in an open economy context. The model economy accounts for 88 percent of the peak-to-trough decline of detrended output per working-age person. Results show that declining productivity was the major cause of the Depression which differs from the recent research by Payne and Uren (2011) who find that monetary/exchange rate shocks were the cause.

## Chapter 2

# Identifying Government Expenditure News Shocks for the Australian Economy

### Abstract

This chapter identifies government expenditure shocks for the Australian economy from 1984:3 to 2009:2. In this identification, the timing of the announcement of government expenditure rather than the actual stream of government expenditure is considered. The motivation for this is that agents start to react from the timing of the announcement of the change in government spending. This research is closely related to Ramey (2011). Using VAR technique, she finds an expansionary impact on GDP and a negative impact on consumption for government expenditure shocks using data from 1939:1-2008:4. She also finds a contractionary impact on the economy during the period 1981:3-2008:4, which excludes the major shocks such as the Second World War and the Korean War, with her news variable based on professional forecasts. My results show that government expenditure shocks based on newspaper sources have a significantly negative impact on GDP, hours worked, investment and the durable consumption variable, i.e. the impact of government expenditure shocks has been contractionary for Australia for the post-1980 sample. A VAR is also run by me using the news variable of Ramey (2011) based on newspaper sources on the US and obtain a contractionary impact on the economy.

## 2.1 Introduction

How does the Australian economy respond to the news of a rise in government spending? Do consumption and hours worked rise or fall? What happens to other macro variables? Are the responses similar to those that have been identified for the US economy? In a neoclassical framework for a positive government expenditure shock, private consumption and real wages decrease, on the other hand in a Keynesian framework private consumption and real wages increase. There are two branches of empirical literature which address the first three of these questions using the VAR technique. The last question is very important as it tells about comparing with the US economy, upon which most empirical works of macro econometrics are done. When the economist does not consider timing of news of government expenditure then gets an increase in both consumption and real wages (Keynesian results).<sup>1</sup> On the other hand, considering the timing of news Ramey (2011) and Ramey and Shapiro (1998) get the neoclassical result, i.e. consumption and real wages decrease due to a positive government expenditure shock. For identifying government expenditure shocks recent work that is closely related to my research is Ramey (2011). The main contribution of Ramey (2011) is that she gets the neoclassical result for an increase of government expenditure using the VAR model considering the timing of government expenditure news, while most other VAR (SVAR) model users get Keynesian results (consumption and real wage increases) without considering the timing of government expenditure news.

Timing of the news of government expenditure is important to identify the impact of government expenditure shocks on the economy. If we just consider the actual government expenditure stream from the government's statistics data, then an econometrician has less information on the economy than the agents. For example, during the time of war or any big defence build-up/expenditure plan, the government announces the plan before the stream of expenditure starts to be implemented gradually over the years. As neoclassical theory assumes rational behaviour of the agents, so the agents start to react from the timing of news of government expenditure (reaction of the agent could be reduction of consumption from the time of news). So when an

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<sup>1</sup>See Blanchard and Perotti (2002); Fatás and Mihov (2001); Mountford and Uhlig (2009); and Perotti (2005) for Keynesian results.

econometrician does the analysis of finding the effects of shocks from the actual expenditure stream then they are wrongly measuring the real shocks in a VAR. There is another advantage of the Ramey (2011) method. To identify government expenditure shocks (or shocks of any variable) in a VAR, exogeneity of the government expenditure variable (or that variable) is necessary. The actual stream of data of total government expenditure may have pro-cyclical or counter-cyclical effects. To separate out the only exogenous part of government expenditure, so that structural shocks are identified, here I am considering the news of government defence expenditure rather than total government expenditure. Barro and Redlick (2011) and Hall (2009) focus on defence expenditure to analyse the macroeconomic effects of government spending. In brief, they say that non-defence expenditure is strongly endogenous. They consider defence expenditure to identify government expenditure shocks but they do not consider the timing of the news of defence expenditure which is considered by Ramey (2011).

There are similarities and differences between the government expenditure characteristics of the US and Australia. During time of wars like the Second World War, Korean War, Vietnam War and wars in Afghanistan and Iraq, there were big swings in the government expenditure of the US. During the post-1980 period, exogenous shocks in government expenditure also happened in Australia due to long-term government plans, for example, the 2000 Defence White Paper and due to wars in Afghanistan and Iraq. In this chapter my intention is to apply the Ramey (2011) method of identification for Australia. In her paper Ramey (2011) creates two defence news variables to identify the fiscal shocks, one is based on newspaper sources and the other one is based on professional forecasts. Her news variable based on news paper sources is a long time series 1939:1 to 2008:4 and news variable based on professional forecasts is created for the period 1969:1 to 2008:4. I create a news variable based on newspaper sources of Australia considering 1984:3-2009:2 period.

My results show that the government expenditure shock that considers the timing of news has a significantly positive impact on total government expenditure but a significantly negative impact (at 90 percent confidence level) on GDP, hours worked and private investment. The shock also has a negative impact at 68 percent confidence level on the durable consumption to GDP ratio. I also extend my research considering



the fact that Australia is affected by the world economy as it is an open economy. In this respect I include some external variables in my model but results are not much different: a positive government expenditure shock has a contractionary impact on the economy. I also do an exercise on the US economy considering the data 1980-2008 period using the Ramey (2011) defence news variable based on newspaper sources. Results show a contractionary impact on the US economy for a government expenditure shock.

My motivation for this research in this chapter and related literature is in section 2.2. In section 2.3 VAR methodology is provided. Then construction of the dataset is given in detail in section 2.4 to describe the appropriate counterpart variables for Australian data for the variables used by Ramey (2011).<sup>2</sup> Section 2.4 shows arguments for following Ramey (2011) for Australia and arguments for considering the timing of news. Section 2.5 presents the results of the dummy variable approach. Section 2.6 presents and explains the results of the defence news variable on Australia including robustness of results and the consideration of the openness of the Australian economy. Then I compare my results with the US data from 1980:1 to 2008:4 in section 2.7. Finally, there are some concluding remarks.

## 2.2 Motivation, Literature and the Research Gap

My research is closely related to Ramey (2011), which enquires into the ability of the data to match the findings of the basic neoclassical model that if government expenditure is going to increase, anticipating future tax increases, there will be a negative wealth effect which will reduce the consumption by the agent. The agents will also increase labour supply, assuming that leisure is a normal good, which will reduce real wages initially. Using the VAR/SVAR model, the findings of many studies like Blanchard and Perotti (2002), Fatás and Mihov (2001), Mountford and Uhlig (2009) and Perotti (2005) are parallel to the Keynesian result, that is that output and consumption increase after a positive government expenditure shock. Ramey (2011) finds the neoclassical result (consumption decreases) by considering the timing of news of gov-

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<sup>2</sup>The ABS (Australian Bureau of Statistics) database follows SNA93, that means all the data are in chain volume measure and we cannot sum up two components of an aggregate just by adding.

ernment expenditure in the VAR approach.

Neoclassical theory is based on rational behaviour of the agent. So if we want to identify a government expenditure shock then it is essential to consider the change of expectations of the agent about future government expenditure. If government expenditure increases, the agent anticipates future tax increases that actually affects his or her budget constraint. Ramey (2011) accounts for the change of expectation of rational agents on government expenditure in an empirical model. This is done by considering the timing of the news of government expenditure changes, rather than the actual stream of government expenditure.

Some recent macro econometrics work considers government expenditure as an aggregate variable, such as Blanchard and Perotti (2002), and Blanchard and Quah (1989). They do not consider which part of government expenditure accounts for all the volatility. They use different identification procedures to estimate the structural shocks and impulse responses. Blanchard and Quah (1989) have looked at long-term restrictions, such as the fact that the effect of one shock on another macro variable could be zero in the long run although it may have a short-run effect. Blanchard and Perotti (2002) describe the SVAR model with only three variables, but rather than getting all the parameter values directly from the data they estimate the elasticities from institutional information and then get the impulse responses. So rather than zero restrictions they apply elasticities for identification of fiscal policy. It is a mixed structural VAR event study approach. My approach differs from theirs as I am considering firstly, the timing of government defence news; secondly, I am not considering estimated elasticities; thirdly, my approach is a standard VAR approach. On the other hand some researchers focus on defence spending as this accounts for almost all of the volatility of government spending. This type of work includes Barro (1981); Hall (1990); Barro and Redlick (2011); Ramey (2011, 2009b); and Hall (2009).

Ramey (2009b) describes a new identification method with a quantitative defence news variable. She shows that most components of consumption fall after a positive shock to government spending. At first she considers a neoclassical growth model with

total government spending and non-distortionary taxes.<sup>3</sup> She calibrates the parameters of the production function and the capital accumulation equation from previous studies. Her technology shock equation is standard. She calibrates the MRS (marginal rate of substitution) shock and government expenditure shock parameters from the data. She sets up two government expenditure news related equations. News follows an AR(3) process, and government expenditure at period  $t$  depends on the news which was available two periods earlier.<sup>4</sup> She shows the theoretical impulse response function (IRF) of the model. She simulates data from the stylized model and runs two types of trivariate VARs on the simulated data, then gets the impulse responses that show the neoclassical result.

Ramey (2011, 2009b) shows the neoclassical prediction where she does three types of empirical experiments. These are (1) dummy variable, (2) news variable based on newspaper sources, and (3) news variable based on professional forecasts. Her first experiment is to use a dummy variable approach. With the data after the Second World War she considers four particular quarters when the news was available that defence expenditure is going to increase. These are 1950:3 for the Korean War, 1965:1 for the Vietnam war, 1980:1 for the Carter-Reagan Buildup and 2001:3 for 9/11. She uses this dummy variable in her VAR as the first variable.

She also mentions that the dummy variable approach does not exploit the potential quantitative information that is available, so she creates a better measure of defence news collected from *Business Week*, *New York Times*, *Washington Post* and from yearly budget documents of the US government. Her defence news variable measures the expected discounted value of government spending changes due to foreign political events.<sup>5</sup> Her created variable possesses exogeneity. This is similar to the idea of Romer and Romer (2010), where they use information from the legislative record to document

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<sup>3</sup>In her final version, i.e. in Ramey (2011), she does not include the VAR from simulated data and she does not explain her theoretical model.

<sup>4</sup> $\ln G_t = \ln News_{t-2}$ . News becomes available at period zero but government spending does not start to increase until period two.

<sup>5</sup>She has a companion paper where she describes the creation of the defence news variable in detail (Ramey, 2009a).

tax policy changes.<sup>6</sup> The constructed series of Ramey (2009b) is an approximation to the changes in expectations at the time.

Ramey (2011) uses another variable which is based on professional forecasts. The defence news variable is not very informative for the post-Korean War sample, so she constructs this second news variable. This variable measures the one-quarter ahead forecast error, based on the survey of professional forecasters. This time series has the data range 1969:1 to 2008:4. From 1969:1 to 1981:2 prediction was on nominal defence spending. Using the forecasters' predictions about the GDP deflator, she gets the forecast of real defence spending. The shock is defined here as the difference between actual real defence spending growth between  $t - 1$  and  $t$  and the forecasted growth of defence spending for the same period, where forecast was made in quarter  $t - 1$ . From 1981:3 to 2008:4 the forecasters predicted real federal spending. She constructs the shock based on actual and predicted growth of real federal spending from period  $t - 1$  to  $t$ .

### 2.2.1 Literature Using the VAR Method for Australian Data

Perotti (2005) uses the Blanchard and Perotti (2002) approach to identify fiscal policy shocks on OECD countries including Australia. A great deal of research has been done applying VARs and SVARs starting with Trevor and Thorp (1988). Papers include Orden and Fisher (1993), Huh (1999), Moreno (1992), Weber (1994), Brischetto and Voss (1999), Fisher (1996), Dungey and Pagan (2000, 2009). Most of this research focuses on monetary policy. In some of the literature foreign variables like US GDP, interest rate, etc. are included in the model for taking into account Australia's wider integration with the world economy. Dungey and Pagan (2000) do a SVAR approach, where at first, they put foreign variables and then domestic variables in order. Dungey and Pagan (2009) is an extension of their 2000 paper. They relate that model with emerging literature on dynamic stochastic general equilibrium (DSGE) modelling of a small

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<sup>6</sup>Their narrative analysis separates revenue changes resulting from legislation from changes occurring for other reasons. They also separated legislated changes into those taken for reasons related to prospective economic conditions, such as counter-cyclical actions and tax changes tied to changes in government spending, and those taken for more exogenous reasons, such as reducing an inherited budget deficit or to promote long-run growth (Romer and Romer, 2010).

open economy based on the new Keynesian approach. Nimark (2009) and Jääskelä and Nimark (2011) analyse the impact of different shocks (domestic and international) on the Australian economy. They estimate a new Keynesian open economy DSGE model with a sizeable number of frictions and rigidities, using the Bayesian technique. However, there is no research on government news shock with Australian data. My research is the first analysis with Australian data on government expenditure shocks based on timing of the news, using the VAR technique.

### 2.2.2 Research Gap

My research contributes to the literature in multiple ways. Firstly, there is not any work done similar to Ramey (2011) with Australian data on government expenditure shocks that considers the timing of the announcement of government expenditure. To identify government expenditure shocks a defence news variable has been created and this is an original contribution to the literature. This appears to be partially worthwhile given the ongoing and unresolved discussion on the effectiveness of Labor Government's 2008 stimulus package in Australia. Secondly, some external variables (such as terms of trade) are included considering the open economy structure of Australia which Ramey (2011) does not use in her identification. Thirdly, I compare my results with the Ramey (2011) data from 1980:1 to 2008:4 on the US. Although there is little difference with my time period (1984:3 to 2009:2) and the time period I choose from Ramey (2011), there is one similarity. During this post-1980 time period two big shocks of Ramey (2011) are included (Carter-Regan Buildup and 9/11) and also there are two big shocks in my time period (Defence White Paper 2000 and Defence White Paper 2009).

Results show largely similar impulse responses for the US and Australia. The contractionary effect of the government expenditure shock for the post-1980 time period was previously evidenced in Perotti (2005) for the US and Australian data using the Blanchard and Perotti (2002) approach in his identification. I get similar results to the Ramey (2011) identification approach for both the US and Australia. Lastly, anticipation of future changes in government policy have important consequences for econometric models. Some literature compares the anticipated and unanticipated tax changes empirically but only a few authors compare anticipated and unanticipated gov-

ernment expenditure changes empirically.<sup>7</sup> This chapter contributes to understanding the effects of anticipated government expenditure changes.

## 2.3 Methodology

The VAR method is used here to present my arguments. This tool is widely used in empirical macroeconomics. To identify fiscal shocks, I emphasize the timing of news of fiscal expenditure rather than when the expenditure is actually happening. I use equation (2.3.1) for estimation,

$$X(t) = A(L)X(t-1) + U(t) \quad (2.3.1)$$

where  $X(t)$  is a vector stochastic process,  $A(L)$  is a vector polynomial in the lag operator, and  $U(t)$  is a vector of reduced form errors. Ramey (2011) identification approach is followed here. It is an augmentation of the standard VAR approach. Here for the dummy variable approach I consider the dummy variable at the beginning of ordering. For the quantitative approach I consider the defence news variable at the beginning of ordering followed by total government expenditure, GDP and other variables. Then shocks to the first variable (dummy variable or news variable) are identified with the Cholesky decomposition. Here the impulse response function (IRF) is the orthogonalized impulse response function. Details are described in the technical appendix (Appendix A.3). Considering Australia's wider economic integration with the world economy, some variables are included here which are affected by the situation of other economies. These are the terms of trade index, exchange rate, etc. To compare my responses with the US, I use the US data from 1980 to 2008, rather than considering the whole time period (1939 to 2008) of Ramey (2011).

## 2.4 Data

### 2.4.1 Construction of Australian Time Series

The analysis is based on Australian data. All the data are taken from the ABS (Australian Bureau of Statistics), RBA (Reserve Bank of Australia) and Australian Taxation Office statistics. ABS quarterly data were accessed on 8 June 2011. The data

<sup>7</sup>See Leeper et al. (2009) and Mertens and Ravn (2008).

range is 1984:3 to 2009:2. All of the data I use are real (in chain volume measure). Chain volume is a better measure but it has the problem that it is not additive<sup>8</sup> so some approximation procedure is used in creating total government expenditure variable.<sup>9</sup> I aggregate the nominal values of general government final consumption expenditure and gross fixed capital formation (government investment) and then deflate by the non-farm GDP deflator to create the total government expenditure variable. In another specification in the VAR, instead of total government expenditure variable, I choose the ratio of total nominal government expenditure to nominal GDP. The total defence expenditure variable is also created in the same way by adding up the nominal values of final consumption of defence and gross fixed capital formation of defence and then deflating by the non-farm GDP deflator. Unlike the US some data used by Ramey are not available in Australia. For example, three major categories of consumption data, durable, non-durable and services consumption, are not available from the ABS. There are 16 categories of consumption in the ABS data but deflators are not available for every component of consumption. So I am not able to use the approximation method and not able to create durable, services or non-durable components of consumption. Using the GDP deflator is not appropriate here, so firstly, I consider aggregate real consumption as a variable in the VAR. Then instead of aggregate consumption variable, I use either the variable ‘nominal durable consumption to GDP ratio’ or ‘nominal non-durable and services consumption to GDP ratio’ in the VAR.

Ramey uses the three-month treasury bill rate in her analysis to include a control for monetary policy. Here I use the 90-days bank accepted bill.<sup>10</sup> Ramey (2011) uses

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<sup>8</sup>Generally, chain volume measures are not additive. In other words, components of chain volume measures do not sum to a total in the way original current price components do. In order to minimize the impact of this property, the ABS uses the latest base year as the reference year. By adopting this approach, additivity exists for the quarters following the reference year and non-additivity is relatively small for the quarters in the reference year and the quarters immediately preceding it. (Source: ABS).

<sup>9</sup>I sum up nominal values of government final consumption expenditure and gross fixed capital formation, then I deflate with the non-farm GDP deflator. Ramey (2011) also needed the addition of the chain volume measure to sum up services and non-durable consumption. She used the Whelan (2002) method. She has the advantage that US data of chain volume is constructed using the chain Fisher Index, but Australian data follow the chain Laspeyres’s Index. So Whelan’s method was not used.

<sup>10</sup>I take these data from the RBA website. There is only the monthly rate available. I add up the

another variable which she calls Barro-Redlick average marginal income tax rates taken from Barro and Redlick (2011). There is no appropriate counterpart of this variable for Australia, so I choose the average tax rate for Australia as the best suitable counterpart.<sup>11</sup> The idea of calculating the average tax rate in this simple way is followed from Kennedy et al. (2004). For the real wage variable I do not get an exact counterpart. Ramey (2011) uses manufacturing wages. In this analysis non-farm unit labour cost is used.<sup>12</sup> Data sources are given in detail in Appendix A.2.

## 2.4.2 Creation of the News Variable

A key part of this research is to identify the timing of the news and the quantity of expected change of defence expenditure and in order to do this I exploit the quantitative information from news sources. The defence news variable seeks to measure the expected discounted value of government spending changes due to exogenous events. Ramey (2011) includes mostly those shocks which are due to foreign political events (wars). She also includes big military build-ups by the government without a war, such as the Carter-Reagan military build-up (in early 1980s) as government expenditure news shocks. Here I consider the definition of exogeneity from both Ramey (2011) and Romer and Romer (2010). Romer and Romer (2010) consider exogenous tax changes that are motivated by a desire to raise long-run growth.<sup>13</sup>

For creating the news variable I depend on *The Australian Financial Review*, *The* three-months total and take the average.

<sup>11</sup>This calculation is done in the following way:

$$\text{Average tax rate} = \frac{(\text{Net tax}/\text{No of Taxpayer})}{(\text{Taxable Income}/\text{No of Taxpayer})} = \frac{\text{Net Tax}}{\text{Taxable Income}}$$

I collected all the information from *Taxation Statistics* which is a publication of the Australian Taxation Office. Net tax is gross tax - tax offsets + medicare levy + medicare levy surcharge.

<sup>12</sup>Real unit labour cost is an estimate of the real cost to employers of employing labour (including such things as fringe benefits and payroll tax) to produce one unit of output.

<sup>13</sup>They classify as exogenous any tax changes not motivated by a desire to return output growth to normal. One common type of action in this category is tax increases to deal with an inherited budget deficit. All other tax changes in this category can be thought of as being, at some level, motivated by a desire to raise long-run growth (Romer and Romer, 2010).



*Australian*, *The Canberra Times*, *Sydney Morning Herald*, and *The Age*. I identify news of shocks in those newspapers from July 1984 to June 2009. I follow a similar procedure to Ramey (2011). In Australia there have been some big defence expenditure shocks during the time period 1984:3 to 2009:2. The shocks are shown in Figure 2.1. The first episode started from 2000:4 which was a long-term plan of the government

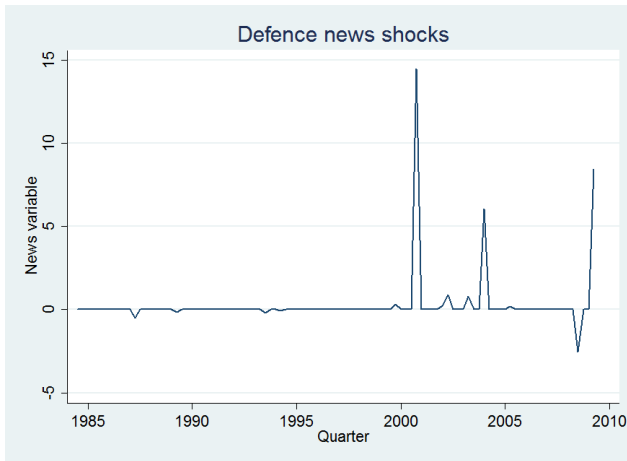


Figure 2.1: PDV of change in defence spending as a percentage of GDP, 1984:3 to 2009:2

*Note:* PDV is present discounted value.

which is called the Defence White Paper 2000 after decades of low spending for defence. This episode and the 9/11 attacks increased the subsequent defence expenditure. The discounted value of the expected change in defence spending as a percentage of previous quarter GDP is 14.31 percent in 2000:4 (see Figure 2.1 and Table A.1). Detailed calculation of the creation of the news variable is given in Appendix A.4. The Rudd government's announcement of another Defence White Paper in the second quarter of 2009 was also a big defence news shock. The discounted value of expected change in defence spending as a percentage of previous quarter GDP is 8.42 percent (see Appendix A.1) in this quarter. In the discount rate calculation, for calculating expected change of government expenditure, Ramey (2011) uses the three-year treasury bond rate prevailing at the time. The suitable counterpart for this in Australia is the five-year government bond rate. The data for the three-year government bond rate are only available from 1992. The constructed defence news variable should be viewed as

an approximation to the changes in expectation at the time. If the shock occurred in the last week of a quarter, it is dated as the next quarter since it could not have had much effect on aggregates for the entire current quarter.

### **2.4.3 Arguments for Using Defence Expenditure to Represent Total Government Expenditure for Australia**

A basic question: can defence expenditure in Australia represent total government expenditure for identifying fiscal shocks. Ramey (2011) chooses defence expenditure to represent total government expenditure as most of the volatility of government expenditure is captured by defence expenditure by the US. Is it also true for Australia? To enquire into this, I do a simple correlation between seasonally adjusted quarterly total defence expenditure and total government expenditure. The correlation is 0.95 for the data range 1984:3 to 2009:2. Secondly, a simple regression is done of the log of total government expenditure on the log of total defence expenditure. This shows a positive relation and the coefficient is significant at the 95 percent confidence level. The R-squared is 0.90. Thirdly, the annual data in Figure 2.2 show that there was similar trend in both of the variables for Australian data. Ramey (2011) also presents similar figures for the US. In Figure 2.2 vertical lines represent the years 1984, 1986, 1994, 2001 and 2009. These vertical lines are drawn arbitrarily to show that when defence expenditure is high, government expenditure is also high, such as during 1984 to 1986 both variables are upward sloping. Fourthly, the cyclical components of these two variables are calculated using the HP-filter. The correlation between the cyclical components of these two variables is around 0.54. With all this information, defence expenditure can be used to represent government expenditure in the analysis and it is relevant to apply the Ramey (2011) method for Australia for identifying government expenditure news shocks. From the historical side, Australia was involved as an ally with all the wars in which the US participated, so it is worthwhile to find out how macro variables reacted when there was news of an increase in the defence spending in Australia.



Figure 2.2: Annual data of per capita government expenditure and defence expenditure

#### 2.4.4 Consideration of News Rather Than Actual Value of the Variable

Here I explain why considering the defence expenditure news is more important than considering the actual defence expenditure to identify government expenditure shocks. This is done to incorporate the rational behaviour of the agent. Comparison has been done here between the VAR identified shocks of the actual defence expenditure and

the shocks of the news variable. This will explain the logic of considering the timing. In Figure 2.3, the upper part of the figure shows the actual defence expenditure shocks

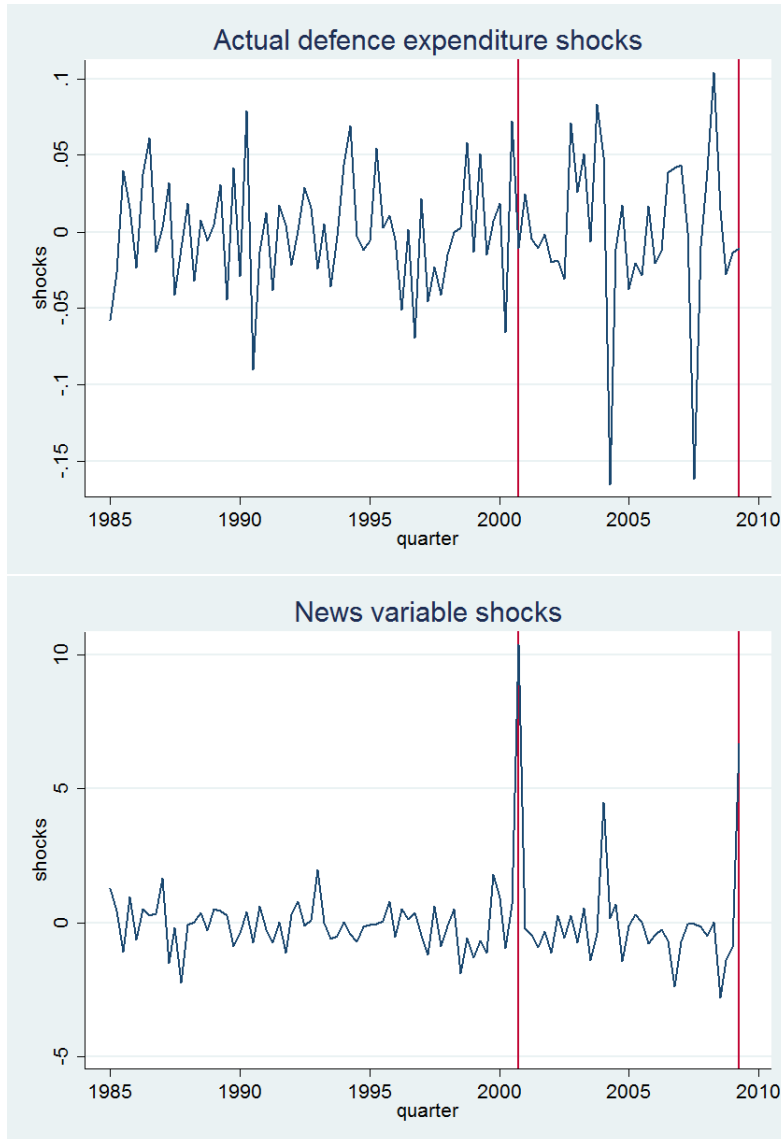


Figure 2.3: Actual defence expenditure shocks and news variable shocks

and the lower part shows the shocks of the news variable. The two vertical lines show the time of two big shocks (2000:4 and 2009:2). These shocks are not directly related to war, but the expenditure commitment was guaranteed due to Australian involvement in the war in Afghanistan and Iraq, within less than one year of the announcement of the Defence White Paper 2000. VAR shocks or actual defence expenditure shocks show a negative shock at the time of the news of the Defence White Paper 2000. At this

Table 2.1: Granger causality test result

Create Granger-cause	Granger caused	$\chi^2$	df	$Prob > \chi^2$
VAR shocks	news variable	0.730	2	0.694
news variable	VAR shocks	4.849	2	0.089

quarter it was known that a big expenditure was going to happen, news was available, so it was reasonable that rational agents would start to react from that time. Also a similar situation is seen in Rudd's Defence White Paper 2009 announcement. At that time the VAR shocks are negative.

Figure 2.3 shows another visible medium level shock in 2004:1. This shock is a revised announcement of the Defence White Paper 2000, so I do not consider that in the dummy variable approach. In this quarter, the actual defence expenditure shock is also negative. Thus, the conclusion is that VAR shocks do not accurately reflect news about defence spending. This shows the inability of the standard VAR to reflect the shocks accurately. A Granger causality test between the news variable and VAR shocks with defence expenditure show that at the 90 percent confidence level the news variable Granger- causes the VAR shocks but VAR shocks do not Granger-cause the news variable shocks.<sup>14</sup> Therefore, VAR shocks are forecastable. Granger causality test results are shown in Table 2.1.

## 2.5 Dummy Variable Approach

In this approach I do not use the defence news variable based on newspaper sources. A dummy variable approach is applied here as a preliminary step to identify shocks which is also done in Ramey (2011). This only considers the timing of big shocks and these shocks are not quantified here.

From the news sources, there were found to be two major defence news shocks during the time period 1984:3 to 2009:2. The first one was the Defence White Paper

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<sup>14</sup>Here I run a VAR with defence expenditure, GDP, hours worked, private consumption, private investment, tax and unit labour cost. Then I get the shocks of defence expenditure, and run a VAR with shocks and the news variable and get the Granger causality test result.

2000, announced in December 2000, so I consider 2000:4 as a dummy variable value of one. The second big defence news shock came in May 2009 (2009:2) which was another Defence White Paper with a big expenditure plan. The government's announcement of these big expenditures was widely published in all Australian newspapers as explained in Appendix A.4.

Figure 2.4 shows the results of the dummy variable approach. I run the VAR with the following ordering: defence dummy variable, log real per capita quantities of total government expenditure, GDP, hours worked, private consumption, private investment, average tax rate and real unit labour cost (last two variables not per capita).

Figure 2.4 shows that after the news shock total government expenditure rises and except the kink in the initial periods it follows a hump shaped like Ramey (2011) then gradually goes down to normal (steady state). The initial response of GDP is significantly negative, after two quarters it becomes positive and reaching its peak by 13 quarters. Consumption, hours worked, GDP, and private investment all start with a negative value and except consumption all are significant at the 90 percent confidence level. Government expenditure news negatively affects the private investment. Due to the uncertainty in the private sector, impact response on hours worked and consumption both are negative.<sup>15</sup> The initial impact on the average income tax rate is not significant then the IRF increases gradually, and this becomes significantly positive after five quarters at the 68 percent confidence level. The standard error bands shown in the figures are 68 percent and 90 percent and based on bootstrap standard errors. Ramey (2011) also shows both error bands but she gave some concluding remarks based on the 68 percent band.<sup>16</sup> For example, her impulse response for non-durable consumption is significantly negative only at the 68 percent band. However, these contractionary results are similar to Ramey's results with the news variable based on professional forecasts with recent data (1981 to 2008). One major observation with the response of government expenditure is that (see uppermost left figure of Figure 2.4), impact response is the highest value of the IRF. Ramey (2011) obtains peak of

<sup>15</sup>Impact response means response at the initial point of the IRF.

<sup>16</sup>Ramey mentions that a 68 percent band is a common practice in government spending literature. Sims and Zha (1999) used a 68 percent band. There is no formal justification for this particular choice.

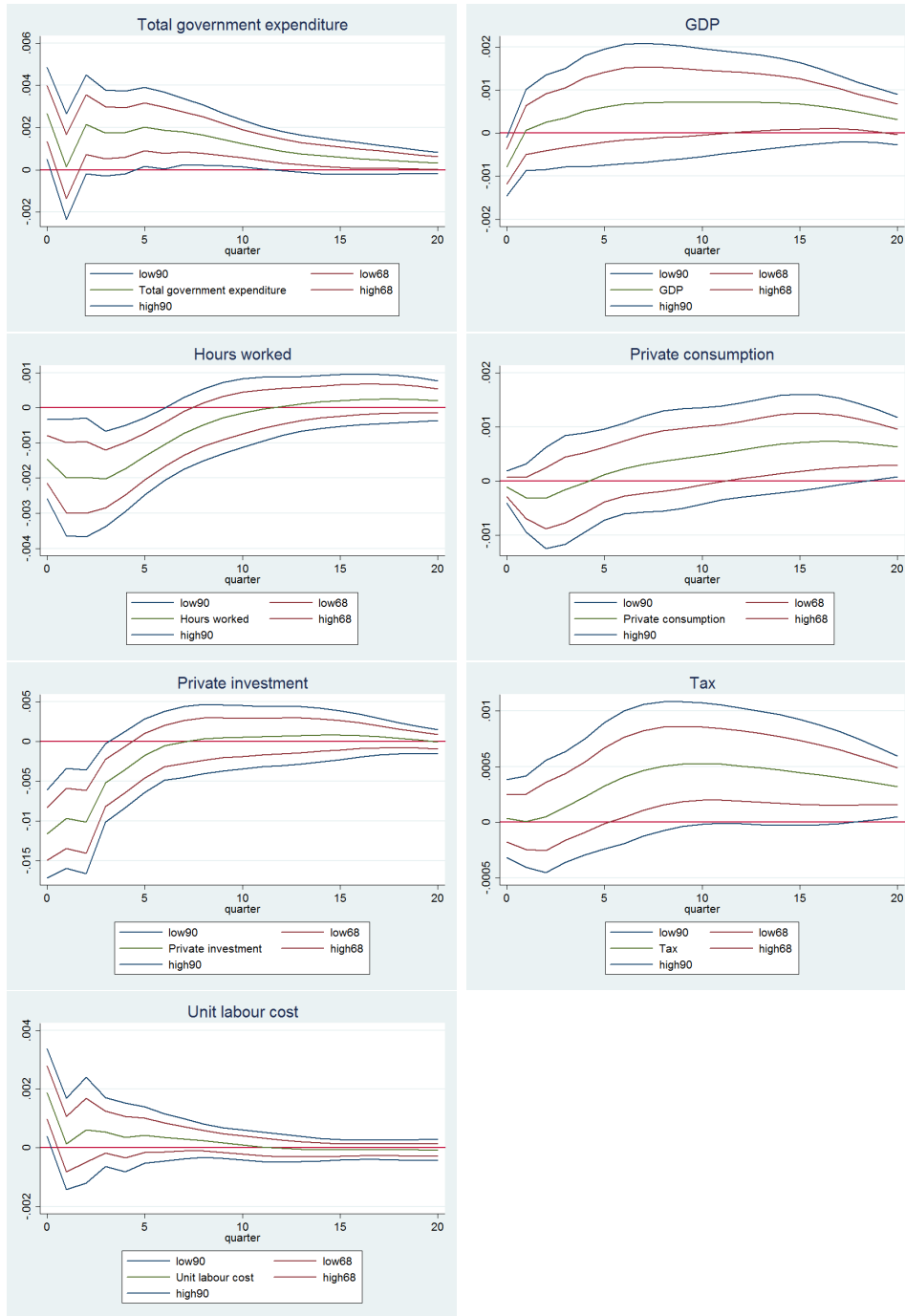


Figure 2.4: VAR with dummy variable approach  
*Note:* Here ‘low90’ means lower confidence limit of the 90 percent confidence level. In the same way, ‘high90’, ‘low68’ and ‘high68’ are defined.

the hump as the highest value of the IRF of total government expenditure with the

news variable based on newspaper sources. Detail theoretical explanations of results are given in the next section.

## 2.6 Defence News Variable

In this section, I use the defence news variable based on newspaper sources. This is a better approach to identify government expenditure shocks than the dummy variable approach as here I quantify shocks either as big or small throughout the period of analysis. In the dummy variable approach only big shocks are identified.

