Essays on Transportation Infrastructure, Urbanisation and Economic Growth: Evidence from China

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ABSTRACT

China's spectacular economic growth during the reform era from 1978 to 2008 has captivated much attention both in academia and in the policy arena. This thesis looks at this period of Chinese economic reforms and the consequences for China's economic growth, urbanisation, and income inequality, in which transportation infrastructure plays a pivotal role.

Among many contributors to the economic growth in China, as measured by GDP per capita growth, recent studies shed light on the importance of transportation infrastructure. Therefore, a comprehensive understanding of the function of transportation infrastructure in the context of China and an accurate quantification of its contribution are desired. Accompanying the GDP per capita growth, China also experienced a rapid process of urbanisation during 1978–2008. However, whether the GDP per capita growth causes urbanisation is not yet clear.

After the accession to the WTO in 2001, China became an important player in world trade. For example, China's exports increased from USD 0.27 trillion in 2001 to USD 1.43 trillion in 2008, which has resulted in massive income growth nation-wide. However, the income has been unequally distributed among wage earners. Since urban wage earners are more likely to work in exporting sectors, it is important to analyse the impact of accessibility to international markets, as measured by length of current transport routes from origin city to its nearest major seaport, on income inequality in urban China.

This thesis explores three major areas and improves upon existing methodology. First, it delineates the effect of changes in the density of transportation infrastructure, as measured by length of highways and railroads per square kilometre, on short-run and long-run GDP per capita growth. Second, it explores the causal impact of annual GDP per capita growth on urbanisation. Third, it quantifies the impact of market access on urban income inequality. Methodologically, this thesis contributes to the literature in terms of providing several identification strategies to pin down endogeneity issues, for instance, reverse causality, measurement errors, and omitted variable bias.

This thesis estimates the short-run (annual) causal effects of changes in the density of transportation infrastructure on economic growth. Using province-level data (1985–2008), this thesis finds that improvement of transportation infrastructure has been statistically significant in raising annual GDP growth per capita. During 1985–2008, on average, a one standard deviation increase in the density of transportation infrastructure accounted for a 6–8.3 percentage point increase in annual GDP per capita growth. This short-run effect is highly robust to a battery of sensitivity tests in magnitude and statistical significance, which confirms previous findings in the literature.

This thesis further quantifies the causal impact of changes in the density of transportation infrastructure on long-run GDP per capita growth, i.e. over a 15-year period. Based on provincial data (1978–2008), the estimates show that a one standard deviation increase in the initial level of transportation infrastructure stock is associated with a 1.54 to 2.44 percentage point increase in GDP per capita growth in the long run. This long-run effect is not reduced by the inclusion of additional control variables. Quantifying this causal impact is crucial, since little work has been done to date about how the initial level of infrastructure drives long-run economic growth.

This thesis also studies whether China's rapid GDP per capita growth has affected urbanisation, since the causal link between these two variables cannot be easily identified. Based on provincial data (1985–2008), this thesis finds that the increase in annual growth in GDP per capita has had a positive causal effect on the urbanisation rate. The effect is strongly robust to a battery of sensitivity tests that bring into the regression different sets of covariates potentially relevant to urbanisation. Thus, the thesis contributes to the literature by confirming the causal impact of economic growth on urbanisation in China as it transforms from a centrally-planned to a decentralised economy.

Finally, this thesis looks at the influence of accessibility to international markets on urban wage earners. Using a cross-sectional individual income dataset (2002), the estimates show that every 1 percent increase in length of current transport routes from the origin city to the international markets (i.e. the nearest seaport), *ceteris paribus*, has a negative impact on individual wages of 0.086 percent. This causal effect remains robust to the inclusion of various additional controls. The finding emphasises that the heterogeneous accessibility to international markets has led to income disparities among urban wage earners following China's accession to the WTO in 2001.

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DECLARATION

I, XIAOBO HE certify