For applying VAR, I use a fixed set of variables and rotate other variables. Ramey (2011) and Burnside et al. (2004) follow this strategy. The fixed set of variables follows the ordering: the defence news variable, log of real per capita total government spending, log of real per capita GDP, 90-days bank accepted bills and average personal income tax rates. The last two variables are included in order to control for monetary policy and tax policy. With that set of five fixed variables I rotate real private consumption, real private investment, hours worked and real unit labour cost, one at a time. If I do not rotate then there will be more variables in the VAR, more parameters to be estimated and estimated parameters will be biased. Figure 2.5 shows the results. The number of lags is two and a quadratic time trend is included. The choice of lags is tested by the AIC (Akaike Information Criteria) and BIC (Bayesian Information Criteria). Most results are similar to my dummy variable approach. Co-movement of GDP, consumption, hours worked and private investment is seen here, although impact response of consumption is not significantly negative at the 90 percent confidence level.

The explanation starts with the response of the total government expenditure variable followed by all other variables. The impact response of the total government expenditure is significantly positive and except the kink in the initial periods it is hump shaped like Ramey (2011) with her news variable based on newspaper sources. Now the response of total government expenditure variable is more similar to Ramey (2011) than the dummy variable result in a sense that (see the both uppermost left figure of Figure 2.4 and Figure 2.5 that shows the response of total government expenditure) in Figure 2.5 impact response is not the highest point of the IRF, rather



highest point is the peak point of the hump. From the previous literature such as Ramey (2011) and Perotti (2005), I draw a hypothesis about the IRF of government expenditure. The hypothesis is, if we do not consider news to identify government expenditure shock (or for a temporary news shock) highest response of the IRF is at initial period and then the IRF goes down to normal. Perotti (2005) does not obtain a hump shaped response for the government expenditure who uses the Blanchard and Perotti (2002) approach (BP approach) for Australia with other OECD countries. BP approach does not consider news of government expenditure and their IRF spikes up in initial period. Also in Ramey (2011) for her news variable based on professional forecast IRF is not hump shaped where news shocks are temporary. My VAR results also supports the hypothesis. I obtain largely hump shaped response. Also here in the VAR if I do not include the news variable, responses of the government expenditure to its own shock, is as like as Perotti (2005).<sup>17</sup> For a robustness check, I also run a VAR with an alternative variable instead of the total government expenditure variable. The variable is the ‘ratio of nominal total government expenditure to GDP’. This is done as I create the total government expenditure time series by summing the government consumption and the government gross fixed capital formation and then deflating by GDP deflator which is a gross approximation as the real data is in chain volume measure. The results are unchanged (Figure A.1).

After a positive shock of the news variable, the response of GDP is significantly negative. A negative impact on GDP for a positive government expenditure shock is not a bizarre response. From the empirical side considering post-1980 data Perotti (2005) finds that positive government expenditure shock has a negative or insignificant impact on GDP for some OECD countries such as Germany and Canada. Ramey (2011) also does an experiment with post-Korean War data where she uses news shocks based on professional forecasts. She finds contractionary effects of the news shock variable on GDP. I calculate cumulative multiplier of government expenditure, that is, using the integral under the IRF. Up to the first 10 quarters the cumulative multiplier is negative, -0.028. After that the multiplier becomes positive where after four years it is 0.32 and after five years it is 0.45 which are much lower than many studies.<sup>18</sup> Ramey (2011)

<sup>17</sup>Figure A.4 shows the response of government expenditure to government expenditure shock with Australian data

<sup>18</sup>Here for calculating the cumulative government expenditure multiplier, I take the ratio of the

also obtains a negative cumulative multiplier for post-Korean War (1955 to 2008) news shocks based on newspaper sources as GDP becomes negative just after one period.

The response of taxes is significantly positive at the 90 percent level of significance after three quarters. The response of taxes should not necessarily be significantly positive at the beginning of IRF as we are explaining the responses of a news shock. In the case of Ramey (2011) impact on tax is not significantly positive at the beginning.

In the VAR there are two variables from the labour market - hours worked and unit labour cost. The response of hours worked is significantly negative and the response of unit labour cost (a proxy variable for wages) is significantly positive. If leisure is a normal good then for an increase of government expenditure, due to the negative wealth effect, leisure should decrease contemporaneously for a rational consumer. This will not necessarily happen if due to the increase of real wages, the negative wealth effect is offset. Thus a higher real wage creates a positive wealth effect and its influence might be higher than the negative wealth effect due to future tax increases. The intra-temporal substitution effect of the agent increases leisure and decreases labour supply. However, the effect of shocks on wages dry out soon. Later on instead of the hours worked variable, I use alternative variables such as employment to check the robustness of the results of hours worked variable. The total employment variable in the VAR shows similar responses i.e. significantly negative responses. Then I segregate total employment into part-time and full-time employment and include one of them in the VAR instead of the hours worked variable. The response of full-time employment is significantly negative although the response of part-time employment is insignificant.

To analyse the consumption behaviour, I run the VAR with three alternative consumption measures. These are total consumption, 'durable consumption to GDP ratio' and the 'non-durable and services consumption to GDP ratio'. The effect on total consumption is not significantly different from zero. Ramey (2011) uses three different categories of consumption, durable consumption, non-durable consumption and services consumption from the BEA (Bureau of Economic Analysis) data. For Australia there are no real data for these three major categories of consumption in the ABS, but  

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cumulative responses of GDP to total government expenditure.

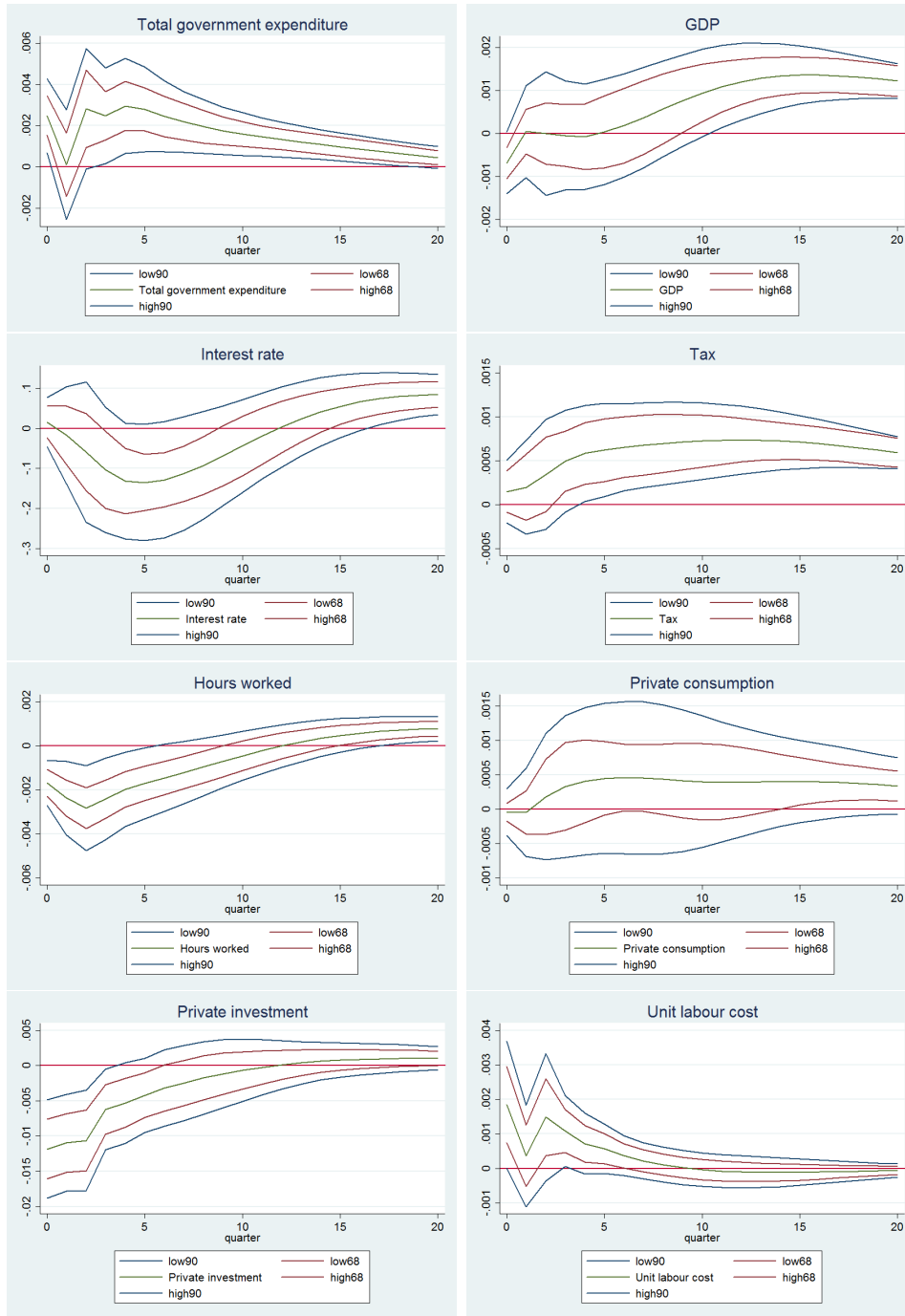


Figure 2.5: VAR with defence news variable

there are real data for 16 categories of consumption. Again as the real data are chain volume, I cannot add up real data for the components of consumption. So I use nominal data which I can add up. I divide the 16 consumption categories into two major

categories ‘durable consumption’ and ‘non-durable and services consumption’. For this categorization I follow the definition of BEA.<sup>19</sup> I use the variable ‘durable consumption to GDP ratio’ and ‘non-durable and services consumption to GDP ratio’ in the VAR. At the 68 percent confidence level the impact response of durable consumption is significantly negative. It is significantly negative at the 90 percent confidence level after three quarters. The ratio of ‘non-durable and services consumption to GDP’ is significantly positive. Ramey (2011) obtains a positive response on services consumption for her news variable based on newspaper sources. The responses of durable and ‘non-durable and services consumption’ are shown in Figure 2.6.

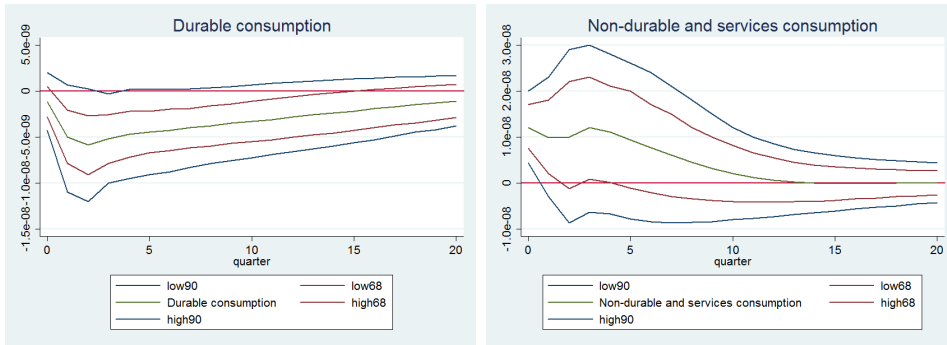


Figure 2.6: VAR with defence news variable

The initial response of the interest rate is not significantly different from zero and becomes significantly negative within four quarters. Since the interest rate does not increase, this makes the discounted future wage more attractive implying that the household is willing to work less today than tomorrow. This is the inter-temporal substitution effect. Hence the theoretical explanation is consistent with the predictions of neoclassical theory. In the neoclassical model the interest rate increases after the increase of government expenditure. This happens as labour supply increases and that raises the marginal productivity of capital. Here, due to the real wage increase, labour supply does not increase so the impact on the interest rate is not significantly positive. The initial response of 90-days bank accepted bill is not significantly different from zero, then it is significantly negative after three quarters. Ramey (2011) also gets

<sup>19</sup>In the ABS categorization of consumption, there are two components such as ‘operation of vehicles’ and ‘hotels, cafes and restaurants’ which include both non-durable and services consumption. So it is not possible to show separately non-durable consumption and services consumption.

similar results for the three-month Treasury bill rate with her news variable based on newspaper sources.

My results are similar to Ramey (2011) data (1981:3-2008:4) where she uses the news variable ‘professional forecast errors’ and obtains contractionary effect of government expenditure shocks. In brief, my result is similar to Ramey (2011) for a shorter time period. Her results from the longer time period (1939-2008) are mostly driven by the World War II and Korean War.

### **2.6.1 Other Variation and Robustness**

Figures 2.5 and 2.6 show the results using hours worked as the sixth variable of VAR ordering. When I use other variables such as consumption as the sixth variable, the IRF of the fixed variables does not change much. Now I am discussing the results of different specifications. I run the VAR including all the variables together rather than rotating. No difference arises in the initial responses. Results are shown in Figure A.2. In another specification, I change the number of variables to only three fixed variables, these are the news variable, total government expenditure, GDP and by rotation other variables. So the VAR does not contain an interest rate and the average tax variable, i.e. do not control for monetary and tax policy. The results show that response of GDP is significantly negative at the 90 percent level of significance. It also demonstrates that the response of consumption is not significantly different from zero up to five years. The response of the private investment is not significantly different from zero. I do another experiment by segregating total government expenditure into its two major components, government consumption expenditure and investment expenditure (i.e. gross fixed capital formation). I run the VAR with the ordering, defence news variable, government consumption expenditure, government investment expenditure and then other similar ordering. Results are shown in Figure A.3. By segregating, the responses of these two components of government expenditure are not significantly positive. All other results are unchanged. In short the results are robust, i.e. government expenditure shock has a contractionary impact on the economy.

The tax variable used in the VAR consists only of the average income tax rate. It does not include movements of other tax rates such as consumption taxes and corporate

income taxes. So we do not know whether total revenue of the government decreases or increases. So I run a VAR with another specification. I take the ratio of total nominal tax revenue of the government to the nominal GDP. The result is the same. All these results of this section and previous sections establish similar conclusions. A positive government expenditure shock creates a recessionary pressure. Households react in a way that resources will be shifted from one sector to another sector of the economy. This transformation may create the recession.

### **2.6.2 Results without News Variable**

From previous literature such as Ramey (2011) and Perotti (2005), I draw the hypothesis about the IRF of government expenditure. The hypothesis is, if we do not consider news to identify government expenditure shocks (or for a temporary expenditure news shock) highest response of the IRF is at period zero and then the IRF goes down to normal. To enquire into this, I conduct another exercise considering all the variables except the news variable. Results show that at the initial period, the IRF of government expenditure spikes up temporarily and then falls to normal. Partly results are similar to Perotti (2005) for Australia who does not consider timing of the news of government expenditure in his SVAR analysis. He obtains similar response of government expenditure due to government expenditure shock using post-1980 data (1980:1 to 2001:2). GDP response is also similar to Perotti (2005) which is significantly positive on impact. Results are shown in Figure A.4. The response of GDP with standard VAR shows different results when the timing of the news of government expenditure is not considered. Response of GDP is significantly positive at the 90 percent level of significance. Responses of hours worked, unit labour cost and consumption are not significantly different from zero. Overall, the results are not informative.

### **2.6.3 Including Externally Affected Variables**

As Australia is a relatively small open economy, it is imperative to investigate the robustness of the results by including some foreign or external variables. During the time period I consider, economies are more open than at the time of the Korean or Vietnam wars. Considering my identification method, it is difficult to set up an open economy structure in the VAR model. In a ‘block recursive’ method it is possible to

include the foreign variables in the first block and keep the domestic variables in the second block and run the VAR or SVAR (See also Dungey and Pagan, 2000). Here due to the existence of the news variable, it is difficult to define the location of externally affected variables in the VAR. However, first I place two externally affected variables followed by the news variable and then put the domestic variables in order. Terms of trade and GNE (gross national expenditure) are some externally affected variables that I can use.<sup>20</sup> In the VAR, after the news variable I include terms of trade and GNE and then other domestic variables in the same order as section-2.6. Results are shown in Figure A.5. There is no difference in the results; responses of terms of trade and GNE are significantly negative. External influences leave the VAR results unchanged.

## 2.7 Comparison Between Australia and the US

### 2.7.1 Comparison with the US with Recent Data

Here I compare VAR results using the post-1980 data for Australia and the US using the news variable based on newspaper sources. Although Ramey (2011) shows her results using different data ranges such as excluding World War II or excluding the Korean War, she does not do the experiment with her post-1980 data for her news variable based on newspaper sources. As in the data for Australia, which includes two big defence news shocks (Defence White Paper 2000 and Defence White Paper 2009; see also section 2.5), US data are chosen in such a way that includes at least two big shocks. Data range is chosen 1980:1 to 2008:4 for the US that includes (1) the Carter-Reagan Buildup and (2) the 9/11.

I run the VAR with aggregate variables. For example, instead of three different components of consumption I employ total consumption and total private investment.<sup>21</sup> As the number of observations in the Ramey (2011) dataset is reduced here for analysis, instead of four lags (that Ramey used in her calculation), I choose two lags. My choice of lags is tested by the AIC and BIC. Impulse response results with the US data are

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<sup>20</sup>GNE is equal to GDP - net exports.

<sup>21</sup>Ramey (2011) segregates consumption in durable, non-durable and services consumption. She also segregates investment in residential and non-residential investment. In the VAR I consider total consumption and total investment.

largely similar. These results are shown in Figure 2.7. The impact response of government expenditure is significantly positive although the response is not hump shaped. Initially the response of GDP is insignificant and within the second quarter it becomes significantly negative. The IRFs of hours worked and consumption are falling.

In brief, Australia and the US show largely contractionary impulse responses for a government expenditure shock, where the news variable is based on newspaper sources. It shows the co-movement of all the major macro variables in these two countries.

### **2.7.2 Some Insights on Contractionary Responses**

In this subsection I want to give some insights on the contractionary responses of government expenditure shocks. So far contractionary responses are seen not only in the results of this chapter but also in some other studies such as Ramey (2011) and Perotti (2005). One common thing between these experiments is that the data are post-1980. On the other hand expansionary results are obtained with long time series such as Ramey (2011) from 1939:1 to 2008:4. Perotti (2005) mentions some reasons behind the contractionary effects of government spending in the post-1980 period. Here I present some insights from the volatility and correlation of the cyclical components of the data. Table 2.2 shows that volatility of US total government expenditure and defence expenditure decreases over time. Another feature is that the volatility of US government expenditure is around 50 percent of that for defence expenditure. As defence expenditure is part of total government expenditure, it has greater contribution than the non-defence expenditure for the volatility of total government expenditure. Again with post-1980 data, the correlation of total government expenditure or defence expenditure with GDP decreases or is negative.

A similar relationship is seen with Australian data. Table 2.3 shows the results for Australia. Quarterly data for Australia are considered from 1959 to 2009. Here also volatility is lower for the post-1980 to 2009 data compared to the larger data range 1959-2009. Also volatility of defence expenditure is around three times higher than for total government expenditure. During 1984:3 to 2009:2 the correlation of total government expenditure or defence expenditure with GDP is negative. These tables are shown here as evidence that the volatility of government expenditure and



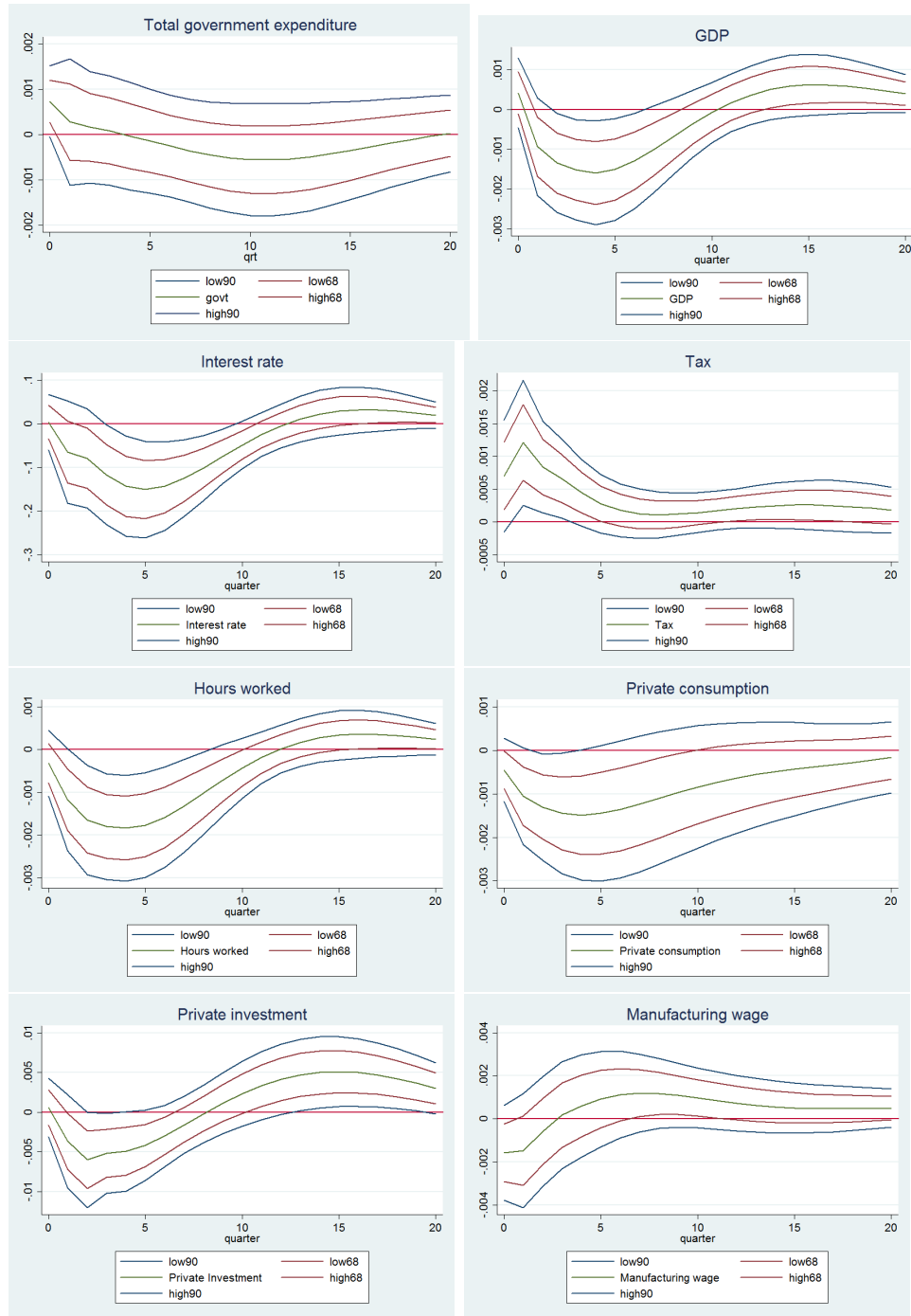


Figure 2.7: VAR with Ramey data 1980:1 to 2008:4

defence expenditure are lower for the more recent dataset. This also can explain the low multiplier values in my calculation. Again negative correlation between GDP and government expenditure is the cause of the negative cumulative multiplier in the initial

Table 2.2: History of the relationship between per capita GDP and government expenditure in the US (HP-filtered, quarterly)

Volatility	1939-2008	1947-2008	1960-2008	1980-2008
Government Expenditure	0.137	0.067	0.016	0.011
Defence Expenditure	0.209	0.116	0.034	0.021
Correlation with GDP	-	-	-	-
Government Expenditure	0.784	0.491	0.078	0.061
Defence Expenditure	0.725	0.483	-0.071	-0.181

Table 2.3: History of the relationship between per capita GDP and government expenditure in Australia (HP-filtered, quarterly)

Volatility	1959-2009	1984-2009
Government expenditure	0.024	0.02
Defence expenditure	0.060	0.048
Correlation with GDP	-	-
Government expenditure	-0.035	-0.039
Defence expenditure	-0.001	-0.037

year.

## 2.8 Conclusion

In this chapter, I have applied the Ramey (2011) method of identifying government expenditure shocks in Australia. In a nutshell, my results show a contractionary impact on the economy for positive government expenditure shocks, when the shocks are created considering the timing of the announcement of government expenditure. Ramey (2011) shows an expansionary impact on the economy for positive government expenditure shocks with a large sample 1939:1 to 2008:4 for the US. She also shows neoclassical predictions on consumption and hours worked. For a better comparison with Ramey (2011), I run a VAR with her news variable based on newspaper sources considering a smaller sample 1980:1 to 2008:4 for the US and I obtain a contractionary impact on the economy for a positive government expenditure shock.

# Chapter 3

## Productivity, Taxes and the Australian Business Cycle

### Abstract

From 1993 Australia experienced an above average growth rate of output per working-age person. During 1993-2004, the average annual growth rate of output per working-age person of the Australian economy was higher than the US (2.63 percent versus 1.98 percent). In various studies including the reports/publications of the Productivity Commission of Australia, it is stated that high productivity growth underpinned the high growth rate of output for nearly a decade. The average yearly growth rate of TFP was 2.95 percent. A model with only TFP shocks shows that TFP was the most important factor for the above average growth during 1993-2004. The model predicts a boom in the economy as also reflected in the data. However, this artificial economy predicts a noticeably larger increase in the output per working-age person (average growth 3.09 percent), compared to the data. So I continue the research to enquire into the role of taxes and government expenditure shocks. If the tax and government expenditure shocks are included in the model, then the model does an impressive job of tracking the output per working-age person where model average growth rate is 2.52 percent. The analysis also shows parallel findings to Prescott (2004) that taxes have negative impact on hours worked. All the models that include tax shocks show a lower average yearly increase of hours worked compared to the model without taxes.

“Unlike the experience of the 1950s and 60s, Australia could not be said to have been carried along by any international productivity boom in the 1990s”. Gary Banks, Chairman Productivity Commission (2003).

“Productivity isn’t everything, but in the long run it is almost everything”. Paul Krugman, *The Age of Diminishing Expectations* (1994)

### 3.1 Introduction

What were the determinants of economic growth in Australia in the 1990s and the 2000s? What was the role of productivity on economic growth? Were there any impact of taxes and government expenditure on business cycle fluctuations? Like many other developed countries Australia faced a slowdown in the early 1990s. After the early 1990s recession, Australia enjoyed an above average growth in productivity from 1993 to 2004. During this time period TFP (Total factor productivity) continued to grow on average 2.95 percent. The growth rate of output per working-age person was higher than in the US (2.63 percent versus 1.98 percent). For the first time, Australia’s productivity exceeded the OECD average. In the midst of the Asian crisis in 1997 Australia exhibited strong growth, when Paul Krugman labelled Australia as a ‘miracle’ economy (Banks, 2003). The fact that most other OECD countries did not share this experience suggests that domestic factors must have provided at least a major part of the explanation (Parham, 2004). During the 80s and 90s significant structural reforms happened in Australia that underpinned the high productivity growth during the 1990s. These include liberalization of trade and investment, deregulation of capital markets, more flexible institutional arrangement for labour market and more active domestic competition policy (Parham, 2004). These reforms are also known as the Keating deregulation.

In the analysis I want to find the causes of slowdown and the causes of above average growth during the entire period from 1988-2009. Starting from a simple neoclassical general equilibrium model, I extend the model by including changes in the tax policy and the government expenditure policy. Within the closed economy versions of the model, I analyse the dominant factors of growth in Australia. Also my objective is to find whether the rise in productivity in the 1990s was really a miracle in quantitative

terms. Some argue that the productivity miracle of the 1990s is an artefact of mis-measurement (Hancock, 2005; McKenzie, 2010; Quiggin, 2006). In a broader context, this chapter contributes to recent literature Nimark (2009) and Jääskelä and Nimark (2011) that analyse contribution of different shocks (domestic and international) in the business cycle fluctuations of Australia. Research with the opposite type of objective has been done by Conesa et al. (2007) on Finland and by Kehoe and Ruhl (2003) on Switzerland and New Zealand.<sup>1</sup>

The left figure of Figure 3.1 shows the log of real GDP per working-age person of Australia from 1960-2010. It also shows the trend line (HP-filtered). The figure on the right of Figure 3.1 shows the movements of cyclical components of the data. It shows that after 1991 recession the economy started to grow rapidly. During 1960 to 2010 the economy was above trend at different times with different durations. The longest duration when the Australian economy remained above trend was 1998-2008. Figure

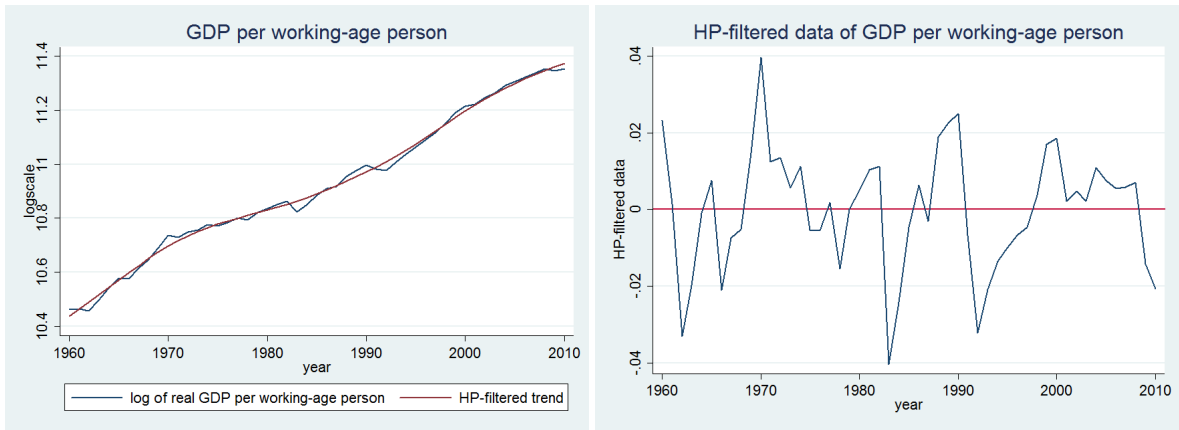


Figure 3.1: Movements of log GDP per working age person and HP-trend, Australia

3.2 shows the comparison between Australia and the US GDP and the GDP growth rates. In the left figure of Figure 3.2, the two vertical red lines are 1993 and 2004. During the time period 1993-2004 the growth rate in Australia (average 2.63 percent) was higher than the United States' (average 1.98 percent) most of the time. It is of interest to find the factors of above average growth during this time period. The figure on the right of Figure 3.2 shows the GDP per working-age person of Australia and the

<sup>1</sup>My objective is to explain the boom while their objective was to explain recent great depressions in the 1990s.

Table 3.1: Decade-wise growth rate (output per working-age person)

Year	1961-70	1971-80	1981-90	1991-2000	2001-09
Average growth rate (%)	2.75	0.98	1.61	2.19	1.38

US. The base year set at a value of 100 is 1960 in the figure on the right-hand-side. During the time period 1993-2004, the GDP per working-age person in the US was always higher than Australia, but if we look at the gap between the two lines from 1991 onwards, we see that the difference is reducing and in 2009 Australian GDP per working-age person is exceeding the US.

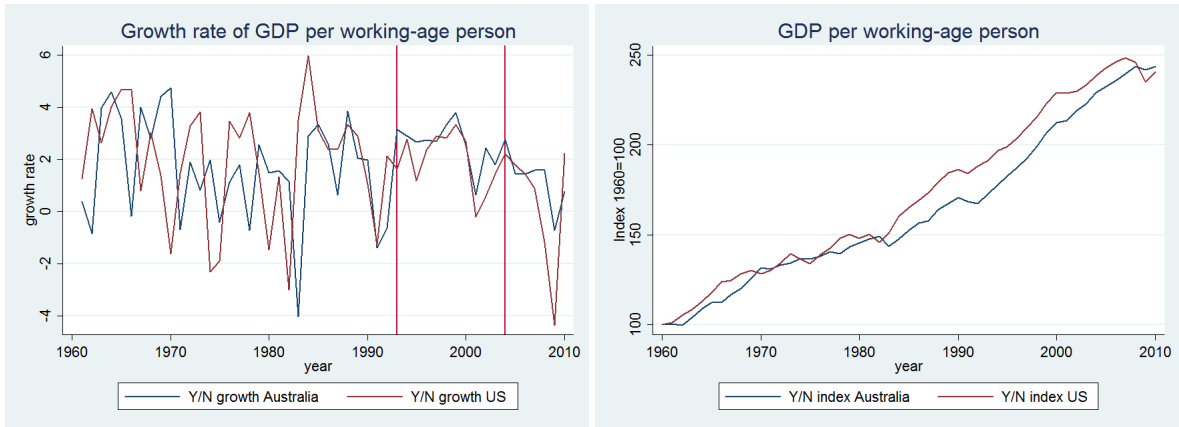


Figure 3.2: Australia and US growth comparison

*Note:* Y is GDP and N is working-age population, So Y/N is GDP per working-age person.

I also present here two tables regarding the average growth rates. Table 3.1 shows the decade-wise average growth rates. The 1960s was a decade with a high growth rate (2.75 percent) followed by the 1990s (2.19 percent). In Table 3.2 peak-to-peak growth rates during 1960-2010 are shown. The peak points are chosen from Figure 3.1. Peak-to-peak average growth in 1961-1970 was the highest (2.75 percent) followed by 1990-2000 (2.17 percent). All these information are given here to show that economic growth in the 1990s was comparatively better than the 1970s and 1980s. Also the left figure of Figure 3.2 shows why my point of interest is the period 1993-2004. The reason of choosing this time period will also be explained later in this chapter in Figure-3.3.

In this chapter I explore the determinants of growth in Australia for the time period 1988-2009. My results show that TFP was the most important factor for the above

Table 3.2: Peak-to-peak growth rate (output per working-age person)

Year	1961-70	1970-82	1982-90	1990-2000
Average growth rate (%)	2.75	1.33	1.61	2.17

average growth rate during 1993-2004 compared to other factors of growth such as capital accumulation and hours worked. Growth accounting shows that TFP grew on average 2.95 percent per year and the growth of output per working-age person was 2.63 percent during the time period (1993-2004). Then I do the analysis with TFP shocks in a neoclassical general equilibrium growth model to compare the movements of the output per working-age person from the model and the data. The model predicts a boom in the economy as also reflected in the data. However, the artificial economy predicts a noticeably larger increase in the output per working-age person (3.09 percent), compared to the data. Then I do the analysis to find the impact of tax policy changes in the model with the same TFP shocks. A model with taxes where all tax revenues are transferred back to the household shows a lower average growth (2.46 percent) of the output per working-age person than that of the data. A model with taxes and government expenditure shows an average growth rate of 2.52 percent. The correlation of the output per working-age person between the model and the data is 0.98 when undretended. The analysis also shows parallel findings of Prescott (2004) that taxes have negative impact on hours worked. All the model that include tax shocks shows a lower average increase of hours worked compared to the model without taxes.

In section 2.2, I review the literature relating to the research gap. The methodology is explained in section 2.3. Section 2.4 presents closed economy versions of the model including tax rates and government in the model. Section 2.5 presents a quantitative comparison of different model versions. Lastly, some concluding remarks are provided.

## 3.2 Literature Review

Productivity has been an important issue for Australia during the period 1988-2009. In various studies including the publications/reports of the Productivity Commission of Australia, it is stated that productivity growth was above average during the 1990s in Australia. Australia's productivity growth performance has been at least three phases

in the second half of the 20th century. The first phase is from 1950 to 1970 which is called the long boom period or the ‘Golden Age’ period. The second phase continued up to the early 1990s which was a slow growth phase. Then again Australia went through a high productivity growth phase called the ‘miracle’ phase when GDP growth averaged just under four percent annually (Parham, 2002). This growth was mostly due to productivity growth. In 1990s productivity continuously increased for nine years. For the first time Australia’s productivity growth exceeded the OECD average.

There was a difference between the Golden Age (1950-1970) phase and the productivity ‘miracle’ phase.<sup>2</sup> In the former most of the developed countries had high growth while in the later growth is an exclusive performance of Australia. Australia’s economic performance in the 1990s stems from high competitive pressure from the removal of tariff barriers and low level of regulation (Bean, 2000). Bean (2000) analyses the macroeconomic performance and labour market of OECD countries. He finds that Australia’s productivity performance in the 1990s was based on key reform activities. Basically, these are a reduction in tariff barriers, greater decentralization in wage setting and industrial relations, the ending of anti-competition legislation, a more vigorous application of competition policy and greater commercial pressure on government business enterprises. Parham (2004) states that labour and multifactor productivity growth reached record highs in the 1990s. This shifted the economy away from its traditional reliance on factor accumulation as a source of growth. Parham (2004) states that Australia’s productivity growth in the 1990s was due to the contribution of three factors namely, increased openness (50 percent), domestic R & D (three-tenths) and ICT related innovation (two-tenths). McLean (2010) states that the negative shocks of 1970s accelerated the policy changes in the 1980s that helped to achieve a high growth rate in the 1990s.

Some studies focus on the slowdown of productivity growth after the early 2000s. Dolman (2009) finds that the cause of the productivity slowdown in 2000s was due largely (almost 50 percent) to unusual developments in the mining industry, the effects

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<sup>2</sup>Note that although the productivity boom of the 1990s is mentioned as a ‘miracle’ in some studies such as Parham (2002), in this chapter I refer to this as an above average growth phase.



of drought and the overstatement of productivity growth in the 1990s. Some other key reasons are slower technological change, unmeasured decline in labour quality, diminishing effects of past reforms and increasing profitability of Australian firms.

None of the literature above uses a dynamic general equilibrium model to explain the role of productivity during the above average growth phase of output per working-age person. The literature, particularly that of Nimark (2009), Jääskelä and Nimark (2011) analyses the impact of different shocks (domestic and international) on the Australian economy. Jääskelä and Nimark (2011) analyses the impact of different shocks to the business cycle fluctuations in Australia. They estimate a new Keynesian open economy DSGE (Dynamic stochastic general equilibrium) model with a sizeable number of frictions and rigidities, using the Bayesian technique. They do the variance decomposition of five major shocks. These are technology shocks, supply shocks, domestic demand shocks, foreign shocks and monetary shocks. They conclude that both domestic and foreign shocks are important drivers of the Australian business cycle. Their data range is 1993:2 to 2007:3. They also find that technology shocks are important but not the most important: 30 percent of the variance of non-farm GDP growth, 26 percent of the variance of consumption and 20 percent of the variance of investment are explained by technology shocks. In their analysis foreign shocks are the most important for the business cycle fluctuations. Nimark (2009) also does similar type of analysis using the Bayesian technique. He finds that an unit shock to Australian productivity increases GDP, inflation falls and nominal exchange rate appreciates. His data range is 1991:1 to 2006:2.

In this chapter the analysis using a dynamic general equilibrium model is closely related to Conesa et al. (2007), who have done a comprehensive study on the Finland depression of the early 1990s. Their analysis begins with a simple neoclassical growth model with TFP shocks to check the model's predictability of the actual movements of the output per working-age person. Then they extend the analysis with several versions of the model including different types of shocks. To find the impact of tax policy changes or tax policy shocks, they include labour, capital and consumption taxes in the model. They further extend the model by incorporating the relative price approach where there are two sectors in the economy: investment and consumption sectors.

Lastly they analyse with an open economy version of the model that includes terms of trade shocks. With the dynamic general equilibrium model they find that the drop in GDP during 1990-93 in Finland was driven by a combination of a drop in TFP during 1990-92 and increases in taxes on labour and consumption and increases in government consumption during 1989-94. They use the great depressions methodology developed by Cole and Ohanian (1999) and Kehoe and Prescott (2002). Another paper on recent depression is Kehoe and Ruhl (2003) on New Zealand and Switzerland. Although in the 50s and 60s the GDP growth rates of New Zealand and Switzerland were higher than the US trend growth rate of 2 percent, after 1973 GDP per working-age person was below trend in both countries (cumulative 30 percent below the trend growth path). They show that a calibrated dynamic general equilibrium model with TFP shocks can explain most of the decline in output in both of these countries.

Conesa and Kehoe (2005) analyse the driving force of output growth and fluctuations in Spain for three decades (1970-2000). They emphasize the impact of tax rate changes on output fluctuations. Their finding reveals that with exogenously given tax rates, a neoclassical growth model can explain the labour market fluctuations. There are a number of researchers who have looked at depressions during the 1980s and 1990s which are not specifically reviewed here.<sup>3</sup>

### **3.2.1 Research Gap**

This research contributes to the literature in several ways. Firstly, in various studies including the publications/reports by the Productivity Commission of Australia, it is stated that productivity growth was above average during the 1990s in Australia which ensured above average growth of output per working-age person. Some studies dispute the notion that productivity growth was above average. Although there is debate on the issue of the role of productivity, no research has been done so far on Australia, using a dynamic general equilibrium model to explain the cause of above average growth of output per working-age person. Hence, this research will contribute to the ongoing debate on the role of productivity during the 1990s. Secondly, this analysis uses several versions of the model including the role of the tax policy changes

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<sup>3</sup>These include Kydland et al. (2007) on Argentina; Bergoing et al. (2007) on Mexico and Chile; Hayashi and Prescott (2002) on Japan; Bugarin et al. (2007) on Brazil; and Kehoe (2007) on Argentina.

in Australia. In this regard, I calculate consumption, labour and capital tax rates for Australia which is a new contribution to the literature. Both average and marginal tax rates are calculated, following Mendoza et al. (1994).

### 3.3 Methodology

The methodology is based on growth accounting and the neoclassical dynamic general equilibrium model developed by Cole and Ohanian (2001) and Kehoe and Prescott (2002). There are three steps in the method (Dalton, 2008). Firstly, growth accounting quantifies the contributions of total factor productivity (TFP), capital and aggregate hours worked for the growth of output per working-age person. Secondly, the neoclassical growth model serves as a theoretical framework for understanding the dynamics of the economy. Thirdly, the growth model is calibrated and used to conduct numerical experiments. In the numerical experiment actual data are compared with the model data. The model is solved with the Newton method.

At first I test the model with only TFP shocks. Other than TFP I also include the data for the working-age population and hours endowment as inputs of the programme for solving the model. Next, I analyse the model with taxes and transfers and also the model with taxes and government expenditure. In these variations of the model I include consumption, labour and capital tax rates and government expenditure. I calibrate all the parameter values from the data. Initial capital stock is also given in the model from the data. Details of the solution method is given in Conesa et al. (2007) which is also rewritten here in Appendix B.3.

### 3.4 Closed Economy Dynamic General Equilibrium Models

Here I assume Australia is a closed economy and particularly look at the shocks to the TFP. In the following sections I also do the analyses to show the impacts of tax rates and government expenditures.

### 3.4.1 Base Case Model

The model analyses the role of TFP shocks in a simple neoclassical dynamic general equilibrium model.

#### Model

A representative household chooses paths of consumption, leisure and investment to maximize utility. Following is the household utility function.

$$\sum_{t=T_0}^{\infty} \beta^t (\gamma \log C_t + (1 - \gamma) \log(\bar{h}N_t - L_t)) \quad (3.4.1)$$

subject to the budget constraint

$$C_t + K_{t+1} = w_t L_t + (1 - \delta + r_t) K_t \quad (3.4.2)$$

where  $C_t \geq 0$  and  $I_t = K_{t+1} - (1 - \delta)K_t$ . Initial capital stock  $\bar{K}_{T_0}$  is given. In the utility function parameter  $\beta$  is the discount factor where  $0 < \beta < 1$ .  $\gamma$  is the consumption share where  $0 < \gamma < 1$ .  $C_t$  is consumption,  $K_t$  is the capital stock,  $I_t$  is investment,  $L_t$  is the hours worked,  $w_t$  is the wage rate,  $r_t$  is the rental rate and  $\delta$  is the depreciation rate, where  $0 < \delta < 1$ . The total number of hours available for work is  $\bar{h}N_t$ , where  $N_t$  is the working age population and  $\bar{h}$  is the number of hours available. Following Conesa et al. (2007) and Kehoe and Ruhl (2003), I also assume  $\bar{h}$  is equal to 100. The unit of time is one year i.e. 52 weeks. Firms operate in a perfectly competitive market and technology has constant returns to scale. The production function is Cobb-Douglas.

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (3.4.3)$$

where  $Y_t$  denotes total output,  $A_t$  denotes TFP, and  $\alpha$  is capital share, where  $0 < \alpha < 1$ . In a competitive market firms earn zero profit and minimize costs. So the factor price equations can be expressed as,

$$w_t = (1 - \alpha) A_t K_t^\alpha L_t^{-\alpha} \quad (3.4.4)$$

$$r_t = \alpha A_t K_t^{\alpha-1} L_t^{1-\alpha} \quad (3.4.5)$$

In this base case model output is divided between consumption and investment. The feasibility constraint is

$$C_t + K_{t+1} - (1 - \delta)K_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (3.4.6)$$

In this numerical experiment growth accounting is based on Hayashi and Prescott (2002). It is assumed here that TFP and working age-population grow at constant rates,

$$A_{t+1} = g^{1-\alpha} A_t \quad (3.4.7)$$

$$N_{t+1} = nN_t \quad (3.4.8)$$

where  $g^{1-\alpha} - 1$  is the growth rate of TFP and  $n - 1$  is growth rate of population. Then there is a balanced-growth path where capital-output ratio and hours worked per working-age person are constant and output per working-age person grows at the rate  $g - 1$ .

**Definition of equilibrium:** Given sequence of productivity,  $A_t$ , and working-age population,  $N_t, t = T_0, T_0 + 1, \dots$ , and the initial capital stock,  $\bar{K}_{T_0}$ , an equilibrium is the sequence of wages  $w_t$ , interest rate  $r_t$ , consumption  $C_t$ , labour  $L_t$  and capital stock  $K_t$ , such that

- given the wages and interest rates, the representative household chooses consumption, labour and capital to maximize the utility function (3.4.1) subject to the budget constraint (3.4.2), appropriate non-negativity constraints, and the constraint on  $\bar{K}_{T_0}$ .
- the wages and interest rates, together with the firm choices of labour and capital, satisfy the cost minimization and zero profit condition (3.4.4) and (3.4.5) and
- consumption, labour and capital satisfy the feasibility condition (3.4.6).

Next I derive the first order conditions (FOCs) of the household problem of maximizing the utility function (3.4.1) subject to the budget constraint (3.4.2) and obtain,

$$w_t(\bar{h}N_t - L_t) = \frac{1 - \gamma}{\gamma} \quad (3.4.9)$$

$$\frac{C_{t+1}}{C_t} = \beta(1 - \delta + r_{t+1}) \quad (3.4.10)$$

Now the artificial economy has household's optimality conditions (3.4.9) and (3.4.10), the firm optimality conditions (3.4.4) and (3.4.5) and the feasibility condition (3.4.6). Combining these equations, we can specify a system of equations that can be solved to

find the equilibrium of the model.

Here I explain the way of calculating balanced-growth path before explaining the equilibrium path.

**Definition of balanced-growth path:** Suppose that productivity,  $A_t$ , grows at the constant rate  $g^{1-\alpha} - 1$  and that working-age population grows at the constant rate  $n - 1$ , then a balanced-growth path is levels of the wage  $\hat{w}$ , rent  $\hat{r}$ , consumption  $\hat{C}$ , labour  $\hat{L}$ , capital stock,  $\hat{K}$ , and output,  $\hat{Y}$ , such that  $w_t = g^{t-T_0}\hat{w}$ ,  $r_t = \hat{r}$ ,  $C_t = (gn)^{t-T_0}\hat{C}$ ,  $L_t = n^{t-T_0}\hat{L}$ ,  $K_t = (gn)^{t-T_0}\hat{K}$ ,  $Y_t = (gn)^{t-T_0}\hat{Y}$  satisfy the conditions for an equilibrium when the initial capital stock is  $K_{T_0} = \hat{K}$ . To solve the balanced-growth path, I use (3.4.5) and (3.4.10) to solve for the capital-output ratio  $\hat{K}/\hat{Y}$ .

$$g = \beta(1 + \alpha \frac{\hat{Y}}{\hat{K}} - \delta) \quad (3.4.11)$$

Then use (3.4.4) and (3.4.6) to rewrite (3.4.9) as

$$(1 - \alpha)(\bar{h} \frac{N_{T_0}}{\hat{L}} - 1) = \frac{1 - \gamma}{\gamma}(1 - (gn - 1 + \delta) \frac{\hat{Y}}{\hat{K}}) \quad (3.4.12)$$

and use this equation to calculate  $\hat{L}$ . Then I use production function (3.4.3) to solve for  $\hat{K}$  and  $\hat{Y}$ . Using the feasibility condition (3.4.6), I can solve for  $\hat{C}$  and using firm optimality conditions (3.4.4) and (3.4.5), I can solve for  $\hat{w}$  and  $\hat{r}$ .

Now to derive the equilibrium path, I plug the prices (3.4.4) and (3.4.5) into the household's optimality conditions (3.4.9) and (3.4.10) and using the (3.4.6), I obtain the following system of equations,

$$(1 - \alpha)A_t K_t^\alpha L_t^{-\alpha} (\bar{h} N_t - L_t) = \frac{1 - \gamma}{\gamma} C_t, t = T_0, T_0 + 1, \dots, T_1 \quad (3.4.13)$$

$$\frac{C_{t+1}}{C_t} = \beta(1 - \delta + \alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^\alpha), t = T_0, T_0 + 1, \dots, T_1 - 1 \quad (3.4.14)$$

$$C_t + K_{t+1} - (1 - \delta)K_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (3.4.15)$$

and the transversality condition,

$$\lim_{t \rightarrow \infty} \beta^t \frac{\gamma K_{t+1}}{C_t} = 0 \quad (3.4.16)$$

System of equations (3.4.13), (3.4.14) and (3.4.15) involves an infinite number of equations and unknowns. To make the computation of equilibrium tractable, it is assumed here that the economy converges to the balanced-growth path at some date  $T_1$ . Using the feasibility condition (3.4.15) to solve for  $C_t$ , equations could be rearranged as,

$$(1 - \alpha)A_t K_t^\alpha L_t^{1-\alpha} (\bar{h}N_t - L_t) = \frac{1 - \gamma}{\gamma} (A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1 - \delta)K_t), t = T_0, T_0 + 1, \dots, T_1 \quad (3.4.17)$$

$$\frac{(A_{t+1} K_{t+1}^\alpha L_{t+1}^{1-\alpha} - K_{t+2} + (1 - \delta)K_{t+1})}{(A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1 - \delta)K_t)} = \beta(1 - \delta + \alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha}), t = T_0, T_0 + 1, \dots, T_1 - 1 \quad (3.4.18)$$

The solution of the system of equations may involve a negative value of investment in some periods. Then the equation (3.4.18) is replaced by the following equation,

$$K_{t+1} = (1 - \delta)K_t \quad (3.4.19)$$

Conesa et al. (2007) follow a guess and verify approach. For the guess that investment in period  $t$  be 0 to be correct, the condition corresponding to (3.4.10) and (3.4.18),

$$\frac{(A_{t+1} K_{t+1}^\alpha L_{t+1}^{1-\alpha} - K_{t+2} + (1 - \delta)K_{t+1})}{(A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1 - \delta)K_t)} \geq \beta(1 - \delta + \alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha}) \quad (3.4.20)$$

must hold with inequality.

## Base Case Data Description and Calibration

Most of the data are taken from the ABS and OECD databases. Conesa et al. (2007) use data from the OECD and analyse the depression of Finland (1989-93). In the growth accounting calculation, they segregate GDP into two components, private consumption and investment. They include government expenditure and net exports in consumption. There are several strategies in this regard. One strategy in the literature is to sum up only private consumption and private investment and define the sum as the GDP. This GDP does not include government expenditure and net exports. Another strategy by Kehoe and Prescott (2002, 2007) is to consider the actual GDP and allocate government consumption and net exports either to consumption or to investment. The most frequently followed strategy in Kehoe and Prescott (2002, 2007) is to allocate both categories to consumption. Hayashi and Prescott (2002, 2007) include

government consumption in consumption and net exports in investment. They consider GNP (gross national product) rather than GDP.<sup>4</sup>

Here I follow the strategy followed by Kehoe and Prescott (2002, 2007) defining consumption as the sum of private consumption, government consumption and net exports. In the investment I include both private investment and public investment. In the National accounts data of the ABS, other than consumption, investment, government expenditure and net exports there are two small components of GDP which are ‘change in inventories’ and ‘statistical discrepancy’. I include the ‘change in inventories’ in investment and the ‘statistical discrepancy’ in consumption in my calculation. Following Conesa et al. (2007), the depreciation rate and the initial capital stock are derived. First I get the investment series deflated by GDP deflator. Then with the equation of the evolution of capital,

$$K_{t+1} = (1 - \delta)K_t + I_t \quad (3.4.21)$$

and with the following two constraints

$$(1/22) \sum_{t=1988}^{2009} \frac{\delta K_t}{Y_t} = \text{depreciation to GDP ratio} \quad (3.4.22)$$

$$\frac{K_{1960}}{Y_{1960}} = 1/15 \sum_{t=1961}^{1975} \frac{K_t}{Y_t} \quad (3.4.23)$$

I derive the sequence of capital stock and the depreciation rate  $\delta$  so that the capital-output ratio of 1960 matches its average for 1961-75.<sup>5</sup> After solving the system of equations (3.4.21), (3.4.22) and (3.4.23), I calibrate  $\delta$  as 0.0516. The initial capital stock is the capital stock of 1988. ABS has capital stock series but I am following here Kehoe and Ruhl (2003), Conesa et al. (2007) method which is suitable for analytical purposes. For example, in the model  $\delta$  is constant. Now, if both the capital stock and investment series are taken from the ABS and I calculate  $\delta$  using (3.4.21), then it will not remain constant.

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<sup>4</sup>GNP includes the foreign income of domestic residents to GDP and deducts the income within the country of foreign residents.

<sup>5</sup>See Conesa et al. (2007) for detail.



I compute  $\beta$  for each period using equation (3.4.14) and take the average of 1985-1990. That is, I calibrate household behaviour to a period outside that in which I am interested i.e. 1993-2004 following Conesa et al. (2007).  $\gamma$  is calibrated in the same way taking the average of the period 1985-1990 using equation (3.4.13).  $\beta$  and  $\gamma$  are calibrated as 0.9720 and 0.2581 respectively. Then I need to calibrate labour share. In this chapter I calculate labour share following McDaniel (2007). Here labour share is calculated as,

$$(1 - \alpha) = \frac{W}{GDP - (TPI - Sub) - MI} \quad (3.4.24)$$

where  $W$  is compensation of employees,  $TPI$  is taxes on production and imports,  $Sub$  is subsidy and  $MI$  is mixed income. I calibrate the value of  $\alpha$  as 0.3844.

I choose  $T_1$  such that  $T_1 - T_0$  is large (here 60), so I am solving the model over the period 1988-2047. Then I construct the series of exogenous variables (TFP, working-age population and hours endowment). The values for 1988-2009 are as they are in the data. The numbers for 2010-47 are constructed. To do this, following Conesa et al. (2007) I use a constant growth rate after 2009 for the next 38 years up to 2047.<sup>6</sup> The large dataset is used to show that outside the period of consideration (1988-2009) the economy gradually converges to a balanced-growth path. The working-age population series and hours endowment series for the period 2010-2047 are calculated using the average growth rates as follows. The working-age population series (2010-2047) is calculated using the average population growth rate between 1988-2009 (1.014). Conesa et al. (2007) follow a different way to construct their population series after their actual data that ends at 2005. For setting a constant growth rate of the working-age population for 2006-40 they take the growth rate calculated in the last two periods of actual data. For example, in this chapter (if I follow them) the working-age population of 2010 is determined by  $N_{2010} = \frac{N_{2009}^2}{N_{2008}}$ . They follow the same procedure to get the values of total hours endowment up to 2047. If I follow their procedure then working-age population growth parameter is 1.021 in 2010 which is a high rate (2.1 percent) compared with the average working-age population growth rate 1.014 (or 1.4 percent) and the high rate may not be representative for Australia. According to the ABS in

<sup>6</sup>To create TFP series for 2010-2047, I multiply with the average geometric growth rate of TFP between 1988-2009. For example,  $TFP_{2010} = TFP_{2009} * averagegeometricgrowthrate$ . I assume that people are aware of the TFP growth during the entire period. For the base case model it is 1.01035

30 June 2011 the total population growth was 1.4 percent. Finally, I use the average growth rate of the working-age population in my numerical experiment. With the calculated capital stock series and the hours worked from the ABS data, I estimate the TFP series with the following equation.

$$A_t = \frac{Y_t}{K_t^\alpha L_t^{1-\alpha}} \quad (3.4.25)$$

It is of interest to see the difference between my calculated TFP and the productivity estimate of the ABS which is called the multifactor productivity. This is shown in Figure B.1 in Appendix B.4. Figure B.1 shows the value added measure of the multifactor productivity of the private sector (The ABS calls it the market sector). In the calculation of TFP in equation (3.4.25) I use the data of capital and labour of the whole economy. Nevertheless, Figure B.1 shows a strong relation between these two productivity series.

Here it is also important to verify the exogeneity of the calculated TFP. The results of an Evans (1992) like test is

$$A_{t+1} = -3.6955 + 1.019A_t - 0.0080\Delta m_t + 0.0006\Delta G_t$$

Here  $A_t$  is TFP,  $\Delta m_t$  is change in M3 (money supply) and  $\Delta G_t$  is change in government expenditure. Results show that except the lag of TFP all other variables are not significant. This proves the exogeneity of TFP.

Using the calibrated  $\alpha$  from (B.2.5) we can check the properties of the balanced-growth path. The production function (3.4.3) can be written in the following way with some rearrangement,

$$\frac{Y_t}{N_t} = A_t^{1/(1-\alpha)} (K_t/Y_t)^{\alpha/(1-\alpha)} (L_t/N_t) \quad (3.4.26)$$

In the balanced-growth path, the growth of  $Y_t/N_t$  is determined by growth in  $A_t^{1/(1-\alpha)}$  and  $(K_t/Y_t)^{\alpha/(1-\alpha)}$  and  $(L_t/N_t)$  are constant. Figure 3.3 shows the properties of the balanced-growth path using Australian data during 1988-2009. After the mid-1990s TFP was always above the output per working-age person until around 2004. Figure 3.3 also shows that TFP growth slowed after 2004 and the line becomes horizontal and

at the same time output per working-age person was increasing. The main focus of this chapter is the role of TFP, so I limit the period 1993-2004 as the period of interest. The hour variable shows a downward trend during the recession of 1991, but soon after it returns to a horizontal trend.

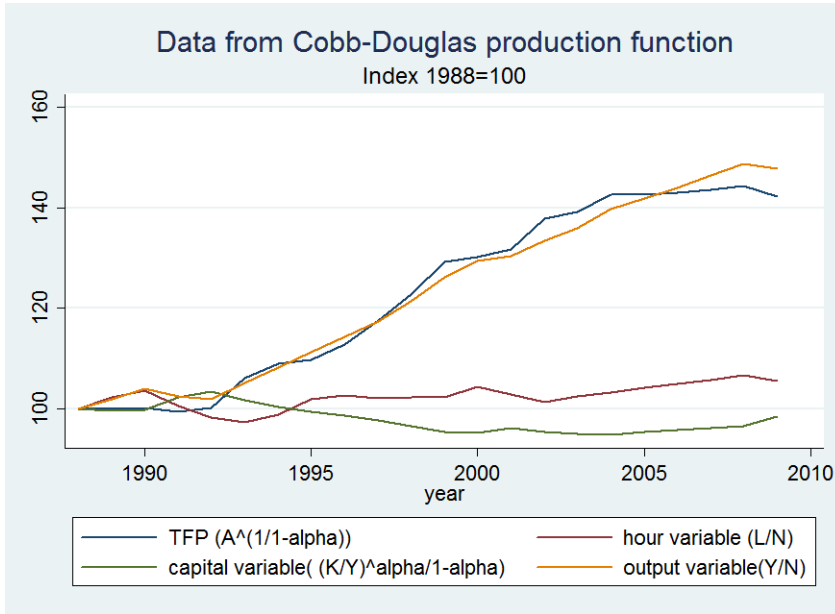


Figure 3.3: Australian data from the Cobb-Douglas production function

## Results

Results of the base case model are presented in Figure 3.4 and Table 3.3. In the figure, output per working-age person is detrended by 2 percent and 1989 is the base year of the index of output per working-age person. In the table the average growth rate of output per working-age person is shown for undetrended data. To calculate the output per working-age person of the model, I follow Conesa et al. (2007).<sup>7</sup> Figure 3.4 and Table 3.3 shows that the model predicts a boom in the economy as also reflected in the data. However, the base case model predict noticeably larger increase of the output per working-age person than actually occurred in Australia during the above average growth period (1993-2004). During this time TFP grew by 2.95 percent per year. The correlation between detrended TFP and output per working-age person

<sup>7</sup>The indexes of the model values are in comparison with the original values. So for the model  $Index_{1988} = \frac{(Y/N)_{model_{1988}}}{(Y/N)_{data_{1989}}}$ , where value in 1989 is set at 100.

(model) is 0.99, so TFP was very important for growth. Hours worked per working-age person contributes lower than the TFP to the above average growth rate of output per working-age person. The model predicts a higher average increase of hours worked 0.5 percent, compared with 0.4 percent in the observed data. The average growth of capital-output ratio is negative for both the model and the data. In brief, the TFP shocks had significant impact on the above average output per working-age person. Further, explanations for the base case model results are given in section 3.5.



Figure 3.4: Comparison between data and Base case model

### Simulation with Constant TFP Growth

A simulation is done with constant TFP growth. If TFP grows at a constant rate, set at the average of 1984-88 which is 1.5 percent, the results are shown in Figure 3.5 and Table 3.3. Here calibration of  $\beta$  and  $\gamma$  and all other parameter values are the same as

the base case model except the TFP growth rate. If TFP had grown at the constant rate of 1.5 percent then there would have been no recession in 1991 and also there would have been steady growth of detrended output per working-age person. During the above average growth period model predicts 2.38 percent growth of output per working-age person per year (See Table 3.3).

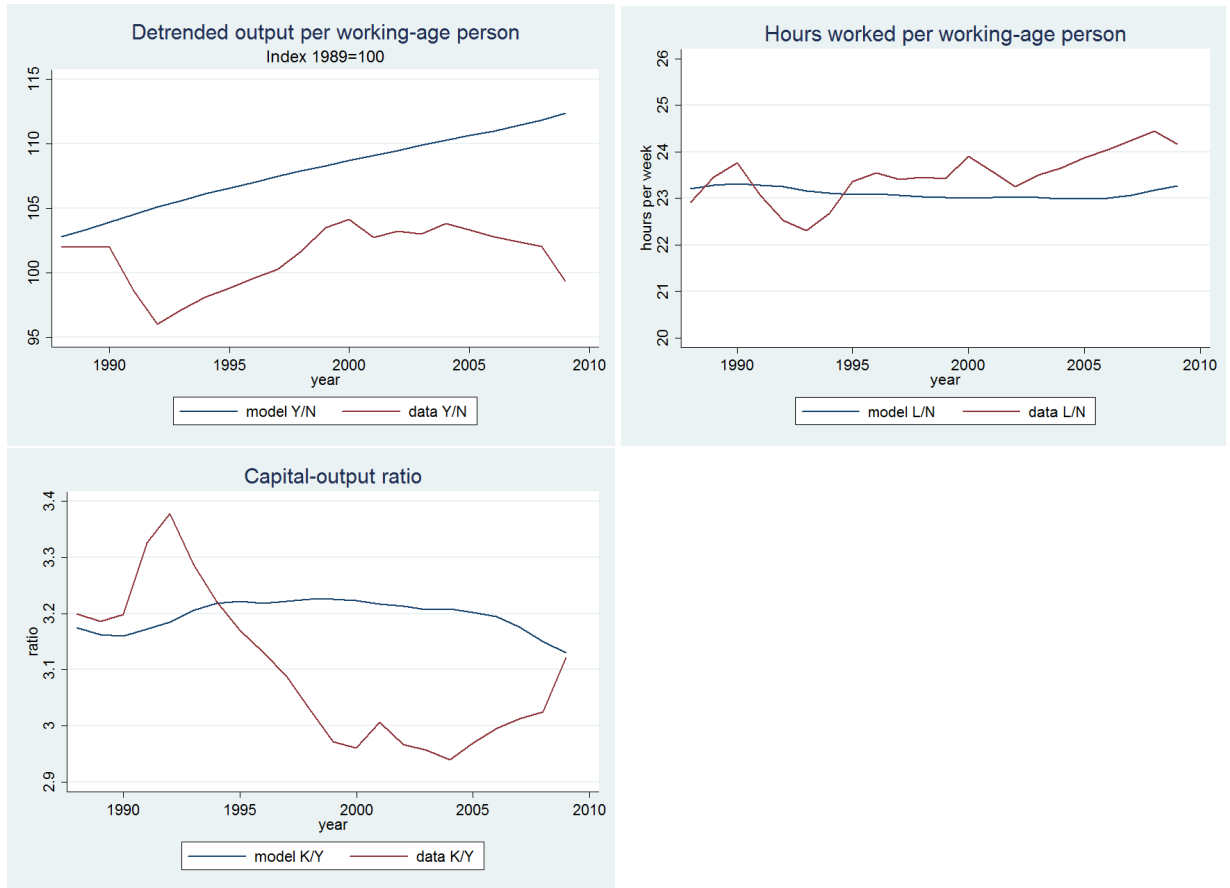


Figure 3.5: Comparison between data and model with constant TFP growth

### 3.4.2 Model with Taxes and Government Expenditure

As the base case model overestimates the output per working-age person, I include more shocks in the model that affect the budget constraint of the household. In this way, I address the impact of taxes and government expenditure shocks in the model. Prescott (2002) and Conesa et al. (2007) have shown that tax rates are important for understanding the fluctuations of output and hours worked. Economics (2006),

Harding et al. (2009) and Hallam and Weber (2008) highlight the impact of tax changes on labour supply in the Australian economy. Figure 3.6 shows the calculated labour, capital and consumption tax rates for Australia. The artificial economy is closely

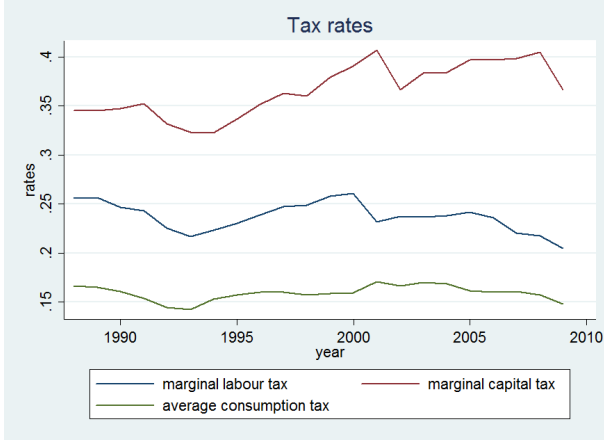


Figure 3.6: Labour, capital and consumption tax rates, Australia

related to Conesa and Kehoe (2005) and Conesa et al. (2007). Two different models are tested here: firstly, the model with taxes and transfers; and secondly, the model with taxes and government expenditure.

## Model

In this economy disposable income of the household is lower than in the base case model as labour income and capital income are reduced by the labour and capital tax, while consumption expenditure increases due to consumption tax. So here, the household budget constraint (3.4.27) is different from the base case model.

$$(1 + \tau_t^c)C_t + K_{t+1} = (1 - \tau_t^l)w_tL_t + (1 + (1 - \tau_t^k)(r_t - \delta))K_t + T_t \quad (3.4.27)$$

Here  $\tau_t^c$  is the tax rate on consumption,  $\tau_t^l$  is the tax rate on labour income and  $\tau_t^k$  is the tax rate on capital income.  $T_t$  is a lump-sum transfer from the government. Now the modified first order conditions are the following,

$$\frac{1 - \gamma}{\gamma} \frac{C_t}{hN_t - L_t} = \frac{1 - \tau_t^l}{1 + \tau_t^c} (1 - \alpha)A_tK_t^\alpha L_t^{-\alpha} \quad (3.4.28)$$

$$\frac{C_{t+1}}{C_t} = \frac{1 + \tau_t^c}{1 + \tau_{t+1}^c} \beta (1 + (1 - \tau_{t+1}^k)(\alpha A_{t+1}K_{t+1}^{\alpha-1}L_{t+1}^{1-\alpha} - \delta)) \quad (3.4.29)$$

The government budget constraint is,

$$\tau_t^c C_t + \tau_t^l w_t L_t + \tau_t^k (r_t - \delta) K_t = G_t + T_t \quad (3.4.30)$$

$G_t$  is government consumption. I apply two versions of this government budget constraint for two versions of the model. In one approach  $G_t = 0$  so taxes equal transfers, in the other approach  $T_t = 0$ , i.e. there are no transfers - taxes are raised and spent only on military expenditure or they are spent on pure public goods. In the second case, specification of utility function is as follows.

$$\sum_{t=T_0}^{\infty} \beta^t (\gamma \log C_t + (1 - \gamma) \log(\bar{h} N_t - L_t) + \eta \log G_t) \quad (3.4.31)$$

With little modification the feasibility condition is as below,

$$C_t + K_{t+1} - (1 - \delta) K_t + G_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (3.4.32)$$

In brief, in the model with taxes where all government revenue is transferred to the household,  $G_t = 0$  but in the model with taxes and government (second version)  $G_t$  is an exogenously given series.

**Definition of equilibrium:** Given sequences of productivity  $A_t$ , the working age population  $N_t$ , consumption taxes  $\tau_t^c$ , labour taxes  $\tau_t^l$ , capital taxes  $\tau_t^k$ , and government consumption  $G_t$ ,  $t = T_0, T_0 + 1, \dots$ , and the initial capital stock,  $\bar{K}_{T_0}$ , an equilibrium with taxes and government consumption is the sequence of wages  $w_t$ , interest rate  $r_t$ , consumption  $C_t$ , labour  $L_t$ , capital stock  $K_t$  and transfer  $T_t$ , such that

- given the wages and interest rates, the representative household chooses consumption, labour and capital to maximize the utility function (3.4.31) subject to the budget constraint (3.4.27), appropriate non-negativity constraints, and the constraint on  $\bar{K}_{T_0}$ ;
- the wages and interest rates, together with the firm choices of labour and capital, satisfy the cost minimization and zero profit conditions (3.4.4) and (3.4.5);
- government consumption and transfers satisfy the government budget constraint (3.4.30); and
- consumption, labour and capital satisfy the feasibility condition (3.4.32).

## Data and Calibration of the Model with Taxes

In this model, households pay taxes but all the revenues earned by the government is transferred to households, so here  $G_t = 0$  and the sum of all taxes equals total transfers. The government gives back all it earns as taxes to the households in a lump-sum amount. This is not to say that there is no public consumption, rather public and private consumption are substitutable here. Implicitly, for example, I assume that public schools are a good substitute for private schools, and a publicly provided police station is a good substitute for privately provided security protection. If a small fraction of GDP is allocated to pure public goods, the conclusion of this analysis might not change significantly. But if there is large military expenditure then this approach is not appropriate, such as the expenditure in 1936-45 by Germany and 1942-45 by the US (Prescott, 2002). Australia never had large military expenditures of this nature.

Here I calculate tax rates for consumption, labour and capital following the methodology of Mendoza et al. (1994). This method calculates average tax rates that do not rely on the data from individual tax returns or taxes paid by income groups. Tax rates are calculated by dividing tax revenues by income or expenditure. They take the tax revenue statistics from OECD revenue statistics. For data on income and expenditure they take the data from OECD national accounts statistics. Based on their methodology McDaniel (2007) calculates average tax rates for 15 OECD countries including Australia up to 2003. He makes some changes to the calculation method, in particular he does not deduct consumption of fixed capital (depreciation) in the calculation of capital tax. Conesa et al. (2007) also collected tax revenue data from OECD but income and expenditure data from national accounts and they deduct the consumption of fixed capital to calculate the capital tax rate.

In this research, McDaniel (2007) is followed for the calculation of tax rates for Australia. Here also tax revenue data are taken from OECD and income and expenditure data are taken from national accounts data (ABS data). But when McDaniel (2007) end up his calculation of tax rates up to 2003, some data were not available in the ABS. So his calculated tax rates are not accurate. For example, the household mixed income has been made available as a separate entity in the ABS, which was not available separately when he calculated tax rates for Australia. Also the operating



surplus of the government was not available at that time, so he considered that as zero for Australia. These data have since been made available in the ABS data and the government operating surplus is therefore no longer assumed to be zero. Hence, recalculation of his tax rates are necessary which is done in this research. My created series is close to McDaniel's rates but not the same for the abovementioned reasons. For comparison, McDaniel's and my tax rates are shown in Figure B.2 in Appendix B.4. Details of the procedure of calculating these tax rates are given in the Appendix B.2.

Analyses are done using both average and marginal labour and capital tax rates. For calculating marginal tax rates, first the average tax rates are calculated. Marginal tax rates are obtained by multiplying average taxes with a factor 1.6 following Prescott (2002) for the US and Conesa et al. (2007) for Finland. Conesa and Kehoe (2005) multiplied average taxes by 1.83 to get the marginal tax rates for Spain. The values for  $\beta$  and  $\gamma$  are calculated using equation (3.4.33) and (3.4.34) where tax rates are included in the equations.

$$\beta = \frac{(1 + \tau_{t+1}^c)C_{t+1}}{(1 + \tau_t^c)C_t} \frac{1}{1 + (1 - \tau_t^k)(r_t - \delta)} \quad (3.4.33)$$

$$\gamma = \frac{(1 + \tau_t^c)C_t}{(1 + \tau_t^c)C_t + (1 - \tau_t^l)w_t(\bar{h}N_t - L_t)} \quad (3.4.34)$$

Parameter values are taken considering the average parameter values of  $\beta$  and  $\gamma$  during 1985-1990. That is, I calibrate household behaviour to a period outside that in which I am interested i.e. 1993-2004 as like as the base case model. For the model using average taxes,  $\beta$  and  $\gamma$  are calibrated as 0.9881 and 0.3274 respectively. For the model with marginal taxes  $\beta$  and  $\gamma$  are calibrated as 0.9935 and 0.3515 respectively. The labour share is chosen as in the base case model with a value of 0.3844. Other parameters are the same as in the base case model. The TFP for the growth accounting is calculated as,

$$A_t = \frac{C_t + I_t}{K_t^{1-\alpha} L_t^\alpha} \quad (3.4.35)$$

Here TFP is calculated with a slight change.  $C_t + I_t$  is the GDP in factor prices. GDP in factor prices is the GDP in market prices minus consumption tax revenues. The consumption variable is as in the base case model. No other change is needed.

During the calculation of the contribution of TFP in Table 3.4, TFP is conventionally measured following Conesa et al. (2007).

$$\hat{A}_t = \frac{\hat{Y}_t}{K_t^{1-\alpha} L_t^\alpha} \quad (3.4.36)$$

where,

$$\hat{Y}_t = (1 + \tau_t^c)C_t + I_t \quad (3.4.37)$$

### Data and Calibration of the Model with Taxes and Government Consumption

This model is the other extreme of the previous model where all government expenditures are used to produce pure public goods - for example national defence. Households do not get back taxes as transfers, so the transfer payment is zero,  $T_t = 0$ . Government expenditure is included in households' utility function, which is equation (3.4.31). Here households produce 'G' (government expenditure) with labour and capital but do not consume 'G' as they do not receive transfers from the government. TFP is calculated using after tax GDP. To calibrate  $\beta$  and  $\gamma$  I use consumption without government expenditure. When I use average taxes in the model,  $\beta$  and  $\gamma$  are calibrated as 0.9898 and 0.2679 respectively. For the model with marginal taxes,  $\beta$  and  $\gamma$  are calibrated as 0.9952 and 0.2894 respectively. Here some other changes are made. The resource constraint is as equation (3.4.32). In this model government consumption is separated from total consumption, now consumption includes only private consumption and net exports. Exogenous TFP is calculated as

$$A_t = \frac{C_t + I_t}{K_t^{1-\alpha} L_t^\alpha} \quad (3.4.38)$$

### Results

The results of the model with taxes and transfers and the model with taxes and government consumption are shown in Figure 3.7, 3.8 and Table 3.4. Figure 3.7 shows the results using average tax rates on consumption, labour and capital. The model now underestimates the output growth during the above average growth period (1993-2004). The model with taxes and transfers shows the average growth rate of 2.45 percent. The model with taxes and government consumption shows 2.53 percent average growth rate which can predicts the fluctuations of output better than the base case model and the

model with taxes and transfers. The yearly average increase of the weekly hours worked per working-age person is lower during the above average growth period, compared to the base case model. While in the base case model it is around 0.5, in the model with taxes and transfers it is 0.34 and in the model with taxes and government consumption it is 0.22.

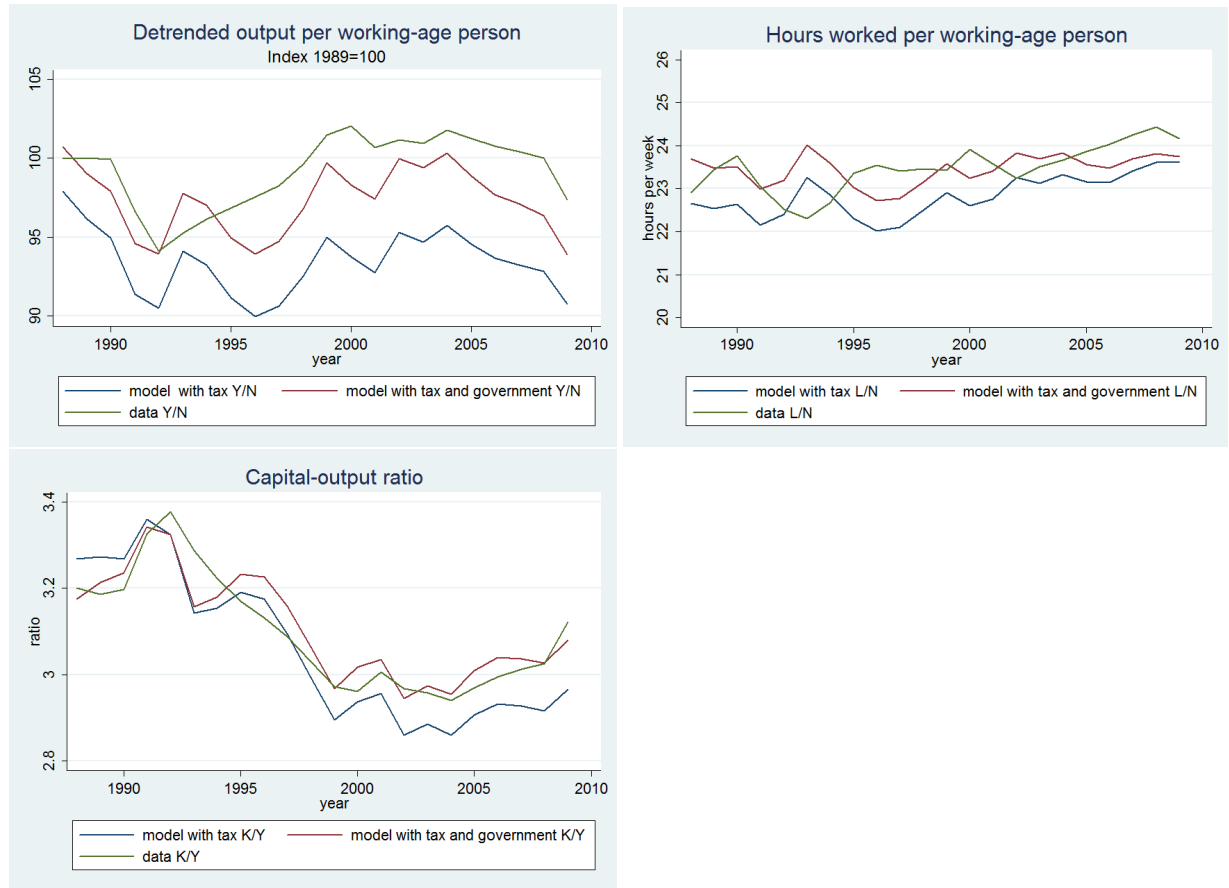


Figure 3.7: Comparison between data and models using average taxes on labour and capital

Figure 3.8 shows the results using marginal tax rates of labour and capital instead of average tax rates. The model with taxes and transfers still underestimates the actual growth rate (2.46 percent versus 2.63). The model with taxes and government consumption shows the average growth rate of 2.52 percent during the above average growth period.

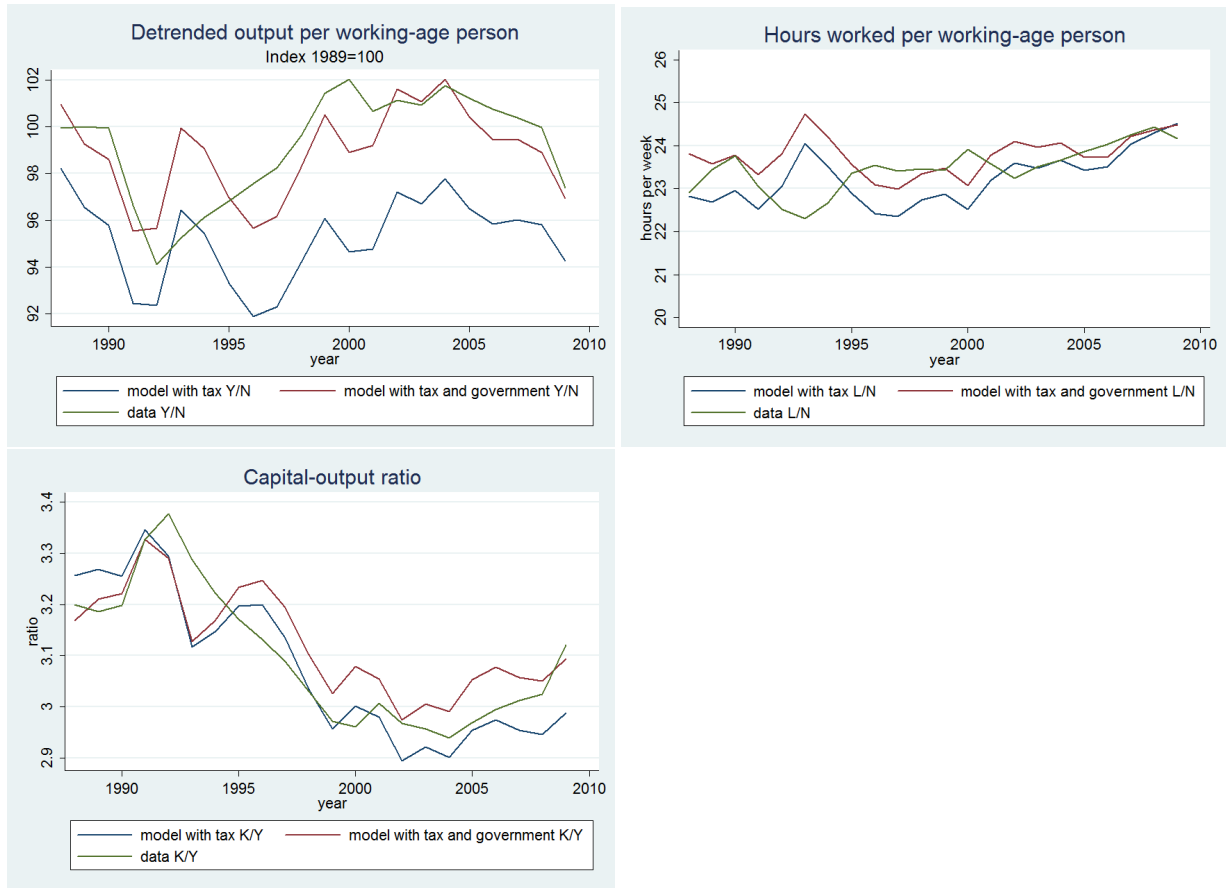


Figure 3.8: Comparison between data and models using marginal taxes on labour and capital

As the households decide on the margin in equations (3.4.28) and (3.4.29), so it is appropriate to use marginal tax rates rather than average tax rates. Considering all the results of the tax model it can be argued that the model with taxes and government consumption predicts the data better than a model with taxes and transfers. Detailed quantitative analysis is presented in the next section.

### 3.5 Comparison and Analysis

In this section, I present a comparison between different models in terms of average growth rates. The natural logarithm is taken on both sides of the equation (3.4.26) so that output per working-age person is the sum of three components. These three

components are TFP, hours per working-age person and capital-output ratio.

$$\log \frac{Y_t}{N_t} = \frac{1}{1-\alpha} \log A_t + \frac{\alpha}{1-\alpha} \log \frac{K_t}{Y_t} + \log \frac{L_t}{N_t} \quad (3.5.1)$$

Using (3.5.1) I present the closed economy base case model results in Table 3.3, where I show the average growth rates of the components of output per working-age person.<sup>8</sup> I divide the 22 years into 3 episodes. The period 1988-92 is the period of slow growth that includes the 1991 recession. A period of above average growth continued for around 12 years until 2004. This period is the main point of interest in this chapter. After this period Australia again faces another slowdown period in 2005-09, which includes the recession of 2008. Table 3.3 shows the comparison between the data, the base case model and the model with constant TFP growth. During the slowdown period 1988-92, the average growth rate of the output per working-age person is 0.09 percent in the base case model, compared with 0.47 percent in the data. Average TFP growth was less than 0.05 percent in the data. Average yearly increase of hours worked is -1.42 percent in the model, compared with -0.41 percent in the data. The base case model shows much lower output growth and higher decline of hours worked compared to data during this slowdown period. The constant TFP model predicts very high output and TFP growth.<sup>9</sup>

During the above average growth episode, i.e. during 1993-2004, average growth of output per working-age person is 3.09 percent in the model compared with 2.63 percent in observed data. The model overpredicts the growth of output per working-age person. The growth of the capital-output ratio is -0.35 percent in the model, compared with -0.72 percent in the data. The average yearly increase of hours worked is higher in the model than in the data (0.49 percent versus 0.41 percent). During the above average growth period, TFP growth was 2.95 percent.

In the slowdown period of 2005-09, the growth of output per working-age person in the model is 0.13 percent, compared with 1.1 percent in the data. Table 3.3 shows

<sup>8</sup>This is done by the equation (3.4.26). Taking log in both sides gets the equation (3.5.1). Then I calculate the log changes of the two consecutive years, and take the average of the years of a particular episode.

<sup>9</sup>Constant TFP model results are hypothetical. It is not my objective to match the model results with data. It shows the strength of TFP in growth if the TFP does not decrease.

Table 3.3: Contribution to growth (average annual)

Episodes	Data (%)	Model Base case (%)	Model constant TFP (%)
Slowdown 1989-92	-	-	-
change in Y/N	0.47	0.09	2.53
due to TFP	0.05	0.05	2.43
due to K/Y	0.84	1.46	0.05
due to L/N	-0.41	-1.42	0.05
Above average growth 1993-04	-	-	-
Change in Y/N	2.63	3.09	2.38
due to TFP	2.95	2.95	2.43
due to K/Y	-0.72	-0.35	0.04
due to L/N	0.41	0.49	-0.09
Slowdown 2005-09	-	-	-
Change in Y/N	1.10	0.13	2.36
due to TFP	-0.08	-0.08	2.43
due to K/Y	0.75	1.11	-0.30
due to L/N	0.43	-0.89	0.23

that TFP growth is negative during this slowdown period. Although the growth of capital-output ratio is positive, average yearly increase of hours worked is negative.

Data are also compared with four versions of the model with taxes and government expenditure. The third and fourth column of Table 3.4 shows the results using average taxes and the fifth and sixth columns shows the results using marginal tax rates. Table 3.4 shows the growth of output per working-age person and the growth of its three components for the models and data. During the slowdown period of 1988-92 growth of output per working-age person in the data was 0.47 percent. For the model with taxes and transfers using marginal taxes growth is 0.44 percent. The model with taxes and government expenditure using marginal taxes shows growth rate of 0.63 percent.

Table 3.4: Contribution to growth (average annual)

Episodes	Data (%)	Average tax (%)	Average tax and government expenditure (%)	Marginal tax (%)	Marginal tax and government expenditure (%)
Slowdown 1989-92	-	-	-	-	-
change in Y/N	0.47	0.02	0.24	0.44	0.63
due to TFP	0.05	0.03	0.05	0.00	0.02
due to K/Y	0.84	0.27	0.72	0.18	0.60
due to L/N	-0.41	-0.28	-0.53	0.26	0.01
Above average growth 1993-04	-	-	-	-	-
Change in Y/N	2.63	2.45	2.53	2.46	2.52
due to TFP	2.95	2.89	2.92	2.90	2.93
due to K/Y	-0.72	-0.78	-0.61	-0.66	-0.50
due to L/N	0.41	0.34	0.22	0.21	0.09
Slowdown 2005-09	-	-	-	-	-
Change in Y/N	1.10	0.91	0.66	1.25	0.96
due to TFP	-0.08	0.20	0.21	0.16	0.19
due to K/Y	0.75	0.46	0.52	0.38	0.43
due to L/N	0.43	0.26	-0.07	0.72	0.34

During the above average growth period (1993-2004), average growth of output per working-age person is 2.53 percent in the model with average taxes and government, compared with 2.63 percent in the data. In the model with marginal taxes and government growth is 2.52 percent. In case of model with taxes and transfers results are not much different using either average or marginal taxes (2.45 percent versus 2.46 percent). Average TFP growth in all four versions of the model are closer and the best prediction comes from the model with marginal taxes and government (model 2.93 percent and

data 2.95 percent). The average yearly increase of hours worked is smaller for all the versions of the model, compared with the data. But hours worked shows some parallel findings of Prescott (2004) that taxes have negative impact on hours worked. All the model that include tax shocks shows a lower increase of average yearly hours worked compared to the model without taxes, i.e. comparing with the base case model. Growth of capital-output ratios are negative for all the versions of the model including the data.

In the latest slowdown period (2005-09) growth of output per working age person is well predicted by all versions of the model except the model with average taxes and government. Although TFP growth rate is negative in observed data, none of the model predicts negative TFP growth.

With the model results and actual movements of the data, there are some important observations regarding the above average growth period. Firstly, results support the view that TFP was the driving force of the above average growth of the output per working-age person during 1993-2004. Secondly, taxes play an important role in output fluctuations as the model without taxes predicts larger increases in output per working-age person and the model including taxes predicts a path of output per working-age person which is much more in line with the actual experience of the Australian economy. Thirdly, model with taxes and government expenditure does a better job of predicting output per working-age person than the model with taxes and transfers. Fourthly, the analysis also shows parallel findings to Prescott (2004) that taxes have a negative impact on hours worked. All the models that include tax shocks show a lower average increase in hours worked compared to the model without taxes. Also using the marginal taxes the growth in hours worked is lower than using the average taxes.

Considering the small open economy structure of Australia I also do an analysis with open economy model assuming balanced trade. Detailed analyses are given in Appendix B.5. The open economy structure also shows an important role of productivity during the above average growth period. I am not including this enquiry in the main part of this chapter as I believe the value added is small.



### 3.6 Conclusion

In this chapter the initiative has been taken to find an appropriate model that can explain the causes of the above average output growth in Australia during 1993-2004. Results show that growth of TFP underpinned the above average growth of output per working-age person. During the above average growth period, average growth of output per working-age person was 2.63 percent and the growth of TFP was 2.95 percent. A simple neoclassical growth model with TFP shocks over estimates the average growth of output per working-age person (3.09 percent). Including tax and government expenditure shocks along with TFP shocks predicts a path of output per working-age person which is much more in line with the actual experience of the Australian economy. In most of the versions of the model using average or marginal taxes, the average TFP growth rates are similar to the data. A model with taxes (including TFP shocks) where all tax revenues are transferred back to households, shows a growth rate of 2.45 percent using average taxes and using marginal taxes growth rate is 2.46. A model with taxes and government expenditure (including TFP shocks) predicts a growth rate of 2.53 percent using average taxes and 2.52 percent using marginal taxes. The analysis also shows parallel findings of Prescott (2004) that taxes have negative impact on hours worked. All the models that include tax shocks shows a lower increase of the average hours worked compared to the model without taxes. Also using the marginal taxes of labour and capital, increase of hours worked is lower than using the average taxes.

## Chapter 4

# The Role of Productivity during the Great Depression in Australia

### Abstract

In 1925 Australia's output per working-age person started to slowdown dramatically. The peak-to-trough (1925 to 1932) decline of detrended output per working-age person was around 35 percent. While in 1925 the unemployment rate was 6.3 percent, it reached 19.7 percent in 1932. What caused this enormous drop in economic activity? Regarding the drop, this chapter finds an important role of a fall of productivity. The analysis begins by abstracting from international factors. The artificial economy driven only by TFP shocks can account for 96 percent of the peak-to-trough output drop. As Australia is an open economy and some authors, notably Valentine (1987a,b) and Siriwardana (1995), suggest a great role of falling terms of trade (or falling export prices) as the cause of the Depression, I also test the impact of productivity in an open economy context. The model accounts for 88 percent of the peak-to-trough decline of detrended output per working-age person. My results show that declining productivity was the major cause of the Depression which differs from the recent research by Payne and Uren (2011).

“Collectively,..government policies that affect TFP and hours per working-age person are the crucial determinants of the Great Depressions of the twentieth century.”  
Timothy J. Kehoe and Edward C. Prescott

## 4.1 Introduction

In 1925 Australia’s output per working-age person started to decline. The unemployment rate started to surge. The peak-to-trough (1925 to 1932) decline of detrended output per working-age person was 35 percent. While in 1925 the unemployment rate was 6.3 percent, it reached 19.7 percent in 1932. Why did the output fall so much in the late 1920s and early 1930s? Why did the output remain so low for a decade? These types of research questions have been addressed by many economists in different countries but Cole and Ohanian (1999) were the first to use a dynamic general equilibrium model to explain the causes of the Depression in the 1930s for the US. Later on similar analyses were done for other western European countries, on the UK (Cole and Ohanian, 2002), on Germany (Weder, 2006b; Fisher and Hornstein, 2002), and on France (Beaudry and Portier, 2002). On Australia there has been little research in this area, most notably Schedvin (1970, 1992); Valentine (1987a,b); Green and Sparks (1988); Siriwardana (1995) and Payne and Uren (2011). In modern macroeconomics neoclassical growth theory is usually tested by looking at the post World War II situation. Now it could be a question of investigation, whether use of neoclassical growth theory can explain the economic movements of the 1930s. Cole and Ohanian (1999) use four major shocks, technology shocks, fiscal policy shocks, trade shocks and monetary shocks to investigate the causes of the Great Depression in the US using neoclassical growth model. They explain that technology shocks can account for 40 percent of the decline of the detrended output between 1929-33. The technology shock cannot explain well the slow recovery from 1934-39. The model predicts a large increase of employment and output during 1934-39 but the data show a slow increase. They conclude that weak recovery of the economy from 1934-39 is a puzzle for neoclassical economic theory.

To look at the situation for Australia in the 1920s and 1930s a graph is drawn of long time series data (1901-1974) that shows the log of the real GDP per working-age person. Figure 4.1 shows that during the 74 years, the fall in GDP per working-age

person was the highest in 1931 for undetrended data.



Figure 4.1: Australian real GDP movement in the long run, 1966/67 prices

In this chapter, the objective is to find the causes of the Great Depression in Australia. The analysis begins by abstracting from international factors. Then it is extended as an open economy within a neoclassical framework. It is a deterministic general equilibrium model. The paper by Payne and Uren (2011) also focuses on the causes of the Great Depression in Australia. Their investigation is within a small open economy New Keynesian framework with sticky prices, and investigates with monetary, fiscal and exchange rate policy. They conclude that pursuing a flexible exchange rate policy would have moderated the fluctuations (5.7 percent below trend) in output in the 1930s compared to the fixed exchange rate regime (13 percent below trend). In the data fluctuation was 8.5 percent below trend which is higher than the output fluctuations of the model with flexible exchange rates. They also find that fiscal policy had a smaller impact on output fluctuations, although government spending reduced a lot. Unlike Payne and Uren (2011) this chapter is based on the neoclassical framework and focuses on the role of productivity and terms of trade.

My results show that the artificial economy driven only by the TFP shocks can account for 96 percent of the peak-to-trough drop of output per working-age person.

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As Australia is an open economy and the literature, notably Valentine (1987a,b) and Siriwardana (1995), suggest that falling terms of trade (or falling export prices) were one of the main causes of the Depression, I also test the role of productivity in an open economy context. The model with exogenously given trade balance (includes both TFP and terms of trade shocks) can account for 88 percent of the peak-to-trough decline of detrended output per working-age person. Opening up the economy does not improve the result ( $88 < 96$ ). My results show that declining productivity was the major cause of the Depression, which is contrary to the findings in Payne and Uren (2011).

This chapter is organized as follows. In the next section, I review the literature including Australian literature on the Great Depression, mentioning the research gap in this area. Then in section 4.3 I explain the economic situation of Australia during the Great Depression. After a brief methodology of the chapter in section 4.4, the closed economy model, its calibration and results are presented in section 4.5. As Australia is an open economy, analyses are also done with open economy models in section 4.6. Then, I delineate a quantitative comparison on the factors of growth in section 4.7. Lastly, some concluding remarks are provided.

## 4.2 Literature Review

My motivation stems from the paper of Cole and Ohanian (1999). They ask the basic question, can real shocks account for the depression? They analyse in detail on the impact of technology shocks, fiscal policy shocks, trade shocks and monetary shocks using US data from the Great Depression period. In brief they find that in a neoclassical framework technology shocks can predict 40 percent of the long deep depression (1929-33) but it cannot predict the recovery period 1934-39. There has been a great deal of research on the Great Depression in developed countries.<sup>1</sup> If we go through all relevant literature, it is seen that different countries differ in their pivotal cause of the Depression. In brief, key causes are negative TFP growth, adverse effects on the labour market due to institutional changes, adverse effects on trade, monetary

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<sup>1</sup>Cole and Ohanian (2002) on the UK, Beaudry and Portier (2002) on France, (Weder, 2006b) and Fisher and Hornstein (2002) on Germany, Perri and Quadrini (2002) on Italy, Amaral and MacGee (2002) on Canada.

policy and the role of government as a spender and as a raiser of tax. In a broader context, this chapter contributes to the recent literature that uses the dynamic general equilibrium neoclassical model to examine the Great Depression, for example, Cole and Ohanian (1999), Weder (2006a) and Harrison and Weder (2006). More information on relevant literature are given in the Appendix C.2.

### 4.2.1 Literature on the Great Depression of Australia

There are some studies on the Australian Great Depression of the 1930s. Schedvin (1970) is one of the writers who finds the causes of the Great Depression in Australia. His conclusion is that not only international but also domestic causes are responsible for the Great Depression of Australia. Later on, Valentine (1987a,b) discusses the causes of the Depression and concludes that domestic factors played a minor role. He finds that rather than domestic causes, Australia fell into the Great Depression due to international causes. He also mentions that there is little disagreement that the slowdown of the world economy was translated to Australia by falling export prices and sales and lack of foreign loan funds. Domestic causes of the Great Depression were mostly structural, such as high level of tariff protection, rate of growth of money wage rates in the 1920s and a plunge in public investment. He simulates a macroeconomic model during the interwar period. He does the simulation with OLS (ordinary least squares). His model is block recursive in the sense that the monetary sector is affected by variables determined in the real sector but monetary sector variables do not affect real sector variables. He predicts from the econometric model what would have happened if there were higher export prices and increased public investment expenditure. He runs a number of simulations, but I am discussing export price changes as my focus is on terms of trade (Table 5 of Valentine, 1987a). Also another simulation (simulation 3) is discussed here on the impacts of public investment done by Valentine (1987a).

- Simulation 1: Export prices have been set at the 1928/1929 value (123) from 1929/30 on.
- Simulation 2: Export prices have been set at value (150) from 1929/30 on.
- Simulation 3: Public investment expenditure has been set at its 1927/1928 value from 1929/30 on.

In simulation 1, the value of 123 for the export price is taken by Valentine from Bambrick (1973) which is a higher value than the values of the following years of the Depression. In simulation 2, he chooses arbitrarily a much higher value (150) of the export price to analyse its impact. Simulation 2 suggests that export prices have a powerful influence on GDP. The simulated unemployment rate is much lower than observed. The negative effect on the international reserves is also smaller. Simulation 1 also shows export prices have influence on GDP but not as much as in simulation 2. In simulation 3, although public investment expenditure is set at a high level, the impact on GDP and unemployment rate is not too different from the data, so his results suggest that a fall in export prices had a significant role in the slowdown rather than the drop of public investment. Green and Sparks (1988) find that Australia was in a deep recession by 1928/29 before the world economy collapsed. They conclude that domestic factors played an important role in contracting the Australian economy and later on international causes further deteriorated the situation. Siriwardana (1995) finds that during the time of the Great Depression capital inflow from around the world decreased tremendously, and that constrained domestic investment. Also there was a big fall in export prices, i.e. deterioration of terms of trade. These two factors are the leading factors in the Great Depression in Australia. His framework is a CGE (computable general equilibrium) model of the Australian economy. Dimsdale and Horsewood (2002) who use the Layard-Nickell<sup>2</sup> model for Australia find the factors that explain the high unemployment during the 1930s. Although real wages had some effect on employment and wage indexation procedures resulted in some wage rigidity this was not the major cause of massive unemployment. They show that demand side variables, mainly changes in the government spending and the terms of trade, were important in both downturn and recovery of employment.

On finding the causes of the Depression, Payne and Uren (2011) follow the New Keynesian model. They find that a flexible exchange rate policy could have moderated the fluctuations of output compared to fixed exchange rate policy during the Great Depression for a small open economy like Australia.<sup>3</sup> In an open economy environment

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<sup>2</sup>See Layard and Nickell (1986).

<sup>3</sup>Under flexible exchange rate policy, the central bank has more freedom to choose its monetary policy. The central bank can deal with two mandates together, i.e. maintain employment and control inflation.

at first they analyse the role of the gold standard in transmitting shocks, then compare the role of modern day practices of flexible exchange rates if implemented at that time. They do similar work already done by McCallum (1990) and Christiano et al. (2004). These two papers focus on closed economies. The Payne and Uren (2011) work is similar to the research done for Switzerland by Bordo et al. (2007) using an open economy approach.

There are major differences between my approach and the approach of Payne and Uren (2011). My approach is a dynamic general equilibrium neoclassical model, where shocks are deterministic, while their approach is a dynamic general equilibrium New Keynesian model in a stochastic setup. Their model assumes sticky prices. In my model, productivity is in its standard form, while in their model productivity is actually labour productivity. In my approach emphasis is on the role of productivity and the terms of trade, where analysis is done with several versions of the model including actual shocks to find the model's ability to predict the movements of observed data. In their approach, they feed the international and domestic shocks to find the model's ability to predict observed data. I detrended data by 2 percent following Cole and Ohanian (1999), while their data is detrended by the HP-filter. In this chapter, analysis is of the fluctuations of the 'output per working-age person' while in their paper analysis is on the fluctuations of 'output'. My results show that declining productivity was the cause of the depression. My argument is that real shocks were the cause of the Great Depression in Australia. On the other hand, Payne and Uren (2011) explain that monetary/exchange rate shocks were the prime cause of the Depression. If governments at that time implemented flexible exchange rates, output decline below trend would have been only 5.7 percent rather than the estimated output decline of 13 percent in a model with fixed exchange rates. In the data, the below trend output decline was 8.5 percent. There are some limitations in their model results. In their model predicted terms of trade does not show any fall during the Depression while in the observed data the terms of trade started to fall from 1929.

### **4.2.2 Research Gap**

There are two major branches of literature that explain the causes of the Great Depression of the late 1920s to early 1930s. One emphasizes the real shocks such as Cole



and Ohanian (1999) and the other one emphasizes the monetary/exchange rate policy shocks such as Friedman and Schwartz (1963). Many studies that explain the causes of the Great Depression in Australia use econometric techniques. The paper by Payne and Uren (2011) on the causes of the Great Depression in Australia uses a dynamic general equilibrium model, and mentions the importance of monetary/exchange rate policy shocks. To date no research has been done on the causes of the Great Depression in Australia emphasizing the role of the real shocks (such as productivity shocks) using a dynamic general equilibrium model. This research will fill the gap on finding the causes of the Great Depression in Australia using a dynamic general equilibrium neoclassical model. The research is also a contribution on the longstanding debate on whether domestic or international factors were the main cause of the Depression in Australia.

### **4.3 The Australian Economy during the Great Depression**

What were the reasons that drove the Australian economy to the Great Depression in the late 1920s to early 1930s? In this section, movements of major macro variables and TFP are shown using the data from Butlin (1977). The policies of the government to recover from the Depression are also presented briefly in this section. Most of the literature which analyses the Great Depression in Australia uses the Butlin (1977) dataset. The series are in real terms (in 1966/67 prices). First we see the movements of GDP for the time period 1901-1974 considering the Butlin (1977) database. Figure 4.2 shows the long-run Australian real GDP (in the left figure) for 74 years in 1966/67 prices. The figure on the right shows the GDP per working-age person. In all the analysis I use this variable, not just the GDP variable. GDP per working-age person and output per working-age person is treated as the same throughout the chapter.

Now aside from the long-run data, I focus on period 1921-39. In Figure 4.3, the upper left and right of the figure show the undetrended data of GDP and its components. GDP dropped 21.2 percent from the 1925 level by 1932. In the upper right figure of

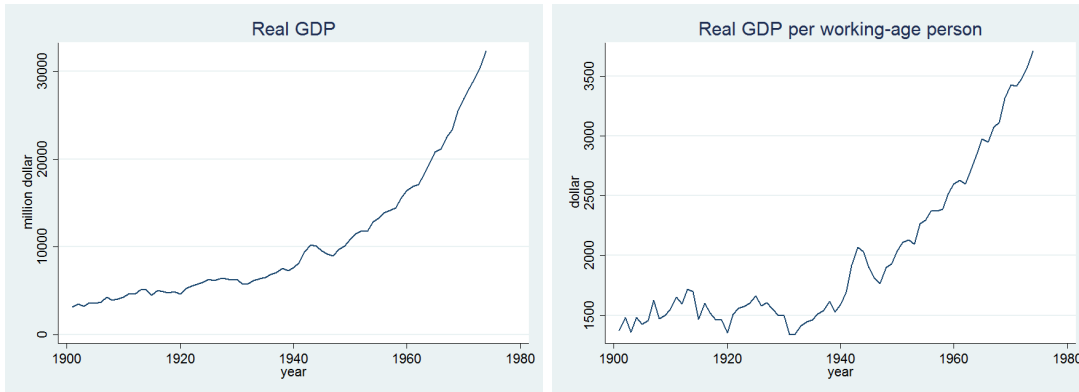


Figure 4.2: Australian GDP movement in the long run, 1966/67 prices

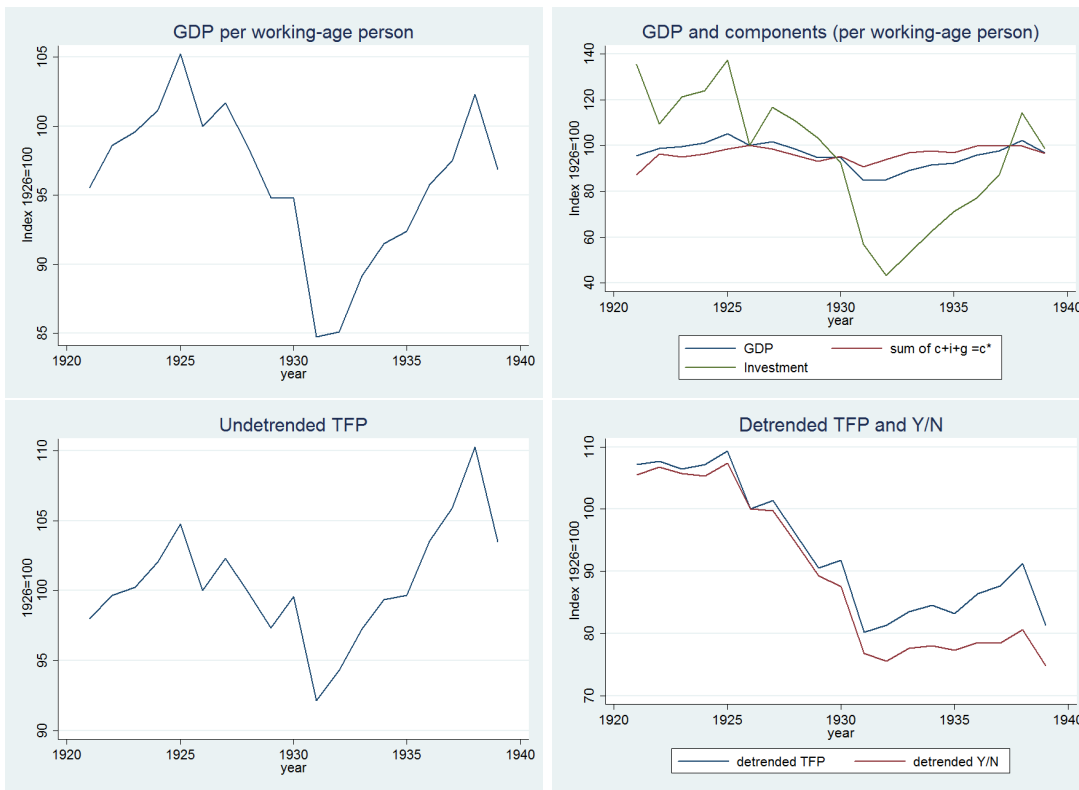


Figure 4.3: Australian data, 1921-39

*Note:* Y/N is output (GDP) per working-age person.

Figure 4.3,  $c^*$  is consumption in the closed economy model.<sup>4</sup> There was also a massive

<sup>4</sup>In this closed economy, I divide GDP into two categories which are consumption and investment. The broader category of consumption is the sum of private consumption, government consumption and net exports.

drop in investment by 1932. Here investment is the sum of public and private investment. The lower left figure shows the movements of undetrended TFP that started to drop from 1925. The lower right figure of Figure 4.3 shows the detrended TFP and GDP per working-age person, these series show a slump during the Great Depression.

Table 4.1 is helpful to understand the situation of Australia during the Great Depression. The second column of Table 4.1 shows that the real growth rate of GDP per working-age person was negative from 1926 to 1931 except 1927. It shows that the Depression in Australia started before the world economy collapsed in 1931.

During the Great Depression the government took the following policies to counter the severity of the Great Depression (Valentine, 1987a).

- Tariff increases were introduced by the Scullin (the then Prime Minister of Australia) government in 1930 and 1931;
- The wage reduction of 10 percent ordered by the arbitration court in January 1931;
- The devaluation of the Australian pound of about 20 percent relative to sterling; and
- The adoption of the Premiers' Plan.

The Premiers' Plan was a deflationary economic policy agreed by a meeting of the State Premiers of Australia in June 1931 to combat the Great Depression. The Premiers' Plan required a reduction of 20 percent in all adjustable government expenditure, a reduction of interest rates on outstanding government debt by 22.5 percent, an equivalent reduction in bank lending and borrowing rates and increases in taxation. The Plan was deflationary as it reduced government expenditure although interest rate cuts should have had a stimulating effect in the economy. Prime Minister of Australia Joseph Lyons who governed from 1932-1939 favoured the tough economic measures of the Premiers' Plan, and pursued an orthodox fiscal policy that helped to recover Australia from the Depression. The Premiers' Plan and other government policies, such as reduction of government expenditure, were introduced much later (1930 or 1931) than the start of the Depression in 1925 when productivity started to decrease.

Table 4.1: Australian economic indicators 1925-32

Year	Growth of GDP per working-age person (%)	Terms of trade (Px/Pm)	Increase in weekly earnings (%)	Unemployment rate (%)
1925	3.95	1.54	0.21	6.3
1926	-5.12	1.12	2.57	4.9
1927	1.68	1.12	2.7	4.2
1928	-3.18	1.25	1.5	6.2
1929	-3.80	1.17	-1.9	6.7
1930	-0.04	0.93	0.13	9.8
1931	-11.17	0.71	-8.3	16.4
1932	0.42	0.71	-9.7	19.7

## 4.4 Methodology

I use the neoclassical growth model to explain the causes of the Great Depression in Australia. The methodology is based on growth accounting and the neoclassical dynamic general equilibrium model developed by Cole and Ohanian (2001) and Kehoe and Prescott (2002). There are three steps in the method of analysis (Dalton, 2008). Firstly, growth accounting quantifies the contributions of TFP, capital and aggregate hours worked to the growth of output per working-age person. Secondly, the neoclassical growth model is used to understand the dynamics of the economy. Thirdly, the growth model is calibrated and used to conduct numerical experiments. In the numerical experiment actual data are compared with the model data.

At first, I do the analysis with only TFP shocks. Working-age population and hours endowment are given in the model and I solve the model with the Newton method, as do Conesa et al. (2007). Also I calibrate the parameter values and estimate the initial capital stock. I choose some parameter values such as  $\delta$  (depreciation rate) and  $\alpha$  (capital share) as standard. The discount rate and consumption share are calculated from the optimality conditions and then calibrated by taking the average of the years 1921-29. Secondly as Australia is a small open economy, I do the analysis with an

open economy neoclassical model. Here I do the analysis with TFP and terms of trade shocks. Working-age population, hours endowment, net exports and the productivity for the Armington aggregator are given in the model.<sup>5</sup> Initial capital stock is also given in the analysis from the data. Details of the solution method are given in Conesa et al. (2007). Also the details of the solution method are attached in Appendix B.3.

## 4.5 Closed Economy Analysis

### 4.5.1 Base Case Model

I define the closed economy model as the base case model from now on. Here I assume Australia is a closed economy and particularly look at the shocks to the TFP. The analysis is based on a dynamic general equilibrium model. A representative household chooses paths of consumption, leisure and investment to maximize utility. The following is the household utility function.

$$\sum_{t=T_0}^{\infty} \beta^t (\gamma \log C_t + (1 - \gamma) \log(\bar{h}N_t - L_t)) \quad (4.5.1)$$

subject to the budget constraint

$$C_t + K_{t+1} = w_t L_t + (1 - \delta + r_t) K_t \quad (4.5.2)$$

where  $C_t \geq 0$  and  $I_t = K_{t+1} - (1 - \delta)K_t$ , where  $I_t \geq 0$ . Initial capital stock  $\bar{K}_{T_0}$  is given. In the utility function parameter  $\beta$  is the discount factor where  $0 < \beta < 1$ .  $\gamma$  is the consumption share where  $0 < \gamma < 1$ .  $C_t$  is consumption,  $K_t$  is the capital stock,  $I_t$  is investment,  $L_t$  is the hours worked,  $w_t$  is the wage rate,  $r_t$  is the rental rate and  $\delta$  is the depreciation rate where  $0 < \delta < 1$ . The total number of hours available for work is  $\bar{h}N_t$ , where  $N_t$  is the working age population and  $\bar{h}$  is the number of hours available. Following Conesa et al. (2007) I also assume  $\bar{h}$  as 100.<sup>6</sup> The unit of time is one year.

<sup>5</sup>The Armington aggregator parameter determines the amount of imports and domestically produced goods needed to produce one unit of the consumption-investment good. It evolves over time to account for the relative price of the consumption-investment good relative to exports. It will be further explained in open economy models.

<sup>6</sup>It means that a person can work a maximum of 100 hours in a week. So total hours endowment is calculated as *working-age population\*100\*52*. Total available weeks in a year are 52.

Firms operate in a perfectly competitive market and technology is assumed to have constant returns to scale that is represented by a Cobb-Douglas production function (4.5.3).

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (4.5.3)$$

where  $Y_t$  denotes total output,  $A_t$  denotes TFP, and  $\alpha, 0 < \alpha < 1$ , is the capital share. In a competitive market, firms earn zero profit and minimize costs. So the factor prices equation can be expressed as,

$$w_t = (1 - \alpha)A_t K_t^\alpha L_t^{-\alpha} \quad (4.5.4)$$

$$r_t = \alpha A_t K_t^{\alpha-1} L_t^{1-\alpha} \quad (4.5.5)$$

In this base case model output is divided between consumption and investment. The feasibility constraint is

$$C_t + K_{t+1} - (1 - \delta)K_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (4.5.6)$$

It is assumed here that TFP and working-age population grow at constant rates,

$$A_{t+1} = g^{1-\alpha} A_t \quad (4.5.7)$$

$$N_{t+1} = n N_t \quad (4.5.8)$$

where  $g^{1-\alpha} - 1$  is the growth rate of TFP and  $n - 1$  is the growth rate of the working-age population. Then there is a balanced growth path where capital-output ratio and hours worked per working-age person are constant and output per working-age person grows at the rate  $g - 1$ .

**Definition of equilibrium:** Given sequences of productivity,  $A_t$ , and working-age population,  $N_t, t = T_0, T_0 + 1, \dots$ , and the initial capital stock,  $\bar{K}_{T_0}$ , an equilibrium is the sequence of wages  $w_t$ , interest rate  $r_t$ , consumption  $C_t$ , labour  $L_t$  and capital stock  $K_t$ , such that

- Given the wages and interest rates, the representative household chooses consumption, labour and capital to maximize the utility function (4.5.1) subject to the budget constraint (4.5.2), appropriate non-negativity constraints, and the constraint on  $\bar{K}_{T_0}$ .
- The wages and interest rates, together with the firm choices of labour and capital, satisfy the cost minimization and zero profit condition (4.5.4) and (4.5.5) and

- Consumption, labour and capital satisfy the feasibility condition (4.5.6).

Next I derive the FOCs of the household problem of maximizing the utility function (4.5.1) subject to the budget constraint (4.5.2) and obtain,

$$w_t(\bar{h}N_t - L_t) = \frac{1 - \gamma}{\gamma} \quad (4.5.9)$$

$$\frac{C_{t+1}}{C_t} = \beta(1 - \delta + r_{t+1}) \quad (4.5.10)$$

Now the artificial economy has household's optimality conditions (4.5.9) and (4.5.10), the firm optimality conditions (4.5.4) and (4.5.5) and the feasibility condition (4.5.6). Combining these equations, we can specify a system of equations that can be solved to find the equilibrium of the model.

Here I explain the way of calculating balanced-growth path before explaining equilibrium path.

**Definition of balanced-growth path:** Suppose that productivity,  $A_t$ , grows at the constant rate  $g^{1-\alpha} - 1$  and that working-age population grows at the constant rate  $n - 1$ , then a balanced-growth path is levels of the wage  $\hat{w}$ , rent  $\hat{r}$ , consumption  $\hat{C}$ , labour  $\hat{L}$ , capital stock,  $\hat{K}$ , and output,  $\hat{Y}$ , such that  $w_t = g^{t-T_0}\hat{w}$ ,  $r_t = \hat{r}$ ,  $C_t = (gn)^{t-T_0}\hat{C}$ ,  $L_t = n^{t-T_0}\hat{L}$ ,  $K_t = (gn)^{t-T_0}\hat{K}$ ,  $Y_t = (gn)^{t-T_0}\hat{Y}$  satisfy the conditions for an equilibrium when the initial capital stock is  $K_{T_0} = \hat{K}$ . To solve the balanced-growth path, I use (4.5.5) and (4.5.10) to solve for the capital-output ratio  $\hat{K}/\hat{Y}$ .

$$g = \beta(1 + \alpha \frac{\hat{Y}}{\hat{K}} - \delta) \quad (4.5.11)$$

Then use (4.5.4) and (4.5.6) to rewrite (4.5.9) as

$$(1 - \alpha)(\bar{h} \frac{N_{T_0}}{\hat{L}} - 1) = \frac{1 - \gamma}{\gamma}(1 - (gn - 1 + \delta) \frac{\hat{Y}}{\hat{K}}) \quad (4.5.12)$$

and use this equation to calculate  $\hat{L}$ . Then I use production function (4.5.3) to solve for  $\hat{K}$  and  $\hat{Y}$ . Using the feasibility condition (4.5.6), I can solve for  $\hat{C}$  and using firm optimality conditions (4.5.4) and (4.5.5), I can solve for  $\hat{w}$  and  $\hat{r}$ .

Now to derive the equilibrium path, I plug the prices (4.5.4) and (4.5.5) into the household's optimality conditions (4.5.9) and (4.5.10) and using the (4.5.6), I obtain

the following system of equations,

$$(1 - \alpha)A_t K_t^\alpha L_t^{-\alpha} (\bar{h}N_t - L_t) = \frac{1 - \gamma}{\gamma} C_t, t = T_0, T_0 + 1, \dots, T_1 \quad (4.5.13)$$

$$\frac{C_{t+1}}{C_t} = \beta(1 - \delta + \alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^\alpha), t = T_0, T_0 + 1, \dots, T_1 - 1 \quad (4.5.14)$$

$$C_t + K_{t+1} - (1 - \delta)K_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (4.5.15)$$

and the transversality condition,

$$\lim_{t \rightarrow \infty} \beta^t \frac{\gamma K_{t+1}}{C_t} = 0 \quad (4.5.16)$$

The system of equations (4.5.13), (4.5.14) and (4.5.15) involves an infinite number of equations and unknowns. To make the computation of equilibrium tractable, it is assumed that the economy converges to the balanced-growth path at some date  $T_1$ . Using the feasibility condition (4.5.15) to solve for  $C_t$  equations could be rearranged, thus:

$$(1 - \alpha)A_t K_t^\alpha L_t^{-\alpha} (\bar{h}N_t - L_t) = \frac{1 - \gamma}{\gamma} (A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1 - \delta)K_t), t = T_0, T_0 + 1, \dots, T_1 \quad (4.5.17)$$

$$\frac{(A_{t+1} K_{t+1}^\alpha L_{t+1}^{1-\alpha} - K_{t+2} + (1 - \delta)K_{t+1})}{(A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1 - \delta)K_t)} = \beta(1 - \delta + \alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^\alpha), t = T_0, T_0 + 1, \dots, T_1 - 1 \quad (4.5.18)$$

The solution of the system of equations may involve a negative value of investment in some periods. Then the equation (4.5.18) is replaced by the following equation,

$$K_{t+1} = (1 - \delta)K_t \quad (4.5.19)$$

Conesa et al. (2007) follow a guess and verify approach. For the guess that investment in period  $t$  be 0 to be correct, the condition corresponding to (4.5.18) and (4.5.10),

$$\frac{(A_{t+1} K_{t+1}^\alpha L_{t+1}^{1-\alpha} - K_{t+2} + (1 - \delta)K_{t+1})}{(A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1 - \delta)K_t)} \geq \beta(1 - \delta + \alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^\alpha) \quad (4.5.20)$$

must hold with inequality.

## 4.5.2 Data Description

For the base case model, we need to divide GDP into two major categories: consumption and investment. Several strategies are followed in the literature. Firstly, sum



up only private consumption and private investment and define the sum as GDP. So GDP does not include government expenditure and net exports. Secondly, Kehoe and Prescott (2002, 2007) consider  $Y_t$  as GDP and include government consumption and net exports either in total consumption or investment. Thirdly, Hayashi and Prescott (2002, 2007) include government consumption in total consumption and net exports in investment. They consider GNP (gross national product) rather than GDP.<sup>7</sup> Here I define consumption as the sum of private consumption, government expenditure and net exports. Investment includes both public and private investment. There is no hours worked series to estimate the TFP from the production function. I use an approximation procedure to compute hours worked. Employment figures of the Great Depression period are available from Butlin (1977). I derive the hours worked series by approximating the coefficient from recent data.<sup>8</sup> There is another method of approximating hours worked following Pensieroso (2010). This is a gross approximation where there is no difference between hours and the employment index.<sup>9</sup> This method does not consider the existence of part-time employment, so I do not use this.

Butlin (1977) has a series of the real gross capital stock but no nominal value of the gross capital stock. Real gross capital stock is deflated by the investment deflator. But for the base case model, every component should be deflated by the GDP deflator as I use the same price deflator for the GDP and its components. For this reason, the GDP deflated investment series is needed. Using the deflators of the investment components I estimate the nominal capital stock for 1921.<sup>10</sup> Then I deflate the nominal value with the GDP deflator to get the initial capital stock value for the base case model. Then

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<sup>7</sup>GNP includes the foreign income of domestic residents to GDP and deducts the income within the country of foreign residents.

<sup>8</sup>I run a simple regression of total male annual hours worked per total male employment with the unemployment rate during the period 1979-2010. Using the coefficient and constant from the regression, I approximate hours worked of historical data. So  $HoursWorked_t = Employment_t * (constant + coefficient * UnemploymentRate_t)$ . Here t is 1921 to 1939.

<sup>9</sup>According to this method: Total hours=total employment\*legal working hours per week (48)\*Number of weeks (50)

<sup>10</sup>For getting the nominal value of private non-dwelling capital stock, I multiplied real value by the private non-dwelling investment deflator. In the same way for getting the nominal public capital stock value I use the non-dwelling deflator for public investment, then summing up I get the total capital stock.

with the calibrated  $\delta$  (0.05) and the real investment (using the GDP deflator) series I estimate the real capital stock series for the growth accounting calculation with the perpetual inventory method. My capital stock series includes both public and private capital. It does not include any types of defence expenditure although some of these expenditures are investment type expenditure. Due to data unavailability of ‘consumption of fixed capital’, I follow the simple way of calibrating  $\delta$  from previous literature, so not following the method of Conesa et al. (2007) to estimate  $\delta$  and initial capital stock that I followed in chapter 3.

In my calculation all real values are in 1966/67 prices. As the GDP and its components are expected to grow at the trend rate of technology, data are detrended with the long-term growth rate. Here I consider 2 percent as the long-run growth rate for Australia which is used for the US economy in many related studies. The reason for using the US growth rate is that the US is a large, diverse and politically stable economy. It has also long been considered to be the world’s economic superpower. I am not detrending here with the Hodrick and Prescott (1997) filter also known as HP-filter. This filtering procedure is suitable for much shorter fluctuations such as the fluctuations after the 1950s. If I apply the HP-filter to the Great Depression data then it will be like a change in trend rather than deviation from trend (Cole and Ohanian, 2007). In my analysis I do not use the Madison database which is used by Payne and Uren (2011).

### 4.5.3 Calibration

Gollin (2002) empirically shows that factor shares are approximately constant across time and space. With this view, I calibrate capital share  $\alpha$  as 0.33 which is used in the literature on the US economy such as Cole and Ohanian (2007). Butlin (1977) or ABS do not have the data on the income of self-employed persons or the mixed income during the 1930s which is necessary to calculate labour share. This is also the reason why I have chosen  $\alpha$  from literature. On a balanced growth path output per worker and capital per worker grow at the same rate and the capital-output ratio and hours worked per working-age person are constant. Figure 4.4 shows the estimated TFP

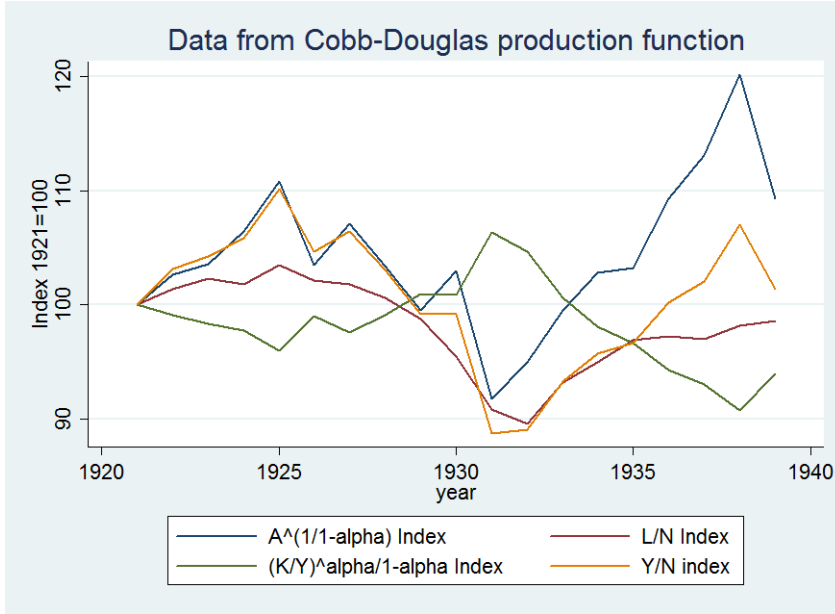


Figure 4.4: Australian data from Cobb-Douglas production function, 1921-39

<sup>11</sup> and other components using the following transformed Cobb-Douglas production function.

$$\frac{Y_t}{N_t} = A_t^{1/1-\alpha} \left( \frac{K_t}{Y_t} \right)^{\alpha/1-\alpha} \frac{L_t}{N_t} \quad (4.5.21)$$

In a balanced-growth path  $(K_t/Y_t)^{\alpha/1-\alpha}$  and  $L_t/N_t$  are constant and growth in output per worker  $Y_t/N_t$  is driven by growth in  $A_t^{1/1-\alpha}$ . The TFP component and  $Y_t/N_t$  are largely moving together. The capital and labour component of the production function are horizontal except during the Great Depression period.

I calibrate the depreciation rate  $\delta$  as 0.05 that I have discussed in section 4.5.2. Discount factor  $\beta$  and consumption share  $\gamma$  are calculated from the FOCs (4.5.13) and (4.5.14). Here I take the average values of these two parameters during the time period 1921-29. The trough year is 1932 for detrended data, so I do not include the years after 1929 for the calibration of  $\beta$  and  $\gamma$  following Conesa et al. (2007). The calibrated values for  $\beta$  and  $\gamma$  are 0.9597 and 0.2572 respectively.

I choose  $T_1$  such that  $T_1 - T_0$  is large (here 60), so I am solving the model over the period 1921-81. Then I construct the series of TFP, working-age population and

<sup>11</sup>TFP is estimated as  $A_t = \frac{Y_t}{K_t^\alpha L_t^{1-\alpha}}$

hours endowment. 1921-43 values are as they are in data. 1944-81 values are constructed. To do this, the TFP growth rate is calculated as the average growth during 1921-43.<sup>12</sup> Using this growth rate I construct the TFP series 1944-81. For setting a constant growth rate of working-age population I take the growth rate calculated in the last two periods of the actual data. The working-age population in 1944 is determined by  $N_{1944} = \frac{N_{1943}^2}{N_{1942}}$ . In this way I calculate the working-age population series up to 1981. After that the population growth parameter is calibrated as  $N_{1945}/N_{1944}$  which is 1.008. As with the working-age population series I construct the exogenous series of total hours endowment.

Here it is also important to verify the exogeneity of the calculated TFP. The results of an Evans (1992) like test is

$$A_{t+1} = 29.26 + 0.5783A_t + 0.09A_{t-1} + 0.0151\Delta m_t + 0.0064\Delta GC_t$$

Here  $A_t$  is TFP,  $\Delta m_t$  is change in M3 (money supply) and  $\Delta GC_t$  is change in government consumption expenditure. Results show that except the first lag of TFP all other variables are not significant. This proves the exogeneity of TFP.

#### 4.5.4 Results

Base case model results are shown in Figure 4.5 and Table 4.2 for the period 1921-39. The upper left part of Figure 4.5 shows the detrended model and data of  $Y_t/N_t$ , i.e. GDP per working-age person. The base case model mostly accounts for the fall in output during the Depression. The model's output per working-age person falls by 19.7 percent during the peak-to-trough period, compared with 21.2 percent in the

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<sup>12</sup>Suppose the 1921 value of TFP is  $y$  and 1943 value of TFP is  $x$ , then the TFP growth rate is  $(\frac{x}{y})^{1/22}$ . Note that in the numerical experiment I take the actual data up to 1943 and show the figures of this chapter up to 1939 that might be confusing to some readers. Actual data is taken up to 1943 to choose a representative parameter value of the TFP growth. In the literature data is taken until the economy is back to normal or steady state. If I take the data up to 1939 then average TFP growth is only 0.3 percent during 1921-39. So I take the data up to 1943 where average TFP growth is 1.3 percent during 1921-43.



Figure 4.5: Comparison between data and Base case model

data. When detrended by 2 percent per year, the model's output per working-age person falls by 33.6 percent, compared with 35.1 percent in the data. This base case model can account for 96 percent of the fall in output. The upper right figure of Figure 4.5 shows the weekly hours worked per working-age person. The peak-to-trough decline of the hours worked is almost same for both the model and data (14.8 percent versus 14.5 percent). The lower left figure of Figure 4.5 shows the capital-output ratio of the model and data that increased during the peak-to-trough period (10.85 percent versus 9 percent). Notice that when output per working-age person is lower, then the capital-output ratio is higher. A probable reason could be the unused capital in the economy during the slowdown as capital stock cannot adjust quickly.

#### 4.5.5 Simulation with Constant TFP Growth

I do another exercise with the base case model. This is just an hypothetical analysis to show the importance of TFP for economic growth. For the base case model the

TFP growth rate is calibrated as 1.013. In 1922 the TFP growth was 1.017.<sup>13</sup> Rather than the base case model calibration of the TFP growth, I assume the TFP growth rate of 1922 as the growth rate of TFP for the entire time period (1921 to 1981). So there is no downward trend of TFP shocks in the numerical experiment. This is done to show that if there were no change in TFP growth of 1922, then whether there would have been any Great Depression. Figure 4.6 shows the results of my numerical



Figure 4.6: Comparison between data and constant TFP model

experiment. Output per working-age person of the model is growing steadily and there is no downward trend of the model, i.e. no depression. Also there is no decrease in hours worked which is horizontal from 1928. The capital-output ratio decreases up to 1928 and then there is no major change of the ratio. In brief Figure 4.6 explains that if hours worked or capital-output ratio had not grown, constant growth of TFP could have avoided the Depression.

<sup>13</sup>Growth is the ratio of the TFP value of 1922 to 1921. It is higher than the average TFP growth rate used in the base case model,  $1.017 > 1.013$ .

## 4.6 Open Economy Models

Although my results for the closed economy model (with only TFP shocks) can account for 96 percent of the peak-to-trough fall of output per working-age person that has occurred during the Great Depression, it is worthwhile to open up the economy for several reasons. Firstly, there is great debate on the causes of the Great Depression in Australia. The debate is between domestic and international causes. Literature that finds the causes of the Great Depression in Australia analyses the influences of terms of trade and exchange rate. Notably, Valentine (1987a) and Siriwardana (1995) mention that falling export prices as well as falling terms of trade was one of the international causes of the Depression. On the other hand Green and Sparks (1988) find that the Depression started due to domestic causes and later on international factors deteriorated the situation. So it is better to identify the role of TFP in an open economy. Secondly, Australia is a small open economy, so a closed economy model may not be the final point of interest. Thirdly, there could be mis-measurement of TFP as I am working with the data of 100 years ago. Fourthly, the recent paper on the Great Depression in Australia by Payne and Uren (2011) is based on a small open economy structure. My objective also is to compare my results with their results. Comparison would be better if I also do the exercise with an open economy model.

In Figure 4.7 some additional information is given. In the upper left figure trade intensity is shown. Trade intensity is the ratio of the total trade volume (exports+imports) in nominal terms to nominal GDP. All through the 1920s trade intensity was around 0.35 and after 1929 trade intensity started to plummet to around 0.27. The upper right figure shows nominal trade balance as a percentage of nominal GDP. As in the first version of the open economy model, balanced nominal trade is assumed (nominal export - nominal import=0). In the observed data it was close to zero for some years but not for the whole series. The lower left figure of Figure 4.7 shows the real trade balance index. This is used in the second version of the open economy model. The lower right figure shows the relative prices which are exogenously given in the model. Here inverse of terms of trade is shown (price of imports relative to price of exports) which is exogenously given in both versions of the open economy models. Another variable in the same figure (lower right figure) is the ratio of the consumption-investment deflator

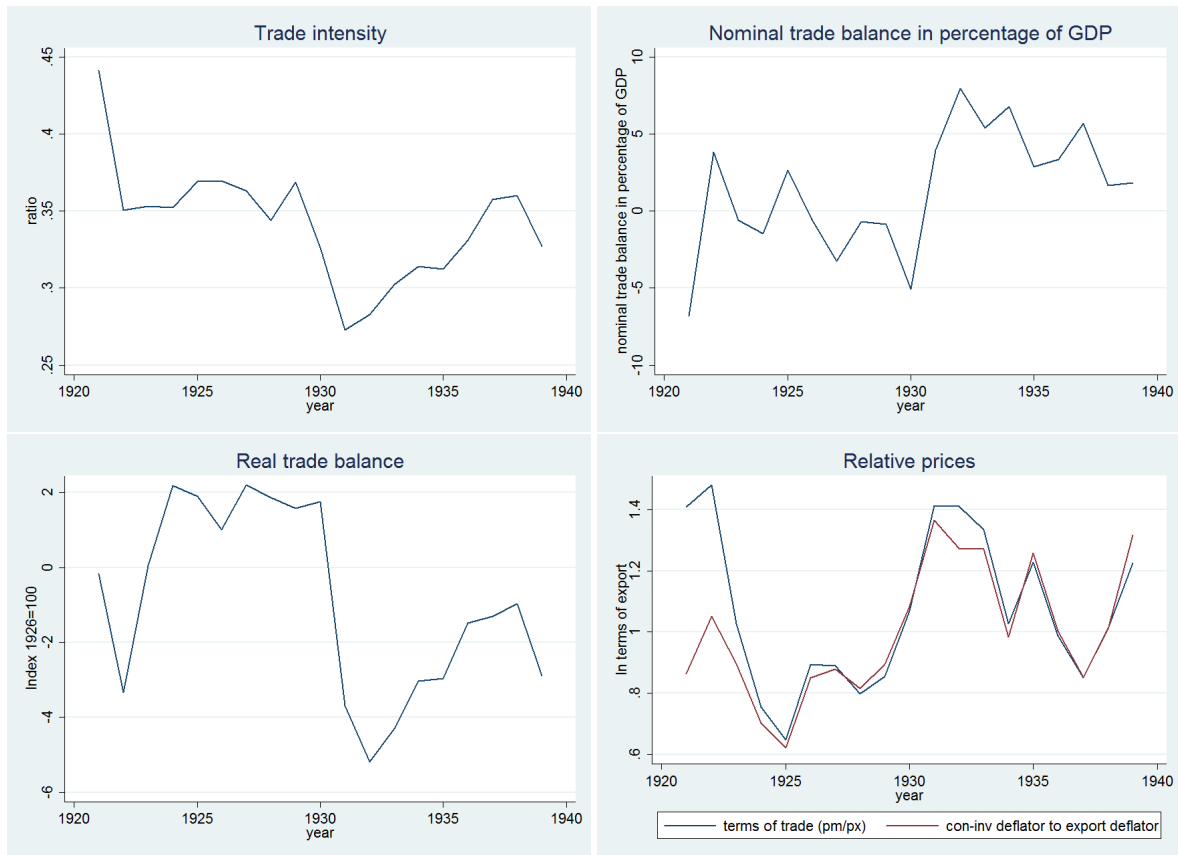


Figure 4.7: Openness of the Australian economy

*Note:* Here con-inv deflator means consumption-investment deflator.

to export deflator. In the model the export price is normalized to one. So import and consumption-investment prices are denoted in terms of export prices. The lower left and right figures show some important information. Real trade balance was positive during 1925-30. Although the terms of trade ( $pm/px$ ) started to worsen from 1925, it improved from 1926-28 then again fall severely from 1929. So the fall of terms of trade was not continuous from 1925 but drop in TFP was close to continuous (See Figure 4.3).

#### 4.6.1 Model with Balanced Trade

In this section, first I describe a model with balanced trade. It is assumed here that nominal exports and imports are equal in every period. This assumption does not mean that the model will be same as the closed economy model, because, although the



nominal trade balance is zero, the real trade balance is not zero. The model is closely related to Conesa et al. (2007).

## Model

In the model economy there are three types of goods - a domestically produced good, an imported good and a non-traded investment good. The representative household chooses consumption of the domestic good, consumption of the imported good and leisure to maximize utility,

$$\sum_{t=T_0}^{\infty} \beta^t (\gamma \log(\nu(C_{d,t}C_{m,t})) + (1 - \gamma) \log(\bar{h}N_t - L_t)) \quad (4.6.1)$$

subject to the following budget constraint

$$p_{d,t}C_{d,t} + p_{m,t}C_{m,t} + q_t(K_{t+1} - (1 - \delta)K_t) = w_tL_t + r_tK_t \quad (4.6.2)$$

Also we need an appropriate non-negativity constraint on consumption and investment and a constraint on the initial capital stock,  $\bar{K}_{T_0}$ . The domestic good price is the numeraire, so we set  $P_{d,t} = 1$ . Some of the domestic goods are exported and the rest are used to produce the investment good, so the domestic good is the same as the exported good. The price of the investment good relative to the domestically produced good is  $q_t$ . The relative price of the imported good is  $p_{m,t}$ . Since it is assumed that the export good is the same as the domestic good,  $p_{m,t}$  is also the terms of trade. The investment good technology is represented by the CES (constant elasticity of substitution) production function and domestic goods technology is represented by the Cobb-Douglas as the base case model. The investment good is made from both the domestic good and imported good using the CES production function which is called the Armington Aggregator.

$$I_t = K_{t+1} - (1 - \delta)K_t = D_t(\omega I_{d,t}^\rho + (1 - \omega)I_{m,t}^\rho)^{1/\rho} \quad (4.6.3)$$

where  $I_{d,t}$  and  $I_{m,t}$  are the use of domestic goods and imports respectively in the production of investment good. The elasticity of substitution  $\sigma$  is defined as  $\sigma = 1/(1 - \rho)$  and I assume that  $\sigma = 2$ ,  $\rho = 0.5$ . A common value of parameter  $\rho$  is 0.5 which is used by Ruhl (2005) and Conesa et al. (2007). The parameter  $\omega$  indicates the proportion of domestic and imported goods used in the production of the investment

good. The parameter  $D_t$  determines the amounts of imports and domestically produced goods needed to produce one unit of the investment good.  $I_{d,t}$  and  $I_{m,t}$  inputs are chosen by the investment good producing firm to minimize the cost of production subject to the constraint

$$D_t(\omega I_{d,t}^\rho + (1 - \omega)I_{m,t}^\rho)^{1/\rho} \geq \bar{I}_t \quad (4.6.4)$$

where  $\bar{I}$  is some target production level of the investment good. Domestic goods are used for three purposes - consumption, investment and export. So the feasibility constraint for the domestic good is

$$C_{d,t} + I_{d,t} + X_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (4.6.5)$$

and the feasibility constraint for the imported good is

$$C_{m,t} + I_{m,t} = M_t \quad (4.6.6)$$

The trade balance condition is

$$X_t = p_{m,t} M_t \quad (4.6.7)$$

The household consumes both domestic and imported goods. I assume that household's preferences over imports and domestic goods are identical to the production technology for producing the investment good, i.e. the CES utility function.

$$v(C_{d,t}, C_{m,t}) = D_t(\omega C_{d,t}^\rho + (1 - \omega)C_{m,t}^\rho)^{1/\rho} \quad (4.6.8)$$

This technology is used here to simplify the model. Defining total consumption as  $C_t$  we can write,

$$C_t = D_t(\omega C_{d,t}^\rho + (1 - \omega)C_{m,t}^\rho)^{1/\rho} \quad (4.6.9)$$

The household problem here is to maximize utility subject to the sequence of budget constraint

$$q_t(C_t + K_{t+1} - (1 - \delta)K_t) = w_t L_t + r_t K_t \quad (4.6.10)$$

Summing up the investment and consumption part of domestic and imported goods we get

$$C_t + K_{t+1} - (1 - \delta)K_t = D_t(\omega Z_t^\rho + (1 - \omega)M_t^\rho)^{1/\rho} \quad (4.6.11)$$

$$Z_t + X_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (4.6.12)$$

The above two equations are the feasibility conditions. Now the model can be simplified further. Rather than assuming investment and consumption good producing firms, we can model a single type of firm that uses all the imports,  $M_t$  and all of the domestically produced good that is not exported,  $Z_t$ , to produce a consumption-investment aggregate. Solving the maximization problem of this single type of firm generates FOCs similar to the conditions when there were two types of firms. The FOCs are,

$$1 = q_t \omega Z_t^{\rho-1} D_t (\omega Z_t^\rho + (1 - \omega) M_t^\rho)^{(1-\rho)/\rho} \quad (4.6.13)$$

$$p_{m,t} = q_t (1 - \omega) M_t^{\rho-1} D_t (\omega Z_t^\rho + (1 - \omega) M_t^\rho)^{(1-\rho)/\rho} \quad (4.6.14)$$

**Definition of Equilibrium:** Given the sequences of productivity,  $A_t$ , the terms of trade,  $p_{m,t}$ , shocks to the investment consumption good production function,  $D_t$ , working-age population,  $N_t$ ,  $t = T_0, T_0 + 1, \dots$ , and the initial capital stock,  $\bar{K}_{T_0}$ , an equilibrium with trade and terms of trade shocks is sequences of wages,  $w_t$ , interest rate,  $r_t$ , consumption-investment prices,  $q_t$ , consumption,  $C_t$ , labour,  $L_t$ , capital,  $K_t$ , output  $Y_t$ , import  $M_t$ , export,  $X_t$ , and domestic goods used in production,  $Z_t$ , such that

- given wages, interest rates and prices the representative household's choices over consumption, labour, and capital solve the problem of maximizing the utility function (4.6.1) subject to the budget constraint (4.6.2), appropriate non-negativity constraints, and the constraint on the initial capital  $\bar{K}_{T_0}$ ,
- the wages and interest rates, together with the domestic good producing firm's choices of labour and capital, satisfy the cost minimization and zero profit conditions (4.5.4) and (4.5.5),
- the terms of trade and price of consumption-investment good, together with the consumption-investment good firm's choices of imports and inputs of the domestic good, satisfy the cost minimization and zero profit conditions (4.6.13) and (4.6.14),
- consumption, labour, capital, inputs of the domestic good, imports, and exports satisfy the feasibility conditions (4.6.11) and (4.6.12),
- trade is balanced (4.6.7).

Combining the two FOCs (4.6.13) and (4.6.14),

$$Z_t = \left(\frac{\omega P_{m,t}}{1-\omega}\right)^{1/(1-\rho)} M_t \quad (4.6.15)$$

Finally, the demand function for imports and domestic goods used in production are the following.

$$M_t = (1-\omega)^{1/(1-\rho)} A_t K_t^\alpha L_t^{1-\alpha} p_{m,t}^{1/(\rho-1)} (q_t D_t)^{\rho/(1-\rho)} \quad (4.6.16)$$

$$Z_t = \omega^{1/(1-\rho)} A_t K_t^\alpha L_t^{1-\alpha} (q_t D_t)^{\rho/(1-\rho)} \quad (4.6.17)$$

Combining the household's optimality conditions with factor pricing equations yields a system of equations which are very similar to the base case model.

$$\frac{(1-\alpha)A_t K_t^\alpha L_t^{1-\alpha}}{q_t} (\bar{h}N_t - L_t) = \frac{1-\gamma}{\gamma} C_t, t = T_0, T_0 + 1, \dots, T_1 \quad (4.6.18)$$

$$\frac{C_{t+1}}{C_t} = \beta \left(1 - \delta + \frac{\alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^\alpha}{q_{t+1}}\right), t = T_0, T_0 + 1, \dots, T_1 - 1 \quad (4.6.19)$$

## Data Description and Calibration

All the data are taken from Butlin (1977). For the open economy model, some extra calculations are necessary for calculating consumption and TFP as here I am using relative prices rather than only GDP deflated values. Deflators are calculated as a ratio of nominal to real values of the variable. I use the export deflator to deflate variables rather than the GDP deflator in this numerical exercise. For determining the relative price of consumption-investment aggregate to export good price ( $q_t$ ), Conesa et al. (2007) take the ratio of real consumption-investment aggregate to nominal consumption-investment aggregate to get the consumption-investment price index then divide that by the export price index. I also follow the same procedure and estimate  $q_t$  series. Due to data unavailability I do not estimate the depreciation rate the way Conesa et al. (2007) have calculated. I calibrate  $\delta$  as 0.05 the same as the base case model. Then I create a new investment series by deflating nominal investment by the consumption-investment deflator rather than the GDP deflator. Given  $\delta$  and assuming the 1921 real capital stock as the initial capital stock I create a new capital stock series with the perpetual inventory method. The parameter  $\omega$  is an approximation of the proportion of domestic and imported goods in production.

$$\frac{\omega}{1-\omega} = \left(\frac{Z_t}{P_{m,t} M_t}\right)^{1-\rho} P_{m,t}^{-\rho} \quad (4.6.20)$$

For calibrating  $\omega$  equation (4.6.20) is used. So first  $Z_t$  should be calculated.  $Z_t$  is GDP minus exports for the economy with trade balance. I choose the value of  $\rho$  as 0.5. The parameter  $\rho$  is chosen on the basis of empirical estimates of the elasticity of substitution between domestic goods and imports. With the data I get an average  $\omega = 0.6940$  during 1921-43. Then I compute  $D_t q_t$ ,

$$D_t q_t = (\omega^{1/(1-\rho)} + (1-\omega)^{1/(1-\rho)} p_{m,t}^{-\rho/(1-\rho)})^{(1-\rho)/-\rho} \quad (4.6.21)$$

Dividing this series by  $q_t$  I get the  $D_t$  series. Now for getting the measure of real GDP, I deflate the components of GDP by export price deflator. Denoting the current values with tilde and real values without tilde I get the export-deflated GDP as the following equation,

$$\frac{\tilde{Y}_t - \tilde{X}_t + \tilde{M}_t}{p_{x,t}} = q_t(C_t + I_t) \quad (4.6.22)$$

real exports are calculated as

$$\frac{\tilde{X}_t}{p_{x,t}} = X_t \quad (4.6.23)$$

and deflating imports by export prices, I get

$$\frac{\tilde{M}_t}{p_{x,t}} = p_{m,t} M_t \quad (4.6.24)$$

Now real GDP is defined as

$$Y_t = q_t(C_t + I_t) + X_t - p_{m,t} M_t \quad (4.6.25)$$

TFP is calculated here in a different way using (4.6.26). This equation is derived using the feasibility constraints (4.6.11) and (4.6.12). It is no longer a simple function of real GDP, capital and labour.

$$A_t = \frac{\omega^{-1/\rho}((C_t + I_t)^\rho D_t^{-\rho} - (1-\omega)M_t^\rho)^{1/\rho} + X_t}{K_t^\alpha L_t^{1-\alpha}} \quad (4.6.26)$$

For calculating  $A_t$  every component of GDP is deflated by their own deflator. When I report the growth accounting in the tables in section 4.7, TFP is calculated with the conventional measure where,

$$Y_t = q_{\bar{T}}(C_t + I_t) + X_t - p_{m,\bar{T}} M_t = (C_t + I_t) + X_t - M_t \quad (4.6.27)$$

Now using the same method as the base case model and using equation (4.6.18) and (4.6.19) I calibrate  $\gamma$  and  $\beta$  as 0.2600 and 0.9723 respectively. For calibrating  $\gamma$  and  $\beta$ , the values are taken averaging their values of the period 1921-29, which is outside the period of severe slowdown (1932) (Conesa et al., 2007).

## Model Results

After calibration of the parameters, I solve the model applying the Newton method for the TFP and terms of trade shocks together. Model results are shown in Figure 4.8 and Table 4.3. In the model the peak-to-trough fall of the output per working-age person is 37.7 percent for detrended data, compared with 35.1 percent in the data. The peak-to-trough drop of the TFP and hours worked per working-age person are 10 and 31 percent respectively. The model predicts much higher drop of the hours worked compared with the data. During the same period, the model capital-output ratio increases around 18 percent which is a higher increase compared with the data. The real trade balance

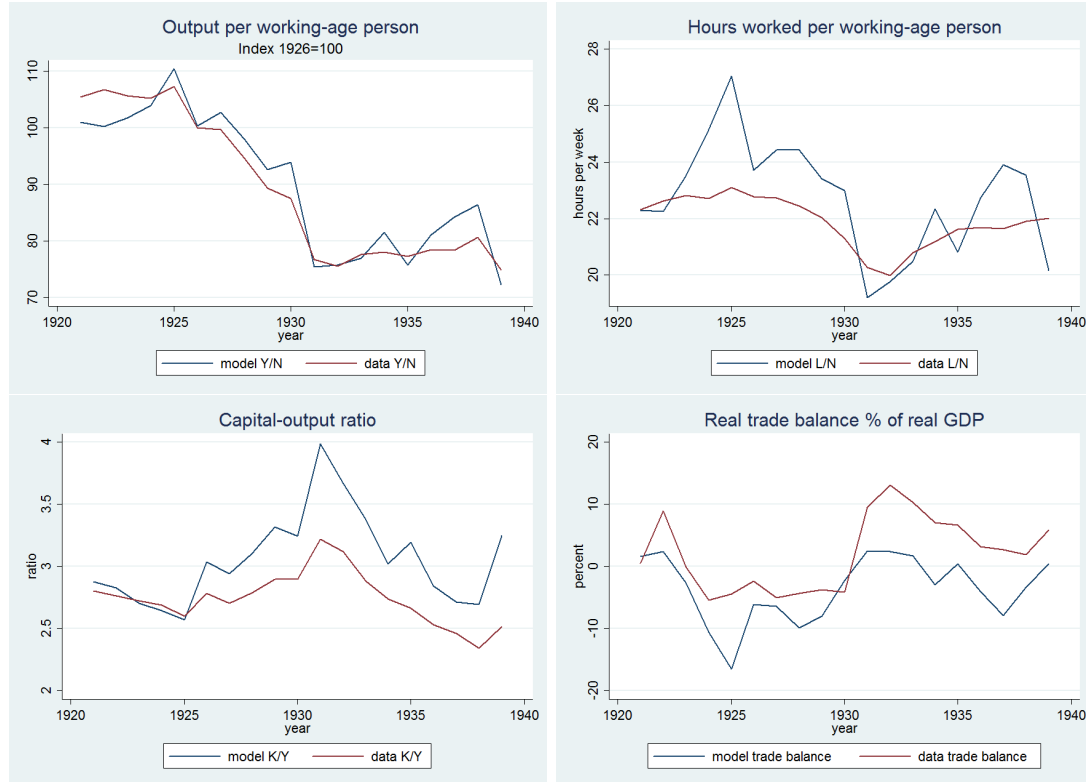


Figure 4.8: Comparison between data and open economy model with balanced trade

for the model is negative up to 1931. This numerical experiment is done assuming balanced trade but in reality trade was not exactly balanced i.e. nominal exports were not equal to nominal imports. So I do another exercise with exogenous trade balance in the next section.

### 4.6.2 Model with an Exogenous Trade Balance

The real trade balance is exogenously given here in the numerical experiment. Unlike the balanced trade model, the real trade balance is given from the data.

#### Model

In the previous subsection, the model is based on an economy with balanced trade. If trade is not balanced there will be only one major change in the model. Suppose  $RX_t$  is the real net exports,

$$Z_t + X_t + RX_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (4.6.28)$$

then the feasibility constraint is given by equation (4.6.28). Considering this resource constraint necessary adjustments are done. There will be a new series for TFP and new parameter values for  $\omega$ ,  $\gamma$  and  $\beta$ .

#### Calibration and Results of the Model

Here one difference lies with the calculation of  $Z_t$  by the equation (4.6.28). In the balanced trade model  $Z_t$  is calculated by (4.6.12). New values for  $\omega$ ,  $\gamma$  and  $\beta$  are calibrated:  $\omega$  is 0.6921,  $\gamma$  is 0.2585 and  $\beta$  is 0.9714. Figure 4.9 and Table 4.3 show the results of the model with exogenous trade balance. The model with exogenous trade balance can predict the fluctuations of the output per working-age person well during the peak-to-trough period. The correlation between the output per working-age person of the model and data is 0.95 after detrending. During the peak-to-trough period output per working-age person falls around 17 percent in the model which is around 31 percent after detrending by 2 percent per year. The model accounts for 89 percent of the drop of output per working-age person in the observed data. TFP and hours worked drop around 10 and 25 percent respectively while capital-output ratio increases around 17 percent.

## 4.7 Comparison and Analysis

So far I have illustrated the effects of TFP and terms of trade shocks to find out the predictability of different versions of the model with figures and tables. Next I present the contribution of the components of growth in more detail. Here an overall analysis

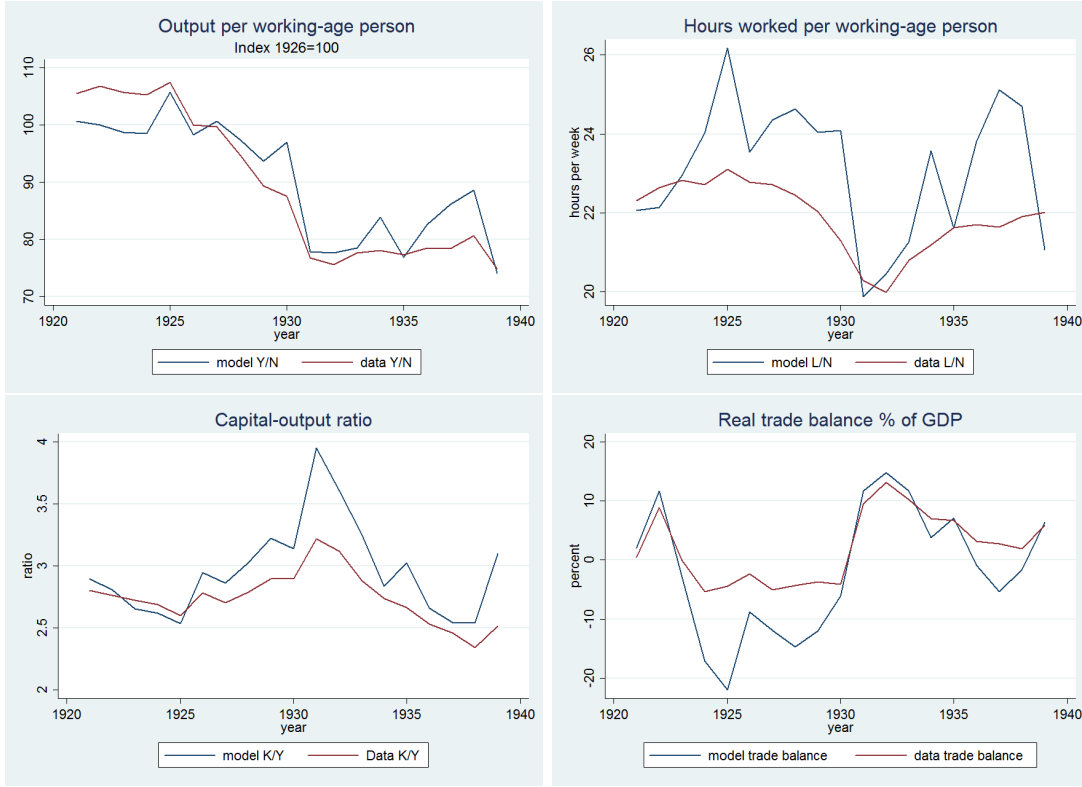


Figure 4.9: Comparison between data and open economy model with exogenous trade balance

is given of the results of the closed economy and the open economy models. Taking natural logarithms in both sides of the equation (4.5.21), output per working-age person can be shown as the sum of three components.

$$\log \frac{Y_t}{N_t} = \frac{1}{1-\alpha} \log A_t + \frac{\alpha}{1-\alpha} \log \frac{K_t}{Y_t} + \log \frac{L_t}{N_t} \quad (4.7.1)$$

I divide the 19 years in to three episodes. The first episode, 1921-25, is the period when output per working-age person was moving towards a peak in 1925. This period is before the start of the crisis. The second episode is the peak-to-trough period is 1925-32. The recovery period is defined as 1932-39.

First, I show the closed economy base case model results in Table 4.2, where the point-to-point growth rates<sup>14</sup> of three episodes are shown. Table 4.2 shows the growth

<sup>14</sup>This is done by the equation 4.5.21. After taking logs in both sides I get equation (4.7.1). I calculate the log changes of the values at the start and end of the year to get the growth rates for each episode.



Table 4.2: Contribution to growth (point-to-point)

-	Data	Model base case	Model constant TFP
Growth 1922-25	-	-	-
change in Y/N	9.66	12.48	8.33
due to TFP	9.99	9.99	9.98
due to K/Y	-3.78	-4.98	-6.06
due to L/N	3.45	7.48	4.41
Peak-to-trough 1925-32	-	-	-
Change in Y/N	-21.23	-19.7	17.75
due to TFP	-15.75	-15.75	17.47
due to K/Y	9.01	10.85	-2.24
due to L/N	-14.49	-14.8	2.52
Recovery 1932-39	-	-	-
Change in Y/N	12.93	8.46	17.91
due to TFP	13.87	13.87	17.47
due to K/Y	-10.60	-5.09	0.37
due to L/N	9.66	-0.32	0.075

rate of output per working-age person and the components of growth: TFP, capital-output ratio and hours worked. The table shows that during 1921-25 the growth of output per working-age person in Australia was around 9.7 percent for the undetrended data. The base case model shows a higher growth of 12.5 percent. The model with constant TFP growth shows a lower growth rate of 8.3 percent. The TFP growth rate was around 10 percent for the base case model and the constant TFP model, which is the same as the data. The growth of capital-output ratio is negative and hours worked is positive for both the model and data.

During the peak-to-trough period (1925-32) growth of output per working-age person is negative for both the base case model and data. The model's output per working-age person falls by 19.7 percent during the peak-to-trough period, compared with 21.2

percent in the data. During the same period, growth in TFP and hours worked are negative while the capital-output ratio growth is positive for both the data and the base case model. So it appears that the crisis started due to negative TFP shocks that might have contributed to negative growth of hours worked. In Australia, growth of average weekly earnings was negative from 1931-34 (Butlin, 1977). The arbitration court ordered a 10 percent wage reduction in January 1931. On the other hand the unemployment rate was increasing from 1928. So the decrease in hours worked was due the adverse effect of both labour supply and demand that did not start in 1925. So the starting point of the Depression is TFP. In 1926 TFP growth was negative that also followed the negative growth in most of the peak-to-trough years.

During the recovery period (1933-39) both the model and the data show positive but slow growth. The model's output per working-age person increases by 8.5 percent during the peak-to-trough period, compared with 12.9 percent in the data. Although the data show an increase in hours worked (9.7 percent), the model predicts a decrease of 0.32 percent. For the constant TFP growth model, output per working-age person is positive during the peak-to-trough period. In this simulation, a higher and fixed TFP shock shows a high growth rate of output.

Similar quantitative comparisons are given in Table 4.3. It shows the results of contribution to growth from the data, the model with balanced trade and the model with exogenous trade balance. In the data, the economy grew 9.66 percent during 1921-25. During this time the model with balanced trade overpredicts (16.9 percent) the growth observed in the data. The model with exogenous trade balance does a better job with a growth of 12.8 percent.

During the peak-to-trough period the model with balanced trade predicts a decline of 23.9 percent of the output per working-age person which is a little higher than the observed data (21.2 percent). The model with exogenous trade balance predicts a decline of 17.0 percent which is lower than the observed data. Although the model with balanced trade does an impressive job of tracking the output per working-age person, it shows a big fall of hours worked compared with the model with exogenous trade

Table 4.3: Contribution to growth (point-to-point)

-	Data	Balanced trade	Exogenous trade balance
Growth 1921-25	-	-	-
change in Y/N	9.66	16.86	12.78
due to TFP	9.91	3.15	2.26
due to K/Y	-3.70	-5.59	-6.62
due to L/N	3.45	19.29	17.14
Peak-to-trough 1925-32	-	-	-
Change in Y/N	-21.23	-23.87	-16.96
due to TFP	-15.75	-10.13	-9.72
due to K/Y	9.01	17.56	17.45
due to L/N	-14.49	-31.3	-24.7
Recovery 1932-39	-	-	-
Change in Y/N	12.93	9.19	9.25
due to TFP	13.91	13.16	13.82
due to K/Y	-10.64	-5.98	-7.54
due to L/N	9.67	2.01	2.96

balance. Also trade was not balanced in every period in the observed data which is an assumption of the balanced trade model.

In the recovery period (1933-39) growth of output per working-age person is positive for the two versions of the open economy model, although these model predict lower growth than the observed data. The average increase of hours worked of these two models is also much lower than the observed data. This slow growth is valid for both the closed and open economy versions of the model. This result is also different from the US situation described by Cole and Ohanian (1999) where their model shows a quicker recovery than the data.

In the closed economy model TFP is exogenously given. In the open economy

model portions of the fluctuations in TFP are endogenous in the sense that terms of trade drives fluctuations in TFP (Conesa et al., 2007). Open economy models are not able to show the actual drop of TFP (10 percent in the model and 16 percent in the observed data). The model accounts for 62 percent of the actual drop of TFP. Again the open economy model accounts for 88 percent of the drop of the output per working-age person while considering exogenous TFP, the base case model can account for 96 percent of the drop in the observed data. So TFP is the most important factor for the drop of output per working-age person rather than the fall in the terms of trade.

## 4.8 Conclusion

This chapter analyses the role of productivity during the Great Depression of the late 1920s to early 1930s in Australia. Investigation is done with both closed and open economy versions of the Australian economy. The peak-to-trough (1925 to 1932) decline of detrended output per working-age person was around 35 percent in the data. Using the growth accounting methodology originally developed by Cole and Ohanian (1999) this chapter finds an important role of the productivity shocks for output fluctuations during the Great Depression. The analysis begins by abstracting from international factors. The artificial economy driven only by TFP shocks can account for 96 percent of the output drop. As Australia is a small open economy and a great role of falling terms of trade (or falling export prices) were suggested by a number of studies (Valentine, 1987a,b; Siriwardana, 1995) as the cause of the Depression, I also test the role of productivity in an open economy context. The open economy model with exogenously given trade balance (includes both TFP and terms of trade shocks) shows a 31 percent peak-to-trough decline of the detrended output per working-age person. Hence the model can account for around 88 percent of the drop. My results show that declining productivity was the major cause of the Depression, unlike the findings by Payne and Uren (2011).

# Chapter 5

## Conclusion

This thesis is an exploration into the sources of aggregate fluctuations and the economic growth of the Australian economy. In this regard, impact of fiscal and technology shocks on the Australian economy are investigated. The thesis consists of three core research papers or chapters. Neoclassical economics is the theoretical base of every chapter. Each chapter explains several important episodes of the Australian economy. Starting from identifying government expenditure shocks from 1980 onwards, I explain the so-called productivity miracle in Australia in the 1990s and the causes of the Great Depression in Australia in the 1920s and 1930s.

Chapter 2 reveals that impact of government expenditure shocks are contractionary from 1980 onwards. In the other two core chapters I find that TFP shocks play an important role for output fluctuations in Australia.

The results presented in Chapter 2 show a contractionary impact on the Australian economy for a positive government expenditure shock. I use a VAR methodology similar to Ramey (2011) to derive the impulse responses. My results show that government expenditure shocks based on newspaper sources have a significantly negative impact on GDP, hours worked, investment and the durable consumption variable, i.e. the impact of government expenditure shocks has been contractionary for Australia. Ramey (2011) shows an expansionary impact on the economy for positive government expenditure shocks with the data range 1939:1 to 2008:4 for the US which includes big government expenditure shocks such as World War II and the Korean war. She shows

neoclassical predictions for consumptions and hours worked. She also finds a contractionary impact on the economy considering the period 1981:3-2008:4 (and therefore without big shocks such as World War II and the Korean War) with her news variable based on professional forecasts. For a better comparison with Ramey (2011), I run a VAR with her news variable based on newspaper sources considering the data range 1980:1 to 2008:4 and I obtain a contractionary impact on the economy for a positive government expenditure shock. In a nutshell government expenditure shocks have been contractionary considering the post-1980 period.

In Chapter 3, the initiative has been taken to find an appropriate model that can explain the causes of the above average output growth in Australia during 1993-2004. Results show that growth of TFP underpinned the above average growth of output per working-age person. During this period, the average growth of output per working-age person was 2.63 percent. The annual average growth of TFP was 2.95 percent which is higher than the growth of TFP during the slowdown period 1988-92 (0.05 percent). I undertake the analysis with several versions of the neoclassical model. The basic model with only TFP shocks shows the importance of productivity in economic growth. The model also predicts a boom in the economy as is reflected in the data. The correlation of the output per working-age person between the model and data is very high (0.99). However, the model predicts a noticeably larger growth of the output per working-age person, compared to the data (average growth 3.09 versus 2.63 percent). Including tax and government expenditure shocks along with TFP shocks improves the model's ability to track the output per working-age person. In most of the versions of the model using average and marginal taxes, the average TFP growth rates are similar to the data. A model with taxes (including TFP shocks) where all tax revenues are transferred back to households shows a growth rate of 2.45 percent using average taxes, and using marginal taxes the growth rate is 2.46 percent. A model with taxes and government expenditure (including TFP shocks) predicts a growth rate of 2.53 percent using average taxes and 2.52 percent using marginal taxes. In all the versions of the model TFP is the highest contributor of the above average growth compared to the contribution of capital and labour components. The analysis also shows parallel findings to Prescott (2004) that taxes have a negative impact on hours worked. All the models that include tax shocks show a lower average yearly increase of hours worked

compared to the model without taxes.

Chapter 4 analyses the role of productivity during the Great Depression in Australia. Investigation is done with both closed and open economy versions of the Australian economy. The peak-to-trough (1925 to 1932) decline of detrended output per working-age person was around 35 percent in the data. Using the growth accounting and great depressions methodology developed by Cole and Ohanian (1999) and Kehoe and Prescott (2002) this paper finds that productivity shocks played an important role in the output fluctuations during the Great Depression. The analysis begins by abstracting from international factors. The artificial economy driven only by TFP shocks can account for 96 percent of the output drop. As Australia is a small open economy and a great role of falling terms of trade (or falling export prices) was suggested by a number of studies (Valentine, 1987a,b; Siriwardana, 1995) as the cause of the Depression, I also test the role of productivity in an open economy context. The open economy model with an exogenously given trade balance (includes both TFP and terms of trade shocks) shows a 31 percent peak-to-trough decline of the detrended output per working-age person. Hence the model can account for around 88 percent of the drop. My results show that declining productivity was the major cause of the Depression, unlike the findings by Payne and Uren (2011) who find that monetary/exchange shocks were the cause.

# Appendix A

## Identifying Government Expenditure News Shocks for the Australian Economy

### A.1 Defence News Variable

Table A.1: Defence news variable based on newspaper sources

Quarter	PDV of expected change in spending, billions of dollars	% of previous quarter GDP
1987:2	-0.350	-0.481
1989:2	-0.135	-0.144
1991:1	0.053	0.05
1993:3	-0.221	-0.193
1994:2	-0.103	-0.086
1999:4	0.5	0.311
2000:4	25.00	14.314
2002:1	0.421	0.225
2002:2	1.684	0.879
2003:2	1.637	0.809
2004:1	13.02	6.049
2005:2	0.5	0.213
2008:3	-7.83	-2.554
2009:2	26.54	8.419

*Note:* PDV is present discounted value.



## A.2 Data Sources

ABS data are taken from the 2009-10 catalogue publication where the base year for real data is 2009.

*Figure 2.2 data source:* Annual nominal values of defence and government expenditure are taken from ABS catalogue 5206.0 Table 32. Annual GDP deflator is taken from catalogue 5204.0 Table 4.

*Figure 2.3, Table 2.3 and all other ABS data:* All are seasonally adjusted quarterly data from ABS catalogue 5206.0 of different tables. Nominal data of government expenditure and defence expenditure are taken from Table 3. Non-farm GDP deflator is taken from Table 20. Real consumption and investment data are from Table 2. Hours worked index and terms of trade index is taken from Table 1. Non-farm unit labour cost is taken from Table 38. There are no quarterly population data before June 1981 which I need for Table 2.3 of chapter 2, but annual population data are available. So I calculate the quarterly population data before 1981 considering the year-on-year growth rate.

*Other quarterly data:* Monthly data for 90-days bank accepted bills are taken from RBA (see Interest Rates and Yields - Money Market). Then I average it for three months. Quarterly population data are taken from ABS catalogue 3101.0 Table 4. For calculating the discount factor (for defence news variable), I calculate the three-month average of the five year government bond rate from RBA (see Capital market yields - Government Bonds). Tax rate is calculated from publications of Australian Taxation Office for all the years. As this rate is annual I put the same rate for every four quarters of the same year.

*News data:* News data are created by me from Australian newspaper sources from 1984:3 to 2009:2. Fairfax newspapers were accessed from [www.afr.com](http://www.afr.com). Newspaper ‘*The Australian*’ were accessed from [www.factiva.com](http://www.factiva.com). Also information from newspapers were taken from Barr Smith Library of the University of Adelaide.

*US data source including Table 2.2:* All the US data are from the Ramey (2011) dataset.

### A.3 Technical Appendix

A  $p$ -th order Vector Autoregressive Model (VAR) with exogenous variable is as follows

$$y_t = v + A_1 y_{t-1} + \dots + A_p y_{t-p} + B x_t + u_t \quad (\text{A.3.1})$$

where  $y_t = (y_{1t}, \dots, y_{kt})'$  is a  $K \times 1$  random vector

$A_i$  are fixed  $K \times K$  matrices of parameters

$x_t$  is an  $R_0 \times 1$  vector of exogenous variables

$B$  is a  $K \times R_0$  matrix of coefficients

$v$  is a  $K \times 1$  vector of fixed parameters, and

$u_t$  is assumed to be white noise;

$$E(u_t) = 0$$

$$E(u_t u_t') = \Sigma$$

$$E(u_t u_s') = 0 \text{ for } t \neq s$$

For simplicity consider a VAR without exogenous variables

$$y_t = v + A_1 y_{t-1} + \dots + A_p y_{t-p} + u_t \quad (\text{A.3.2})$$

It is possible to rewrite the model in moving average form as

$$y_t = \mu + \sum_{i=0}^{\infty} \Phi_i u_{t-i} \quad (\text{A.3.3})$$

where  $\mu$  is a  $K \times 1$  time-invariant mean of  $y_t$ , and

$$\Phi_i = I_K \text{ if } i=0$$

$$\Phi_i = \sum_{j=1}^i \Phi_{i-j} A_j \text{ if } i=1,2,\dots \quad (\text{A.3.4})$$

IRF (impulse response function) (A.3.4) shows the effect of unit increase in the  $k$ th element of  $u_t$  on the  $j$ th element of  $y_t$  after  $i$  periods, holding everything else constant. But as  $u_t$  are contemporaneously correlated, we cannot assume that everything is held constant. Contemporaneous correlation among the  $u_t$  implies that a shock to one variable may be accompanied by shocks to some of the other variables.

We can solve this problem if we had a matrix  $P$ , such that  $\Sigma = PP'$ . Then we can write  $P^{-1}\Sigma P'^{-1} = I_k$

We can thus use  $P^{-1}$  to orthogonalize the  $u_t$  and rewrite as follows

$$y_t = \mu + \sum_{i=0}^{\infty} \Phi_i P P^{-1} u_{t-i} \quad (\text{A.3.5})$$

$$y_t = \mu + \sum_{i=0}^{\infty} \Theta_i w_{t-i} \quad (\text{A.3.6})$$

where  $\theta_i = \Phi_i P$  and  $w_t = P^{-1} u_t$ . Here  $w_k$  would be mutually orthogonal. Now we need identification restrictions. Sims (1980) popularized the method of choosing  $P$  to be the Cholesky decomposition of  $\hat{\Sigma}$ . The IRFs based on this choice of  $P$  are known as orthogonalized IRFs or OIRFs.

## A.4 Creation of Defence News Variable

### Defence News Shocks for Australia, 1984:3-2009:2

This section is to describe the creation of the defence news variable for Australia with a view to replicate Ramey (2011). During the time period there were two big defence expenditure shocks. The first one started from 2000:4 which was a long-term plan of the government after decades of low spending for defence called Defence White Paper 2000. It was a 10-year programme of the government to spend an extra \$23.5 billion in 2000 prices. With less than one year the 9/11 attacks in 2001 also increased the future defence expenditure. Second, big shocks in defence expenditure came from the Defence White Paper 2009 which was also a long-term plan of the government started in 2009:2. The variable created here is the discounted change of defence expenditure of the government. I include only the defence expenditure shocks of the government which are due to foreign political events or due to long-term plans of the government, not due to the response of other macro variables of the economy. To construct the news variable I used the following formula.

$$\sum_{t=0}^T (1/1 + i)^t \quad (\text{A.4.1})$$

So for one period, the discount factor is calculated as  $(1/1 + i)$  where  $i$  is nominal five-year government bond rate. In calculating the discount rate Ramey (2011) used the three-year US treasury bond rate. The suitable counterpart for this in Australia

is the five-year government bond rate. The three-year government bond rate has data only from 1992. The unit of all the PDVs (present discounted value) are in billion of Australian dollars. I used the following news sources for the creation of variables.

*Australian Financial Review*

*The Australian*

*Canberra Times*

*Sydney Morning Herald*

*The Age*

Creation of variables are described below.

### **February-March 1986: Gorbachev announces Perestroika**

#### **20 March 1987: *Sydney Morning Herald***

“The Government’s new Defence White Paper proposes to spend \$25 billion over the next 15 years on capital equipment and new facilities in pursuit of its new self-reliant defence policy.

How can the government find the money for the largest peacetime defence capital investment programme ever? The report carefully avoids any firm commitment on annual defence spending. The clue is that government is already spending \$2 billion annually on new equipment and facilities and can do the job without any real increase in defence spending.

About \$60 million a year, or about one percent of real growth in the budget, is to be saved through the rationalization of the defence industry.”

#### **14 May 1987: *Sydney Morning Herald***

“The defence budget in 1987 is to be cut by \$350 million, undermining the Hawke Government’s move to a strategy of defence self-reliance. For the first time since 1981-82, military spending is to be cut, by 1 percent in real terms after this year’s zero growth of Defence. The planned cut will drastically affect the operating budgets of the three armed services, and are likely to cause deferral of some planned capital equipment programmes outlined in the Defence White Paper tabled in March. The three services will suffer some reduction in operational capabilities, and staff is likely to be reduced in civilian establishments. Forward defence planning has previously been based on a 3 percent annual real growth rate, but has been reduced to minus 1 percent next year,

and 1-2 percent real increases in 1988-89 and 1989-90 respectively.”

**Defence news shock:** Although the government declared a Defence White Paper for defence in 1987 the government never followed it through. Also it did not need any increase in defence spending at that time. It was just a confirmation of the government about spending which was not in excess of the current trend. Therefore, I did not put \$25 billion as a shock. I did include a negative value for the creation of defence news variable, because the news shows a cut of \$350 million. As it is for one year, so discounting is not necessary.

**1987:2 : PDV= -A\$0.350 billion**

**03 December 1987: *Sydney Morning Herald***

“The prime minister Mr Hawke has predicted a substantial increase in two-way trade with Soviet Union following his talks with Soviet leaders. ...Its account of Mr.Hawke’s talk with the Soviet prime minister Mr.Nikolai Ryzhkov, reported that Mr. Hawke welcomed the Soviet Union’s Perestroika (restructuring) policy and spoke highly of Soviet efforts to lessen world tension.”

**March-April 1989-First Free Election in USSR**

**13 April 1989: *Australian Financial Review***

“The department of defence is to have its budget slashed by almost \$150 million over the next 3 years, one of the few sectors of the government to suffer as a result of the treasurer’s statement. The cut of \$71 million next financial year, \$37.9 million in 1990-91 and \$40.1 million in 1991-92 will be achieved by a reduction of 0.5 percent on the base forecast figures. The spending reduction is a major departure from the government’s white paper on defence, Review of Australia’s Defence Capabilities, which proposed growth in spending for the 1986-91 financial period of 3.1 percent.”

**Defence news shock:** It is a cut over three years of \$149 million (71+37.9+40.1). After discounting I get the amount -0.1348 billion. Interest rate is 14.36 percent.

**1989:2: PDV = -A\$0.1348 billion**

**October 1989 Berlin Wall falls**

**4 August 1990 Iraq attacked Kuwait**

**30 January 1991: *Australian Financial Review***

“The Department of Defence estimates that the bill for sending forces to the Gulf could soon blow out to \$150 million. The department had earlier calculated that it would cost about \$50 million for the first six months but spending has ballooned with extra equipment and supplies for the ships that have so far seen service in the region. Department sources said yesterday that estimates for expenditure so far now ranged from \$90 million to \$150 million. A government spokesman said on Monday that the Minister for Defence, Senator Roy, had confirmed that the Gulf deployment could cost \$50 million for the first six months but more detailed estimates were still being prepared.”

**12 February 1991: *Australian Financial Review***

“The Defence Department will receive an extra \$53 million to pay for deploying forces in the Gulf since September, following the approval by Federal Caucus yesterday of an appropriation bill to supplement the defence budget. The Minister for Defence Senator Roy, said last year it would cost about \$50 million to keep Australia’s forces in the Gulf for six months, but department sources said the bill could reach \$150 million.”

**Defence News Shock:** Although there was a possibility of \$150 million, the finally approved amount was \$53 million. So I consider only \$53 million.

**1991:1: PDV= A\$0.053 billion**

**3 August 1993: *Sydney Morning Herald***

“The Australian defence force already under extraordinary financial pressure, is to be hit with further big cuts as the government seeks to rein in the budget deficit...Defence is already facing a real cut of 0.5 percent in 1993-94 (\$50 million), with spending held at that real level in future years - a move foreshadowed in last years budget.

Sources said last night that the size of the reductions in the defence budget would be spread over several years and would not reach the full additional 1.5% proposed by the economic departments.”

**18 August 1993: *Australian Financial Review***

“Future defence spending has taken a \$237 million cut in the Budget forcing the scrapping of one major project and the deferment of others...The cuts will reduce the defence outlays by \$237 million over the 4 years of the forward estimates and involve a further reduction of \$144 million each subsequent year.”

**Defence News Shock:** Here I consider a cut of \$237 million over four years. Assuming an equal amount cut in each of the four years the discounted expected negative change is \$ 221 million. The interest rate is 4.90 percent.

**1993:3: PDV= -A\$0.221 billion**

**11 May 1994: *Sydney Morning Herald***

“The defence budget of almost \$10 billion is to be cut by \$163 million in 1994-95...No major programmes will be affected. But giant budget - 8 percent of Commonwealth’s entire expenditure, and 2.1 percent of GDP - will hardly register the cut.”

**11 May 1994: *The Age***

“The defence budget has been cut by 1.7 percent or \$163 million for the 1994-95, to 2.1 percent of GDP, with cuts in the number of permanent forces expected during the year. Defence now takes up 8 percent of total budget outlays. The cuts reflect a decision last year to reduce the defence budget by 0.5 percent in real terms each year until 1996-97. The budget was slashed by 0.75 percent last year, forcing the closure of several bases and cancellation of some defence purchases.”

**Defence News Shock:** As I already consider on average \$59.25 million cut last year in 1993-94 (as  $237/4=59.25$ ). Now I consider the rest as a shock. That is  $163-59.25=103.75$

**1994:2: PDV= -A\$0.103 billion**

**29 November 1994: *Sydney Morning Herald***

“The federal government will this week claim its post-cold war peace dividend and downgrade the priority of defence spending to its lowest level since the Vietnam War. In its 1994 Defence White Paper to be published tomorrow the government will recommend future defence spending of about 2 percent of gross domestic product despite widespread fears in defence department that Australia now faces a highly uncertain security climate. This is a sharp decline from a spending target of between 2.6 and 3 percent of GDP needed to maintain adequate defence forces set in the 1987 Defence White Paper, although the government never met the earlier target. The Defence Department had been urging the Government to guarantee spending of 2 percent of GDP but senior government sources said yesterday that Minister for Finance, Mr Beazley, had rejected this plea.”

**Defence News Shock:** Here is no shock although a Defence White paper is going to be published.

**1994:4: PDV= A\$0 billion**

**30 September 1999: *The Age***

“...However, the East Timor emergency, coupled with Mr Howard’s belief that the defence budget must be increased from its present \$11 billion a year, has placed urgent pressure on the process. About three weeks ago the Government instructed the departments to accelerate their review, and political pressure has increased substantially since then. Mr Howard told parliament yesterday that his original estimate of \$500 million to send 2000 troops to East Timor for six months would obviously rise if the deployment continued longer, and would be higher again if the number of troops rose to 4500 he has said he would be prepared to commit.”

**Defence News Shock:** Here I consider the shock \$500 million.

**1999q4: PDV: 0.500b**



**7 December 2000: *The Australian***

“The Defence white paper, released yesterday sets out a blueprint for the next two decades and backs it up with a funding plan for the next 10 years...The paper recommended the first sustained funding increase for the sector in two decades: Investment would rise from \$12.2 billion in a year to \$16 billion a year by the end of the decade...It will take spending from 1.8 percent of GDP to 1.9 percent of GDP.”

**7 December 2000: *Australian Financial Review***

“The government has committed itself to an increase in the defence budget next financial year (2001-02) of \$500 million, and in the following year (2002-03) of \$1 billion, and thereafter an average increase over the decade of 3% real growth a year...This means that defence expenditure is expected to increase by a total of almost \$24b in real terms over the decade, compared to total defence spending had the defence budget been held flat at its current level.”

**Defence News Shock:** With this information I first considered the inflation rate of 2000-01. The inflation rate was 4.47 percent in 2000-01. Using the inflation rate I calculated the nominal value. Then I used the discount rate of 0.945, calculated from the five-year government bond rate (5.81 percent) to get the discounted nominal value. Table A.2 shows the calculations. Second column is showing the stream of defence expenditure if Defence White Paper is implemented. Third column is showing the yearly extra expenditure in nominal terms. Fourth column is showing the yearly extra expenditure in nominal terms after discounting.

Expected discounted expenditure in 10 years is A\$25.00 billion that I consider as a shock.

**2000:4: PDV = A\$25.00 billion**

**23 May 2001: *The Age***

“The defence force will receive \$5 billion rise over four years in Australia’s largest peacetime investment in military.”

Table A.2: Calculation for Defence White Paper 2000

Year	Predicted defence ex- penditure \$billion	Extra nomi- nal \$billion	Extra dis- counted nominal \$billion
fy00-01	12.20	0	0
fy01-02	12.70	0.50	0.5
fy02-03	13.70	1.50	1.42
fy03-04	13.33	1.73	1.54
fy04-05	13.73	2.35	1.98
fy05-06	14.14	3.00	2.39
fy06-07	14.57	3.68	2.77
fy07-08	15.00	4.39	3.13
fy08-09	15.46	5.13	3.46
fy09-10	15.92	5.91	3.76
fy10-11	16.40	6.72	4.04
Extra Total	23	34.90	25.00

**23 May 2001: *Sydney Morning Herald***

“Defence Minister, Mr Reith, said yesterday that the budget had delivered on White Paper commitments with an extra 4.7 billion over 4 years as part of a 10-year, \$23.5 billion upgrade.”

**Defence News Shock:** During the announcement of the budget of 2001-02 the Australian Government declared the defence expenditure in line with the Defence White Paper commitment. Although there was some change in the plan, such as indicating expenditure for next four years, but it did not change the total amount. So I did not include any shock here.

**2001:2: PDV = A\$0 billion**

**9/11 attacks**

**18 October 2001: *Australian Financial Review***

“Westpac Australia chief economist Mr.Nigel Stapledon said the action could tip the budget into deficit, given the government was forecasting a slim \$500 million surplus in 2001-02. Mr.Costello said that even though the deployment was not factored into Tuesday’s budget forecast, additional defence expenditure outlined in the Defence White Paper reduced the need for additional short-term expenditure, barring unforeseen events. But he conceded that if the military commitment went on for some time there might be a need for extra funding.”

**30 January 2002: *Australian Financial Review***

“Government sources said the department were seeking urgent cabinet approval for a total of \$590 million in extra funding for the rest of the financial year alone an amount that would eliminate the estimated budget surplus of \$500 million. The department will also push for an extra funding of 1.2 billion in 2002-03.”

**15 February 2002: *The Age***

“Four months after promising that the cost of the war on terror would be absorbed in the budget, the Howard government has asked parliament for a \$320 million top-up to meet the cost of sending troops to Afghanistan.”

**Defence News Shock:** News is conflicting here with one newspaper reporting \$590 million and another \$320 million. So I looked at the budget document. The ultimate cost was \$348 million.

**2002:1: PDV = A\$0.348 billion**

**1 May 2002: *The Australian***

“The Howard Government is working towards a surplus in this year’s Budget of between \$500 million and \$1 billion - but there is a shadow over future surpluses. Intelligence and defence assessments are causing concern in the Coalition that military spending will have to grow substantially beyond the Government’s \$27 billion 10-year plan. Under the DWP, the coalition has already approved extra military spending of \$5.1 billion over four years, with additional spending of \$507 million this year, growing to an extra

\$2 billion in 2004-05. John Howard and Peter Costello have warned tax payers to expect to pay more for the war against terror than first forecast. Senior cabinet sources say there will not be an immediate impact on the May 14 budget, but within three years there will be much heavier defence demand than expected.”

**15 May 2002: *Newcastle Herald***

“The budget commits more than \$2.8 billion extra to Australia’s defence and security forces to help combat terrorism following the September 11 attacks on the United States but it contains a bitter bill for the sick and disabled. With more than 1100 Australian soldiers involved in land, sea and air operations in support of war on terrorism, Mr. Costello announced an extra \$524m for the defence forces, on top of the \$1 billion already earmarked under the DWP.”

**15 May 2002: *The Age***

“Afghanistan and terrorism are pushing up the cost of security, Mark Forbes reports. Defence spending has jumped nearly \$1 billion to fund the military’s highest level of operation since Vietnam and meet the threat of increasing global instability. The commitment to war in Afghanistan will cost nearly \$200 million next year, navy ships will continue to seek out against asylum seekers and a new terrorist response group and bio-terrorism regiment will be set up.”

**Defence News Shock:** There is some conflicting information on extra defence spending, so I checked with the budget document. The amount is around \$0.5 billion for one year. Furthermore, for upgrading domestic security \$1.3 billion is spent in five years (Budget Document). The interest rate is 5.91 percent. I calculate the discounted value of \$1.3 billion over five years which is \$1.162 billion. Then I sum up  $0.5+1.162=1.662$  billion.

$$\mathbf{2002:2: PDV = \$0.5 + \$1.162 = \$1.662 \text{ b}}$$

**12 October 2002: Bali Bombing**

**31 October 2002: *The Australian***

“Extra budget spending on defence will be considered in the wake of the Bali bombings, Treasury Peter Costello has said - but it might not be the predicted \$1 billion. Mr. Costello said yesterday Australia’s \$14.6 billion-a-year defence budget already had received a big boost following Australia’s involvement in East Timor and Afghanistan, and further requests would be considered on their merits.”

**22 November 2002: *Australian Financial Review***

“Defence Minister Hill’s 1.5 billion plan rejected.”

**Defence News Shock:** Although there was a probability of extra expenditure after the Bali bombing, that did not happen as already there was enough funding for defence and national security. So nothing is added as shocks.

**2002:4: PDV = A\$0 billion**

**29 April 2003: *Australian Financial Review***

“The federal government is committed fully to supplementing Defence for the \$300 million to \$500 million cost of the war and to maintaining 3 percent real growth in funding agreed in the 2000 Defence White Paper.

...It will sidestep what Paul Dibb has called the ‘coming train smash’ in defence spending the widening gap between rising personnel, operating and acquisition costs and projected increases in defence funding.

The extent of this gap will be clearer at the end of this year when a review of the 10-year \$50 billion Defence capability plan reveals the updated cost of planned acquisitions. So far the federal government has guaranteed defence \$27 billion for capacity building.”

**14 May 2003: *Canberra Times***

“Australia’s over-stretched military will be upgraded for wear and tear with new funding in the budget on logistics totalling an extra \$1.1 billion over 4 years. The extra moneys will be in addition to the Defence White Paper plan.... In 2003-04 defence will receive \$15 billion in funding, about 2% of GDP. The funding is a part of treasurer Peter Costello’s plan in this budget to spend an extra \$2.2 billion on defence over the next four years. Starting in 2003-04 defence will get nearly \$250m for logistics rising

to \$285m in 2004-05 and 2005-06, before dropping to \$229m in 2006-07.”

**14 May 2003: *The Age***

“National security will receive \$2.5 billion boost designed to defend Australia at home and increase the military capacity to operate abroad. The additional funding is spread over five years and above the increase promised in the government’s defence white paper. It includes \$645m allocated for the invasion of Iraq and participation in peace keeping and reconstruction there.”

**Defence news shock:** There are conflicting amounts of \$2.1 or \$2.5 billion. Looking at the budget document I confirm that it is \$2.1 billion over five years starting from 2002-03. In 2002-03 cost of Iraq was \$0.348 billion which is part of this \$2.1 billion, I deduct that amount and the remainder is  $\$2.100 - \$0.348 = \$1.752$  billion. So I split this amount equally over the next four years and discounted at an interest rate of 4.73 percent.

**2003:2: PDV = A\$1.637 billion**

**14 February 2004: *Australian Financial Review***

“About \$500 million in planned spending on major military equipment this year has been cancelled because the Defence Department cannot spend the money on time. The cancellations, revealed in additional Defence portfolio estimates quietly released last Wednesday, cast doubts on federal governments ability to complete the revised 10-year \$50 billion defence capability plan unveiled recently by Defence Minister Robert Hill.”

**Defence news shock:** If the government sticks to implementing the Defence White Paper 2000, then nominal defence spending would increase to \$50 billion over 10 years. In the news shock of 2000:4 I already considered the nominal amount \$34.90 billion so after deducting  $\$50 - \$34.90 = \$15.1$  billion. Discounting that for the next six years the amount is \$13.02 billion.

**2004:1: PDV = A\$13.02 billion**

**11 May 2005: *The Age***

“The cost of joining the war in Iraq has blown out to \$1.2 billion, including a projected \$240 million for the 450 troops who arrived in the southern province of Al-Muthanna last month. Increasing cost of operations such as Iraq, along with military counter-terrorism measures, brings the total defence budget to \$17.5 billion next year, an increase of \$500 million. That rise does not include the \$2.3 billion that three percent annual increase guaranteed under the government’s Defence White Paper. The government has also brought forward \$300 million for buying new weapons, delayed in the previous budget.”

**Defence News Shock:** The news makes it clear that \$0.5 billion expenditure is not part of the Defence White Paper commitment. So I add up \$0.5 billion as the defence news shock.

**2005:2: PDV = A\$0.5 billion**

**27 May 2006: *The Australian***

“Next financial year the government will spend \$19.6 billion on defence, up \$1.9 billion on this year and equivalent to 1.9 percent of GDP. This represents an 8 percent increase in real terms - the largest single annual increase since Australia expanded its commitment in Vietnam in 1967.”

**Defence News Shock:** Although it was a big increase, I already included this in the previous Defence White Paper shocks. The Defence White Paper also iterates defence expenditure as 1.9 percent of GDP. So at this time the shock is zero as this is not extra spending.

**2006:2: PDV= A\$0 billion**

**07 July 2008: *Sydney Morning Herald***

“The Minister for Defence, Joel Fitzgibbon, has highlighted the need to improve efficiency and instructed his department to find \$1 billion in savings each year for the

next 10 years.”

**26 September 2008: *Australian Financial Review***

“While guaranteeing 3% real increases in spending every year until 2018, Prime Minister Kevin Rudd still managed to slash \$1 billion from the defence budget this year. Rudd also moved to break with the Howard era by withdrawing Australian combat forces from southern Iraq. The move had threatened to upset the alliance with the US but was deftly handled and coincided with a dramatic improvement in conditions in the strife-torn country.”

**Defence News Shock:** News shows that the government wants a cut in defence spending. From the news I consider \$10 billion over the next decade, with \$1 billion each year. It is a nominal amount. After discounting the amount is \$7.83 billion. My data in this research are only up to 2009. So the question is whether we should use the whole amount as a shock. Here I followed Ramey (2011). In her last shock 2008:4 she added the planned cut of the US government up to 2013 although her data are up to 2008:4, So here I consider the total amount.

**2008:3: PDV: A\$-7.83b**

**25 April 2009: *The Australian***

“Kevin Rudd is set to announce Australia’s biggest military build-up since World War II, led by a multi-billion dollar investment in maritime defence, including 100 new F-39 fighters, a doubling of the submarine fleet, and a powerful new surface warships. Senior government sources say Mr Rudd has insisted that defence spending remain largely insulated from the government’s budget difficulties, but the defence department will still have to find at least \$15 billion of internal savings over the next decade to help pay for the \$100 billion-plus long-term equipment plan.”

**28 May 2009: *Australian Financial Review***

“The defence white paper released by prime minister Kevin Rudd in April laid out a \$146 billion-plus 20-year weapons wish list including new submarines and jet fighters, and was predicted on the possibility of a conflict involving China. But some analysts



suggested the wish list would run to as much as \$170 billion....Dr.Thomson, who was a member of the government’s white paper consultative team, says in the report that in terms of long-term weapons plan the government had guaranteed Defence 3 percent real average increases out to 2017-18 but this would fall back to 2.2 percent from 2018-30.”

**Defence News Shock:** From the news, the government committed to a 3 percent average annual increase of defence expenditure up to 2017-18. In 2008-09 defence expenditure was \$22.7 billion. Considering a 3 percent real increase, I get the nominal value using the inflation rate of the time 1.5 percent. The interest rate was 4.54 percent for the five-year government bond rate, so the discount rate was 0.96. Table A.3 shows the calculations. The second column shows the stream of defence expenditure if the 2009 Defence White Paper is implemented. The third column shows the yearly extra expenditure in nominal terms. The fourth column shows the yearly extra expenditure in nominal terms after discounting.

Table A.3: Calculation for Defence White Paper 2009

year	Predicted defence expenditure	Extra nominal	Extra discounted nominal
fy09-10	23.38	1.03	1.03
fy10-11	24.08	1.74	1.67
fy11-12	24.8	2.48	2.27
fy12-13	25.55	3.23	2.83
fy13-14	26.32	4.01	3.36
fy14-15	27.10	4.81	3.85
fy15-16	27.92	5.63	4.31
fy16-17	28.76	6.49	4.76
fy17-18	29.62	7.36	5.16
Extra Total	25.58	36.78	29.23

After calculation I get expenditure of \$29.23 billion up to 2017-18. I deduct values for 2009-10 and 2010-11 as I already included that in previous years. I get the net value

of  $\$29.23 - \$1.03 - 1.664 = \$26.54$  billion.

**2009:2: PDV: A\$26.54**

## A.5 Figures

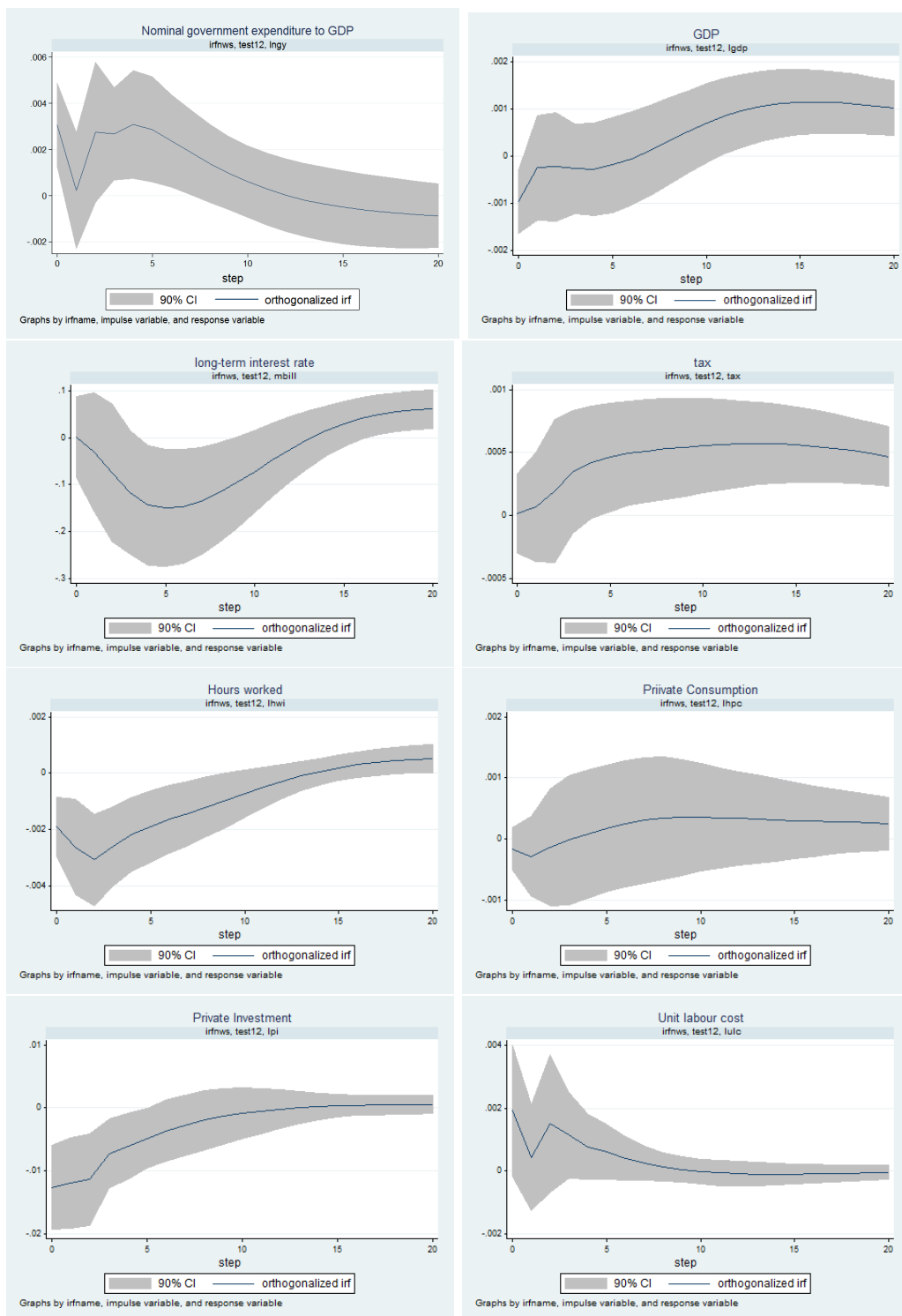


Figure A.1: VAR with defence news variable  
*Note:* Here nominal government expenditure to GDP ratio is the second variable instead of total government expenditure.

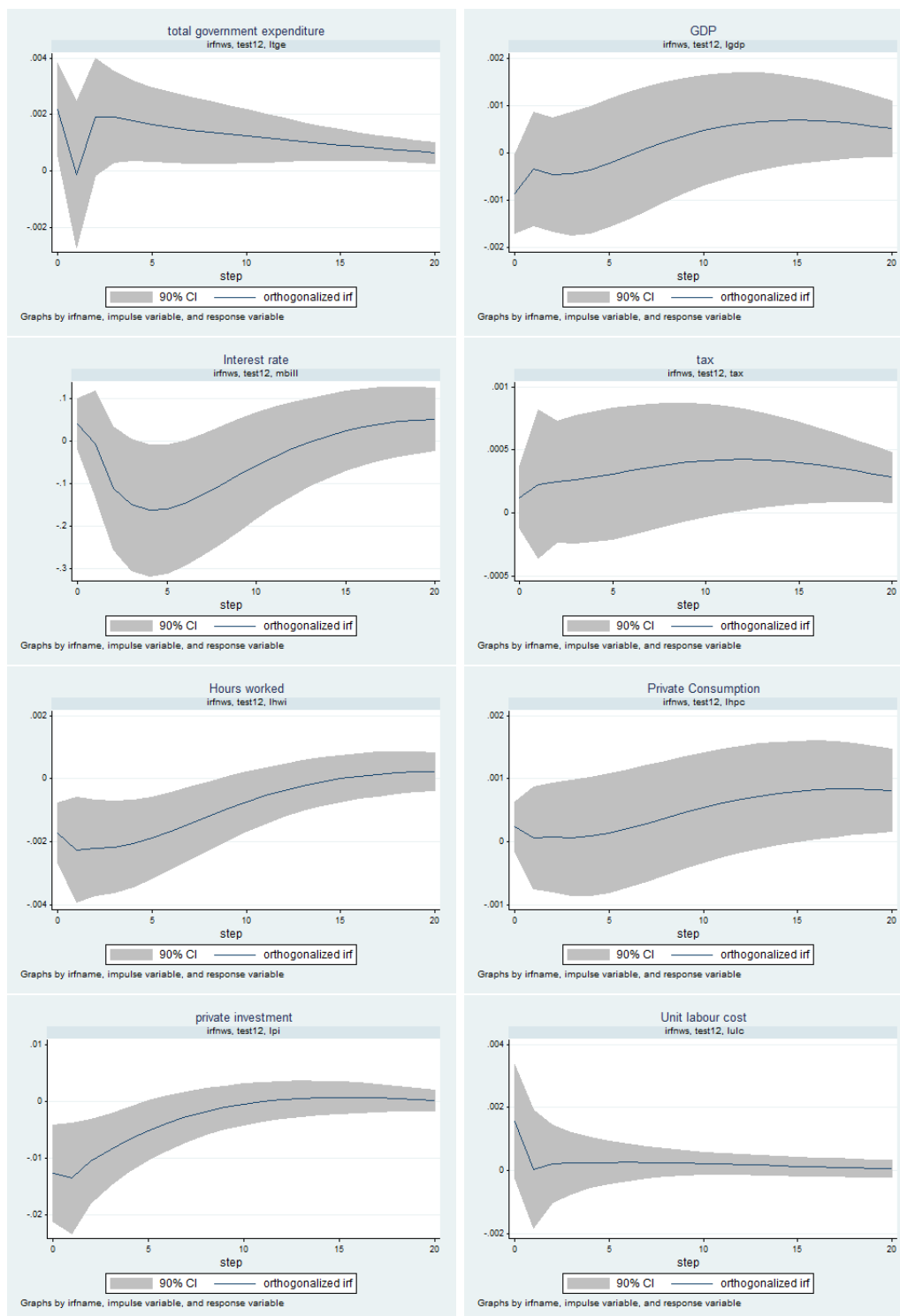


Figure A.2: VAR with defence news variable without rotation

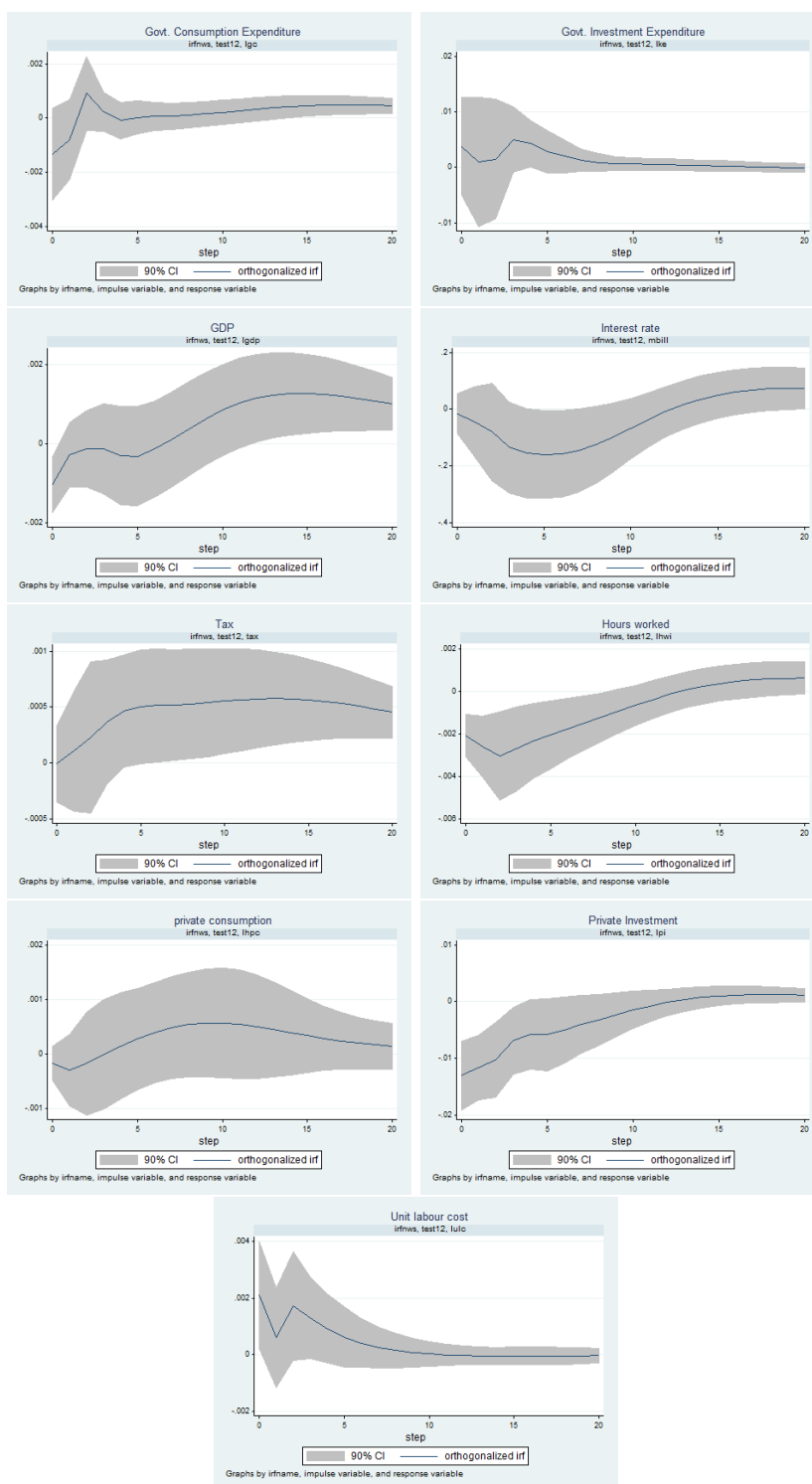


Figure A.3: VAR with segregating government consumption and investment expenditure

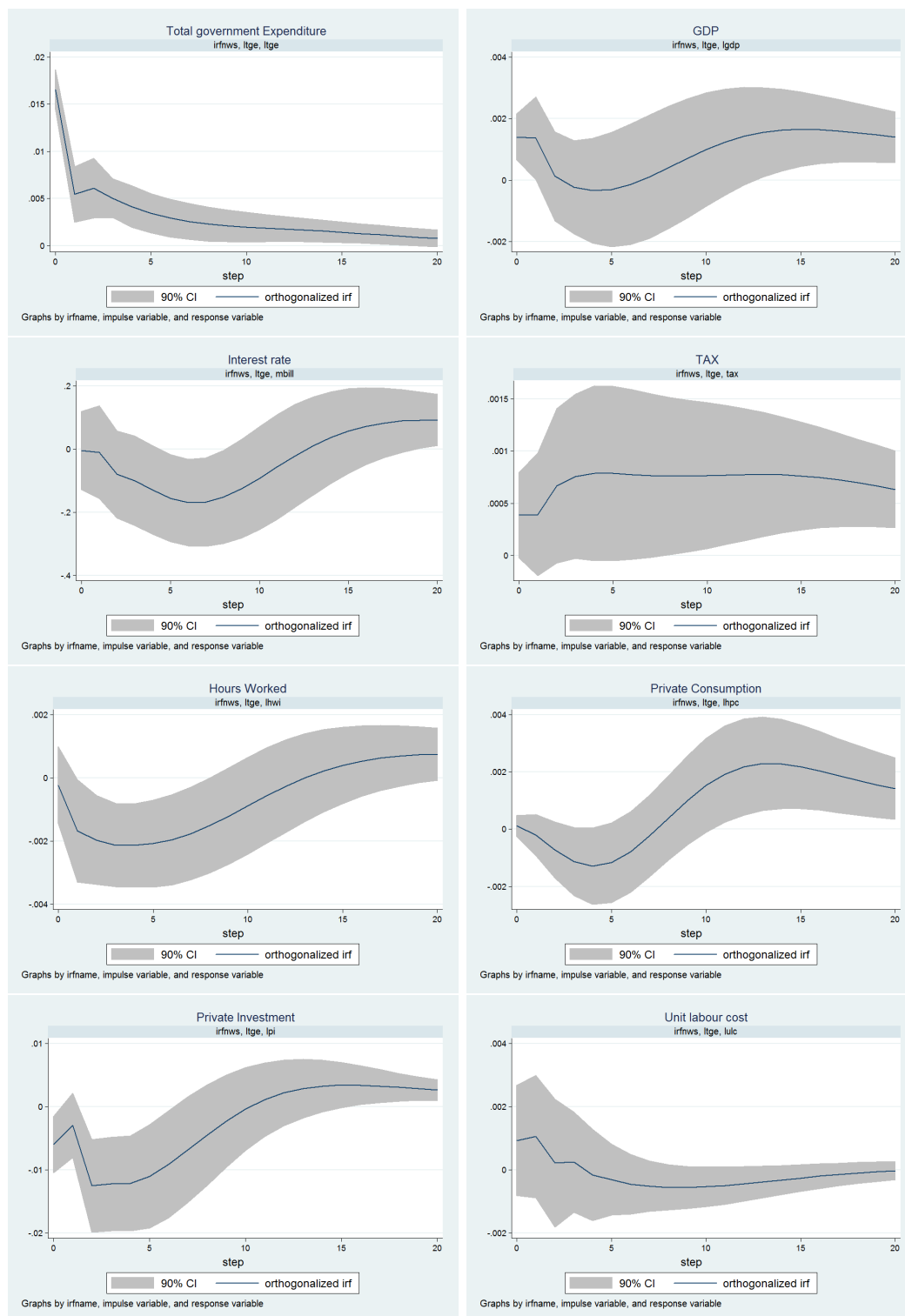


Figure A.4: VAR without news variable and with rotation

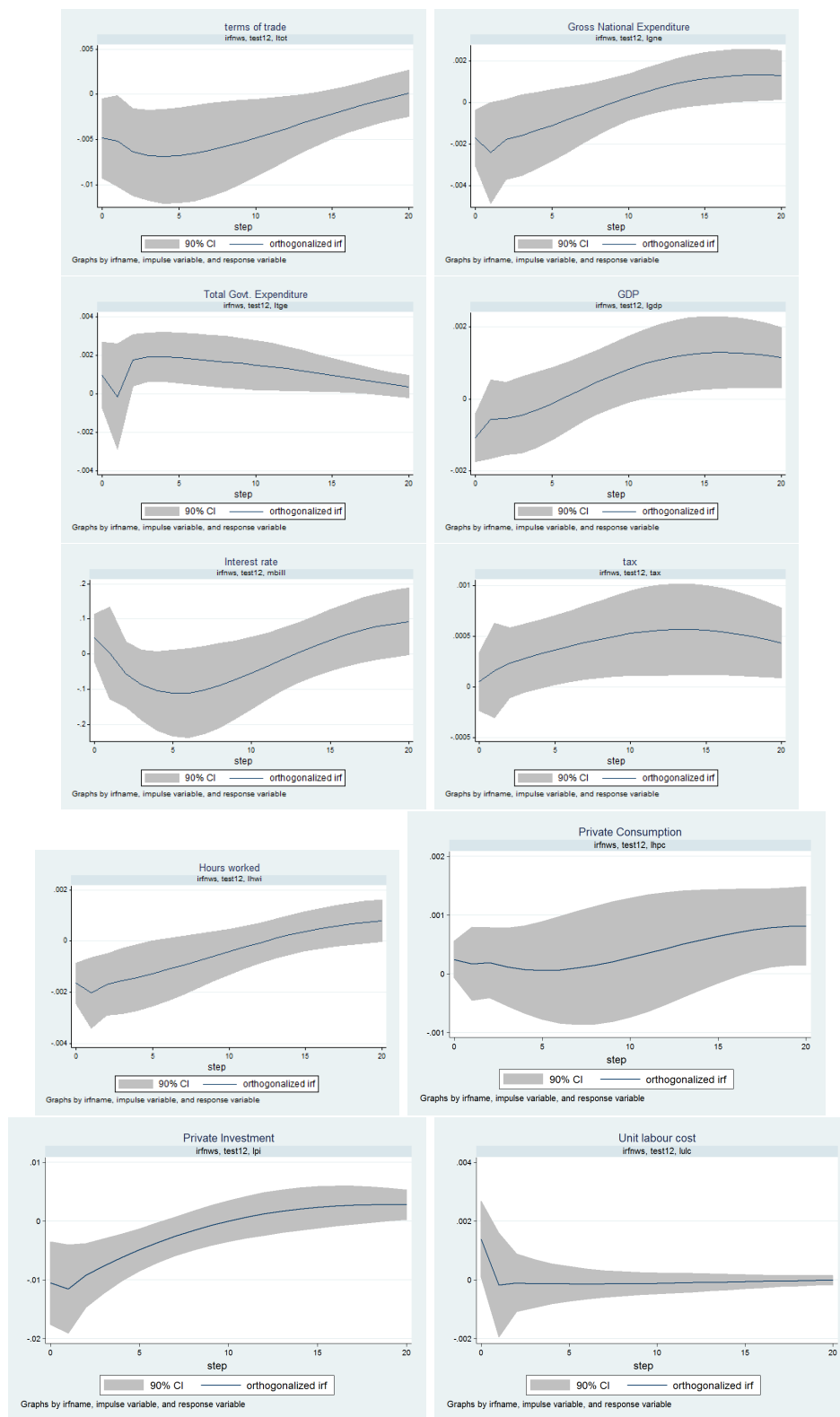


Figure A.5: VAR with externally affected variables

# Appendix B

## Productivity, Taxes and the Australian Business Cycle

### B.1 Data Sources

*Figure 3.1, 3.2 data source:* Working age (15-64) population data are taken from catalogue 3105.0.65.001 of the Australian historical population statistics of the ABS. I calculate the working-age population by adding up the population of relevant age groups. Annual GDP data are taken from catalogue 5204.0 Table 2. US GDP data are taken from the BEA database. US population data are taken from the US Census Bureau. Adding up the population of the relevant age groups I calculate the working-age population.

*Data for model:* All relevant data are taken from different tables of catalogue 5204.0 of the ABS.

*Note:* All the ABS data taken for the calculation of this chapter are chain volume real data. For the growth accounting, here I add up or deduct data as like as fixed base year real data (for example,  $\text{consumption} = \text{GDP} - \text{investment} - \text{government} - \text{net export}$ ). If we use chain volume data we cannot add or deduct the components of GDP. If we add or deduct then it is a gross approximation if I add up or deduct few components or choose a shorter time period from the base year (base year is 2009). Here, in my calculation I needed to add up or deduct only two or three components to get necessary data and my data is not a long time series (only 22 years), so overall the results will not be so much different.



## B.2 Calculation of Tax Rates

I calculate tax rates following the methodologies of McDaniel (2007) who followed the idea from Mendoza et al. (1994). In the literature there are many ways of calculating tax rates. Here I explain the way I have calculated tax rates for Australia.

### Consumption tax rates

McDaniel (2007) method: He considers that the taxes on production and imports,  $TPI$  are the sum of consumption and investment taxes. Tax on production and imports consists of general taxes on goods and services, excise taxes, import duties and property taxes. Then there are two issues to be dealt with (1) Treatment of property taxes (2) Proper division of  $TPI$  across consumption and investment. Only a small fraction of property tax is paid by entities other than households, such as business. So it should be taken out. He calculates that the proportion of property taxes that goes to entities other than household is  $\mu = 0.119$  for Australia considering data 1960-2003. In my tax rate calculation, I also choose  $\mu = 0.119$  for Australia. Tax revenue of this part is allocated to capital. Tax revenue that falls on households for consumption and investment are therefore  $\widetilde{TPI} = (1 - \mu)TPI$ . He allocates  $\widetilde{TPI}$  in consumption and investment taxes according to their share. He identifies taxes that fall strictly on consumption expenditure, and calculates revenue collected from consumption expenditure.

$$TPI_c = (\lambda + (1 - \lambda)\frac{C_t}{C_t + I_t})(\widetilde{TPI}_t - Sub_t) \quad (B.2.1)$$

Consumption expenditure is reported in the National accounts gross of taxes. Taxable consumption expenditures are then  $C - TPI_c$  and consumption tax is measured as

$$\tau_t^c = \frac{TPI_c}{C_t - TPI_c} \quad (B.2.2)$$

Since  $TPI_c$  represents revenue from consumption taxes, the remaining part of  $\widetilde{TPI}_t - Sub_t$  is attributed to taxes on investment. I choose the same  $\lambda$  as McDaniel (2007), with a value of 0.469.

*Data Source:* ‘Taxes on production and imports’ and ‘subsidies’ data are taken from ABS catalogue 5204.0 Table 30. Private investment and consumption data are taken from ABS catalogue 5204.0 Table 2.

### Labour and capital income tax

McDaniel (2007) calculates the tax rates in a similar way of Mendoza et al. (1994),

but one difference. Mendoza et al. (1994) deducts consumption of fixed capital or depreciation in calculating capital tax rates but McDaniel (2007) does not deduct that. Regarding ignoring the depreciation, he mentions that consumption of fixed capital can vary widely relative to capital income across years for a given country. So calculating tax rates on net income would produce tax rates that fluctuate a great deal on the basis of the variation of the entry of consumption of fixed capital. Household average income tax rate is calculated by

$$\tau_t^{inc} = \frac{HHT_t}{GDP_t - (TPI_t - Sub_t)} \quad (B.2.3)$$

where  $HHT_t$  is total taxes on income of the household at year t,  $GDP$  is gross domestic product,  $TPI$  is taxes on production and imports and  $Sub$  means subsidy. Now to calculate labour and capital taxes we need to divide labour and capital income. Let  $\alpha$  be the share of income attributed to capital and  $1 - \alpha$  is the share of income attributed to labour. Following McDaniel (2007) I set up an accounting identity from which labour share is calculated.

$$(1 - \alpha)(GDP_t - (TPI_t - Sub_t)) = W_t + (1 - \alpha)MI_t \quad (B.2.4)$$

Here  $W_t$  is compensation of employees and  $MI$  is mixed income. Rearranging I can write,

$$(1 - \alpha) = \frac{W_t}{GDP_t - (TPI_t - Sub_t) - MI_t} \quad (B.2.5)$$

Household income taxes paid on labour income are calculated as,

$$HHT_t^L = \tau_t^{inc}(1 - \alpha)(GDP_t - (TPI_t - Sub_t)) \quad (B.2.6)$$

Labour income is also the source of social security contributions ( $SS_t$ ). Australia does not have a compulsory social security contribution scheme. In the OECD database it is shown as zero. Also email correspondence with ABS confirmed that it is zero. Now the average tax rate on labour income can be calculated as,

$$\tau_t^l = \frac{SS_t + HHT_t^L + TPW}{(1 - \alpha)(GDP_t - (TPI_t - Sub_t))} \quad (B.2.7)$$

Here  $SS$  is total social security contribution which is zero for Australia.  $TPW$  is taxes on payroll and workforce. Here following Conesa et al. (2007) I add up taxes on payroll and workforce with the income taxes paid on labour income. For calculating

the marginal labour tax, I multiplied the household average tax rate by 1.6 following Prescott (2002). Marginal household income tax rate is

$$\tau_t^{inc} = 1.6 * \frac{HHT_t}{GDP_t - (TPI_t - Sub_t)} \quad (B.2.8)$$

This household tax rate is used to get both the average and marginal tax rates for labour and capital. I assume that the household faces the same tax rates on capital income and labour income.

Total capital tax revenue collected from household is,

$$HHT_t^C = \tau_t^{inc}(\alpha(GDP_t - (TPI_t - Sub_t)) - OSGOV_t - CT_t) \quad (B.2.9)$$

where OSGOV is the gross operating surplus of the government and CT is taxes on income profit and capital gains of corporations. Then the average tax rate on capital income is calculated as,

$$\tau_t^k = \frac{HHT_t^C + CT_t + \mu TPI_t}{\alpha(GDP_t - (TPI_t - Sub_t)) - OSGOV_t} \quad (B.2.10)$$

*Data Source:* In the ABS data mixed income (MI) is ambiguous household income that includes both labour and capital income of private unincorporated enterprises. MI data are taken from ABS catalogue 5204.0 Table 36.  $TPI - Sub$  is taken from ABS catalogue 5204.0 Table 30. Data of the taxes on income, profit and capital gains of individuals (HHT) are taken from OECD data on income and profit code 1100. In the OECD website there is no data of Australia on total social security contribution (SS). Also corresponding with the ABS I confirmed that Australia does not have a compulsory social contribution scheme from the government like the European countries . Therefore it is shown as zero in the OECD website. Taxes on payroll and workforce are taken from OECD website, code 3000. For calculating the capital tax  $CT_t$  data are taken from the OECD website on income and profit, code 1200. OSGOV data are taken from ABS catalogue 5204.0 Table 6.

### B.3 Solution Method

Choosing  $K_{T_0+1}, K_{T_0+2}, \dots, K_{T_1}$  and  $L_{T_0}, L_{T_0+1}, L_{T_0+2}, \dots, L_{T_1}$  to satisfy (3.4.17) for  $t = T_0, T_0+1, \dots, T_1$ , and (3.4.18) for  $t = T_0, T_0+1, \dots, T_1-1$  requires solving  $2(T_1 - T_0) -$

1 equations in  $2(T_1 - T_0) - 1$  unknowns. A MATLAB programme is used here where Newton's method is used to solve the system of equations. Let us define the stacked vector of variables  $x = [K_{T_0+1}, K_{T_0+2}, \dots, K_{T_1}, L_{T_0}, L_{T_0+1}, L_{T_0+2}, \dots, L_{T_1}]'$  and arrange the system of equations so that they are of the form  $f(x) = \bar{0}$ , where  $\bar{0}$  is  $2(T_1 - T_0) - 1$  vector of zeros. The algorithm involves making an initial guess at the variables,  $x^0$ , and updating the guess by  $x^{i+1} = x^i - Df(x^i)^{-1}f(x^i)$ , where  $Df(x^i)$  is the matrix of partial derivatives of  $f(x)$  evaluated at  $x^i$ . The system of equations does not have closed-form expressions for the partial derivatives needed to compute  $Df(x^i)$ , and so the derivatives have to be evaluated numerically. A solution is obtained when the function, evaluated at the new iterate of  $x$ , has a maximum error less than some value  $\epsilon$ , where  $\epsilon$  is a small number. Although this method of solving a system of nonlinear equations can converge to a solution quickly, this method is not globally convergent and can become stuck away from a zero of  $f(x)$  or may not converge at all. The initial guess,  $x_0$ , is important. Further details on the implementation of Newton's method can be found in Press et al. (2002). To increase the probability of the algorithm converging to the correct answer, we solve a sequence of models, beginning with a simple version of the model, which we know how to solve, and progressing to the model that we would like to solve. The first model we solve is the one in which TFP, population, and available hours are constant and equal to their average values from 1988 to 2009, and the tax rates are all zero. The solution to this problem is relatively easy to find. The next model takes TFP, population, available hours, and tax rates to be convex combinations of the constant values used in the initial model and the actual values of TFP, population, available hours, and tax rates from the data. Let  $\lambda$  be the weight on the constant values, so that  $(1 - \lambda)$  is the weight on the values from the data. The algorithm requires repeatedly decrementing  $\lambda$  and solving the resulting model, each time using the solution to the model before it as the initial guess. The algorithm proceeds until it solves the case in which  $\lambda = 0$ , which corresponds to the model whose solution we desire. If the value of investment becomes negative in some period  $t$ , we replace the corresponding equation (3.4.18) with equation (3.4.19). As we change  $\lambda$ , we check that the inequality (3.4.20) holds. If it does not, we replace the corresponding (3.4.19) with (3.4.18).

## B.4 Additional Figures

Two additional figures are presented here. Figure B.1 shows a comparison between my calculated TFP and the ABS multifactor productivity. Figure B.2 shows my calculated tax rates and McDaniel (2007) tax rates.

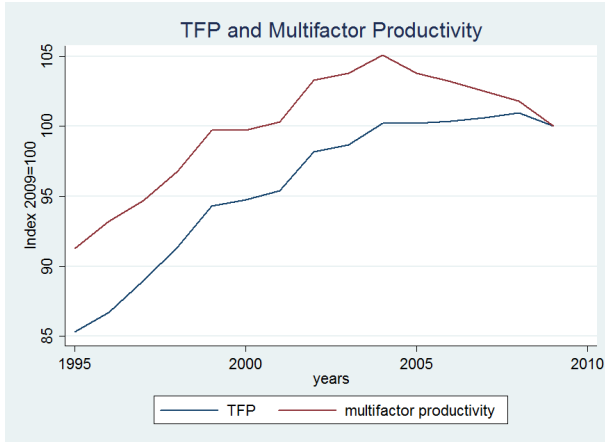


Figure B.1: Calculated TFP and ABS multifactor productivity

*Note:* Here multifactor productivity is value-added multifactor productivity of market sector from ABS. My calculation of TFP is for total economy.

## B.5 Open Economy Model

Australia is a small open economy, so it is reasonable to do the experiment within an open economy framework, which includes the effect of terms of trade. Much of the empirical macroeconomics literature on Australia includes external or foreign variables in the model such as terms of trade, US GDP, interest rate etc especially those using VAR or SVAR approach. In the broader context, examples include Dungey and Pagan (2000), Dungey and Pagan (2009), Nimark (2009) and Jääskelä and Smith (2011). Here the open economy model is similar to Conesa et al. (2007), which includes the role of relative price changes particularly terms of trade shocks. Figure B.3 helps to understand the openness of the Australian economy and its trade balance situation in nominal and real terms. The upper left figure of Figure B.3 shows the trade intensity and upper right shows the nominal trade balance in terms of the percentage of GDP. The lower left figure of Figure B.3 shows the real trade balance index and lower right

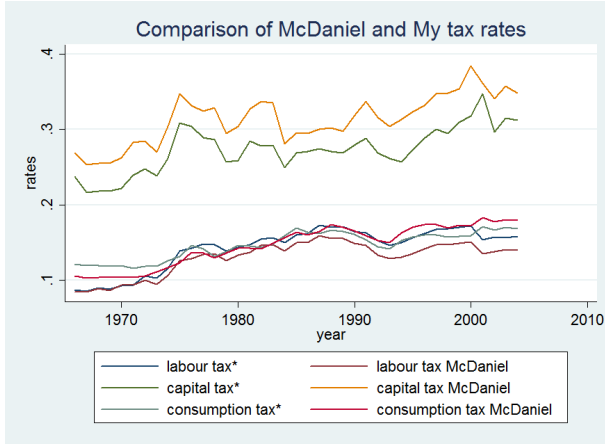


Figure B.2: Comparison of McDaniel and my average tax rates

*Note:* Here star means calculated tax rates by me. Also note that, tax rates are calculated here considering variable labour share. In the calculation of model, tax rates are calculated using constant labour share as in the model, we need to put constant parameter for capital share.

shows the relative prices in terms of exports. In the figure the relative price of export and import is the inverse of conventional terms of trade. It is the price of imports by price of exports.

### B.5.1 Model with Balanced Trade

In this model, it is assumed that the nominal trade balance is zero. It is true that the nominal trade balance was not zero during the time period, but it is more or less around 2% of nominal GDP and the figure shows that in around 50 percent of the years, nominal trade balance was close to zero. The upper right figure of Figure B.3 shows this. However, another exercise is done considering the exogenously given trade balance in the next section.

### B.5.2 Model

First we assume that there are three types of goods in the economy - a domestically produced good, an imported good and a non-traded investment good. The representative household chooses consumption of domestic goods, consumption of imported

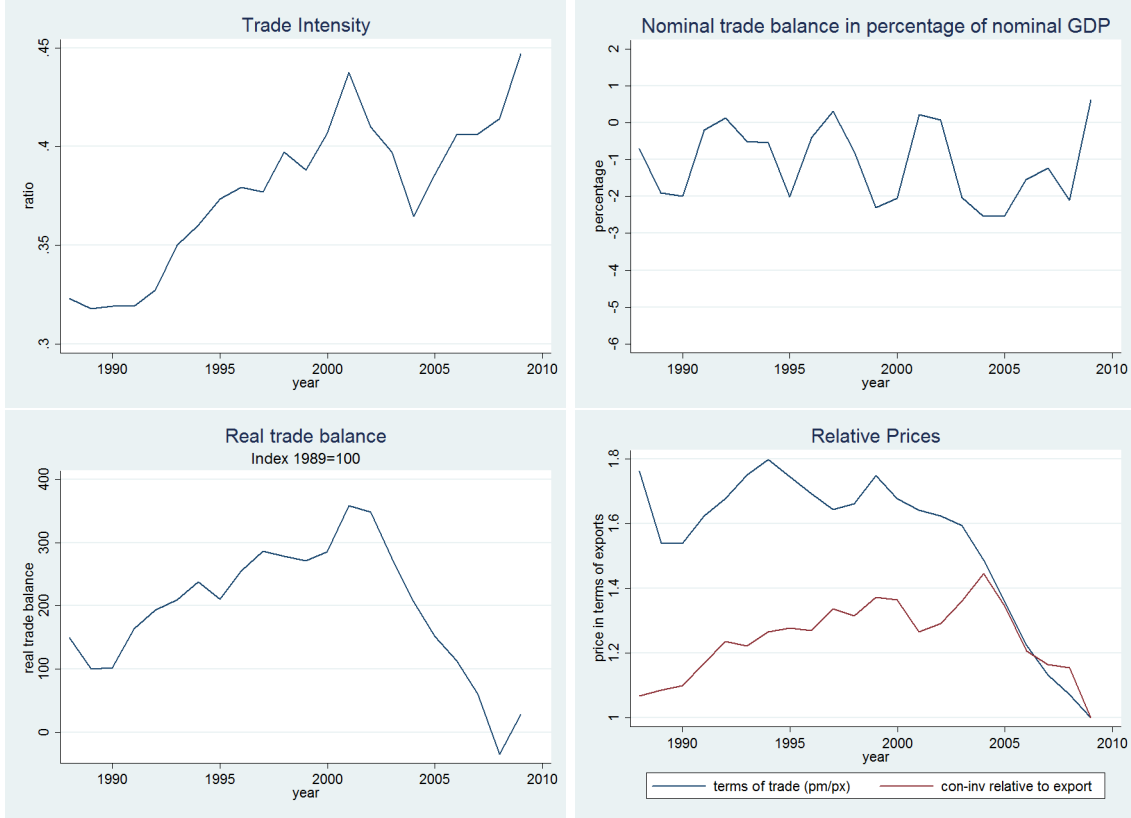


Figure B.3: Openness of the Australian economy

*Note:* Here terms of trade (price of imports divided by price of exports) is the reverse of the conventional definition. A reduction in this ratio means improvement of terms of trade

goods and leisure to maximize utility,

$$\sum_{t=T_0}^{\infty} \beta^t (\gamma \log(\nu(C_{d,t}C_{m,t})) + (1 - \gamma) \log(\bar{h}N_t - L_t)) \quad (\text{B.5.1})$$

subject to the following budget constraint

$$p_{d,t}C_{d,t} + p_{m,t}C_{m,t} + q_t(K_{t+1} - (1 - \delta)K_t) = w_tL_t + r_tK_t \quad (\text{B.5.2})$$

Also we need an appropriate non negativity constraint and a constraint on the initial capital stock,  $\bar{K}_{T_0}$ . The domestic good price is considered as numeraire, so we set  $P_{d,t} = 1$ . Part of the domestic good is exported and the rest is used to produce the investment good, so domestic good is same as exported good. The price of the investment good relative to the domestically produced good is  $q_t$ . The relative price of the imported good is  $p_{m,t}$ . Since we assume that the export good is the same as

the domestic good,  $p_{m,t}$  is also the terms of trade. The domestic good follows the same production technology as in the base case model. Investment goods technology is different, i.e. it is not Cobb-Douglas. It is made by both the domestic good and imported good using a constant elasticity of substitution (CES) production function which is called Armington Aggregator.

$$I_t = K_{t+1} - (1 - \delta)K_t = D_t(\omega I_{d,t}^\rho + (1 - \omega)I_{m,t}^\rho)^{1/\rho} \quad (\text{B.5.3})$$

where  $I_{d,t}$  and  $I_{m,t}$  are the use of domestic goods and imports in the production of the investment good. So domestic goods are produced according to a Cobb-Douglas production function and investment goods are produced according to a CES production function. Here the elasticity of substitution is  $\sigma = 1/(1 - \rho)$ . Assuming  $\sigma = 2$ ,  $\rho = 0.5$ . There is considerable debate over the value of the parameter  $\rho$ , but a common value is 0.5, according to Ruhl (2005) and Conesa et al. (2007). The parameter  $\omega$  indicates the proportion of domestic and imported goods used in the production of the investment good. The parameter  $D_t$  determines the amounts of imports and domestically produced goods needed to produce one unit of the investment good, so  $D_t$  is like the productivity of the CES production function, comparable to  $A_t$  of a Cobb-Douglas production function.  $I_{d,t}$  and  $I_{m,t}$  inputs are chosen by the investment good producing firm to minimize the cost of production subject to the constraint

$$D_t(\omega I_{d,t}^\rho + (1 - \omega)I_{m,t}^\rho)^{1/\rho} \geq \bar{I}_t \quad (\text{B.5.4})$$

where  $\bar{I}$  is some target production level. Domestic goods are used for three purposes - consumption, investment and export. So the feasibility constraint for the domestic good is

$$C_{d,t} + I_{d,t} + X_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (\text{B.5.5})$$

and the feasibility constraint for imported good is

$$C_{m,t} + I_{m,t} = M_t \quad (\text{B.5.6})$$

The trade balance condition is

$$X_t = p_{m,t}M_t \quad (\text{B.5.7})$$

The household consumes both domestic and imported goods. In choosing a functional form for the households utility over imports and domestic goods,  $\nu(C_{d,t}, C_{m,t})$ , it is



assumed here that the household's preferences over the two goods identical to the production technology for producing investment good,

$$\nu(C_{d,t}, C_{m,t}) = D_t(\omega C_{d,t}^\rho + (1 - \omega)C_{m,t}^\rho)^{1/\rho} \quad (\text{B.5.8})$$

This technology is used here to simplify the model. Defining total consumption as  $C_t$  we can write,

$$C_t = D_t(\omega C_{d,t}^\rho + (1 - \omega)C_{m,t}^\rho)^{1/\rho} \quad (\text{B.5.9})$$

The household problem is to maximize utility subject to the sequence of budget constraint

$$q_t(C_t + K_{t+1} - (1 - \delta)K_t) = w_t L_t + r_t K_t \quad (\text{B.5.10})$$

Summing up the investment and consumption part of domestic and imported goods we get

$$C_t + K_{t+1} - (1 - \delta)K_t = D_t(\omega Z_t^\rho + (1 - \omega)M_t^\rho)^{1/\rho} \quad (\text{B.5.11})$$

$$Z_t + X_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (\text{B.5.12})$$

The above two equations are the feasibility conditions. Now we can further simplify our model. Rather than assuming investment and consumption good producing firms, we can model a single type of firm that uses all the imports,  $M_t$  and all of the domestically produced good that is not exported,  $Z_t$ , to produce a consumption-investment aggregate. Solving the maximization problem of this single type of firm generates first order conditions (FOCs) very similar to the conditions when there were two types of firms. The FOCs are

$$1 = q_t \omega Z_t^{\rho-1} D_t(\omega Z_t^\rho + (1 - \omega)M_t^\rho)^{(1-\rho)/\rho} \quad (\text{B.5.13})$$

$$p_{m,t} = q_t (1 - \omega) M_t^{\rho-1} D_t(\omega Z_t^\rho + (1 - \omega)M_t^\rho)^{(1-\rho)/\rho} \quad (\text{B.5.14})$$

Definition of equilibrium: Given the sequence of productivity,  $A_t$ , the terms of trade,  $p_{m,t}$ , shocks to the investment consumption good production function,  $D_t$ , working-age population,  $N_t$ ,  $t = T_0, T_0 + 1, \dots$ , and the initial capital stock,  $\bar{K}_{T_0}$ , an equilibrium with trade and terms of trade shocks is the sequence of wages,  $w_t$ , interest rate,  $r_t$ , consumption-investment prices,  $q_t$ , consumption,  $C_t$ , labour,  $L_t$ , capital,  $K_t$ , output  $Y_t$ , import,  $M_t$ , export,  $X_t$ , and domestic goods used in production,  $Z_t$ , such that

- given wages, interest rates, and prices the representative household's choices over consumption, labour, and capital solve the problem of maximizing the utility function (B.5.1) subject to the budget constraint (B.5.2), appropriate non-negativity constraints, and the constraint on initial capital stock  $\bar{K}_{T_0}$ .
- the wages and interest rates, together with the domestic good producing firm's choices of labour and capital, satisfy the cost minimization and zero profit conditions (3.4.4) and (3.4.5).
- the terms of trade and price of consumption-investment good, together with the consumption-investment good firm's choices of imports and inputs of the domestic good, satisfy the cost minimization and zero profit conditions (B.5.13) and (B.5.14).
- consumption, labour, capital, inputs of the domestic good, imports, and exports satisfy the feasibility conditions (B.5.11) and (B.5.12).
- trade is balanced (B.5.7).

Combining the two first order conditions

$$Z_t = \left(\frac{\omega p_{m,t}}{1 - \omega}\right)^{1/(1-\rho)} M_t \quad (\text{B.5.15})$$

Finally, the demand functions for imports and domestic goods used in production are the following.

$$M_t = (1 - \omega)^{1/(1-\rho)} A_t K_t^\alpha L_t^{1-\alpha} p_{m,t}^{1/(\rho-1)} (q_t D_t)^{\rho/(1-\rho)} \quad (\text{B.5.16})$$

$$Z_t = \omega^{1/(1-\rho)} A_t K_t^\alpha L_t^{1-\alpha} (q_t D_t)^{\rho/(1-\rho)} \quad (\text{B.5.17})$$

Combining the household's optimality conditions with factor pricing equations yields a system of equations that is very similar to the base case model.

$$\frac{(1 - \alpha) A_t K_t^\alpha L_t^{-\alpha}}{q_t} (\bar{h}(N_t - L_t)) = \frac{1 - \gamma}{\gamma} C_t, t = T_0, T_0 + 1, \dots, T_1 \quad (\text{B.5.18})$$

$$\frac{C_{t+1}}{C_t} = \beta \left(1 - \delta + \frac{\alpha A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^\alpha}{q_{t+1}}\right), t = T_0, T_0 + 1, \dots, T_1 - 1 \quad (\text{B.5.19})$$

### B.5.3 Data Description and Calibration

In this open economy structure the required data are different. Firstly, it is necessary to describe the data. Data are deflated here by the export price deflator rather than the GDP deflator. The nominal trade balance is zero. So it is assumed that nominal exports = nominal imports. For determining the price of consumption-investment aggregate relative to the export good price ( $q_t$ ), Conesa et al. (2007) take the ratio of the real consumption-investment aggregate to the nominal consumption-investment aggregate to get the consumption-investment price index then divide that by the export price index. Here I follow the same method and then take the ratio of the consumption-investment deflator to the export price deflator as  $q_t$ . After calculating the relative price of consumption-investment to exports, the depreciation rate  $\delta$  and capital stock series are calculated with the equation of the evolution of capital,

$$K_{t+1} = (1 - \delta)K_t + I_t \quad (\text{B.5.20})$$

and the following two constraints

$$(1/22) \sum_{t=1988}^{2009} \frac{\delta q_t K_t}{q_t (C_t + I_t)} = \text{depreciation to GDP ratio} \quad (\text{B.5.21})$$

$$\frac{K_{1960}}{Y_{1960}} = 1/15 \sum_{t=1961}^{1975} \frac{K_t}{Y_t} \quad (\text{B.5.22})$$

The system of equation (B.5.20)-(B.5.22) are solved using data on investment  $I_t$  to solve for the sequence of capital stock and for the depreciation rate  $\delta$  as the base case model. The parameter  $\omega$  is an approximation of the proportion of domestic and imported goods used in production. For calibrating  $\omega$  following equation is used.

$$\frac{\omega}{1 - \omega} = \left( \frac{Z_t}{P_{m,t} M_t} \right)^{1-\rho} P_{m,t}^{-\rho} \quad (\text{B.5.23})$$

So first  $Z_t$  should be calculated. It is calculated as GDP minus export. I choose real  $Z_t$  deflated by export deflator.  $X_t$  is export deflated by export deflator. I choose the value of  $\rho$  as 0.5 following Conesa et al. (2007).  $\rho$  is chosen on the basis of empirical estimates of the elasticity of substitution between domestic goods and imports. With the data I get  $\omega = 0.647135536$ . Then I compute

$$D_t q_t = (\omega^{1/(1-\rho)} + (1 - \omega)^{1/(1-\rho)} p_{m,t}^{-\rho/(1-\rho)})^{(1-\rho)/-\rho} \quad (\text{B.5.24})$$

Dividing this series by  $q_t$  I get the  $D_t$  series. Now to address the relative price issue, I deflate the components of GDP using the export price. Denoting the current values with tilde and real values without tilde, I get the following equations,

$$\frac{\tilde{Y}_t - \tilde{X}_t + \tilde{M}_t}{p_{x,t}} = q_t(C_t + I_t) \quad (\text{B.5.25})$$

real export is calculated as

$$\frac{\tilde{X}_t}{p_{x,t}} = X_t \quad (\text{B.5.26})$$

and deflating imports I get

$$\frac{\tilde{M}_t}{p_{x,t}} = p_{m,t}M_t \quad (\text{B.5.27})$$

Now real GDP is defined as

$$Y_t = q_t(C_t + I_t) + X_t - p_{m,t}M_t \quad (\text{B.5.28})$$

TFP is calculated here in a different way. It is no longer a simple function of real GDP, capital and labour.

$$A_t = \frac{\omega^{-1/\rho}((C_t + I_t)^\rho D_t^{-\rho} - (1 - \omega)M_t^\rho)^{1/\rho} + X_t}{K_t^\alpha L_t^{1-\alpha}} \quad (\text{B.5.29})$$

For calculating  $A_t$  every component of GDP is deflated by their own deflator.  $p_{m,t}$  is terms of trade not the import price index. When I report the growth accounting in the Table B.1, TFP is calculated with conventional measure where,

$$\hat{Y}_t = q_{\bar{T}}(C_t + I_t) + X_t - p_{m,\bar{T}}M_t = (C_t + I_t) + X_t - M_t \quad (\text{B.5.30})$$

Now using the same method of the base case model and using equation (B.5.18) and (B.5.19), I calibrate  $\gamma$  and  $\beta$  as 0.2581 and 0.9733 . For calibrating  $\gamma$  and  $\beta$  respectively, I choose the average values of  $\gamma$  and  $\beta$  of the duration 1985-90 as like as other versions of the model. Also it is a practice to take average of the whole period of the parameter values. Average values of the whole period are not very different. A separate experiment is not done here to look at. Labour share  $(1 - \alpha)$ , TFP growth rate, population growth rate parameters are calculated following the same procedure as the base case model.



Figure B.4: Comparison between data and open economy model with balanced trade

### B.5.4 Model Results

The open economy model results with balanced trade are shown in Figure B.4 and Table B.1. Table B.1 shows the contribution of components of growth in an open economy model with balanced trade. In the slowdown period 1988-1992, model output growth is 50 percent of data. Growth in the hours worked variable is negative for both the model and the data but for the model it is more than triple. The growth of TFP and capital-output ratio is positive for both the model and data. During the above average growth period (1993-2004) output growth in model and data are almost same (2.50 percent versus 2.63 percent) for the model with balanced trade. The model with TFP and terms of trade shock (without the effect of tax changes) does well to fit the data but is not as good as the model with taxes and government expenditure. Growth in TFP and capital-output ratio are close in both the data and model, but growth in

Table B.1: Contribution to growth (average annual)

-	Data(%)	Balanced trade model (%)
Slowdown 1989-92	-	-
Change in Y/N	0.47	0.22
due to TFP	0.11	0.28
due to K/Y	0.78	1.46
due to L/N	-0.42	-1.52
Above average growth 1993-04	-	-
Change in Y/N	2.63	2.50
due to TFP	3.08	3.13
due to K/Y	-0.86	-0.72
due to L/N	0.41	0.085
Slowdown 2005-09	-	-
Change in Y/N	1.10	-0.51
due to TFP	-0.28	-0.55
due to K/Y	0.94	1.06
due to L/N	0.43	-1.02

hours worked is positive but not close for the data and model.

# Appendix C

## The Role of Productivity during the Great Depression in Australia

### C.1 Data Sources

Mostly data are taken from Butlin (1977). Working-age population data are calculated from ABS catalogue 3105.0.65.001 Australian historical population.

### C.2 More Detail on the Literature

My motivation stems from the paper of Cole and Ohanian (1999). They analyse the basic question, can a real shock account for the Depression? According to them during the Great Depression in the US the output drop was 38 percent in the observed data between 1929 to 1933. A neoclassical model with technology shocks predicts a 15 percent decline. So technology shocks can account for 40 percent of the decline, but cannot explain the slow recovery of 1934-39. The model recovers soon that predict output to be on trend by 1936 but that did not happen in the observed data. Cole and Ohanian (1999) also do an experiment with fiscal policy shock. Government spending shocks (Christiano and Eichenbaum, 1992) and distorting taxes (McGrattan, 1994) are very important for analysing postwar (World War II) economic cyclical activity. Historically changes in government purchases have had large effects on economic activity. Ohanian (1997) shows that a 60 percent increase in output during the 1940s is accounted for by increases in government purchases. However, during the Great Depression period there was not massive decrease in government expenditure that only declined modestly (1929-33). Then government expenditure increased up to 1939. So Cole and Ohanian (1999) mention that government purchase shocks is not the cause of downturn. They

mention that distorting taxes could be a cause of the Depression. Increased factor income taxes could reduce the incentive of individuals to work and save. Although during the Great Depression (1929-33), the tax rate on factor income did not increase considerably, it rose during the recovery period. Effect of tax account for 20 percent of the slow recovery.

Cole and Ohanian (1999) also looked at whether the trade shock caused the depression. Theory predicts that increases in tariffs leads to a decline in world trade. But trade share is small. In this respect Crucini and Kahn (1996) argue that a significant fraction of imports during the 1930s were intermediate inputs. If imported intermediate inputs are imperfect substitutes for domestic intermediate inputs then production could fall. The magnitude of the fall depends on the elasticity of substitution between inputs (domestic versus foreign). Assuming an elasticity of 2/3 Crucini and Kahn (1996) report that output would have dropped about 2 percent as a result of high tariff rates in early 1930s in the US. Cole and Ohanian (1999) also explore whether monetary shocks are the cause of the Depression. Many economists think that monetary shock was the cause of the Great Depression like Friedman and Schwartz (1963). They present evidence that a decline in monetary supply tends to precede a decline in output over nearly a century in the US. They also show that the monetary supply fell sharply during 1929-33.

Cole and Ohanian (1999) are the pioneers to test the applicability of the neoclassical growth model with historical data. This type of research was later continued by different researchers looking at different countries. The book '*Great Depressions Of The Twentieth Century*' compiled papers on the Great Depression of 1930s and also on more recent depressions (after 1970s). It finds the causes of the Great Depression and more recent depressions in some of the developed countries. The recent depressions include depressions in Finland, Switzerland and New Zealand in the 1990s. It also includes recent depressions in some developing countries such as Brazil and Argentina. In this research, I follow the method of Conesa et al. (2007). They model depression of Finland of the 1990s. They investigate the depression within the framework of neoclassical growth theory. With a dynamic general equilibrium model they find that the drop in GDP during 1990-93 was driven by a combination of the drop in TFP during 1990-



92 and of increases in taxes on labour and consumption and increases in government consumption during 1989-94. They also try to endogenize the drop in TFP in variants of the model with an investment sector and with terms of trade shocks but those shocks were not effective to explain the situation. Another paper relating to recent depression is by Kehoe and Ruhl (2003) on New Zealand and Switzerland. Although in 1950s and 1960s GDP growth rate of New Zealand and Switzerland was more than the US trend growth rate of 2 percent, after 1973 GDP per working-age person was below trend in both countries (cumulative 30 percent below the trend growth path). They show that in a calibrated dynamic general equilibrium model, taking TFP as exogenous can explain most of the decline in output in both of these countries. Some researchers find the role preference shocks, i.e. whether preference shocks could be a cause of the Great Depression (Weder, 2006a and Weder, 2006b). Research shows that preference shocks play a central role in understanding the cause of the Great Depression in the US and Germany. Weder (2006a) shows that when the model economy includes variable capital utilization and mildly increasing returns to scale in production, then the model is able to account for most of the decline of the output. Shocks were calculated by using the Taylor-approximated households's intratemporal optimality condition as in Baxter and King (1991). There are many other research papers on the Great Depression and on recent depressions on the developed countries. If we go through all relevant literature, it is seen that different countries differ in their pivotal cause of depression. In a nutshell, causes are negative TFP growth, adverse effects on the labour market due to institutional changes, adverse effects on trade, monetary policy and the role of government as a spender and as a raiser of tax.

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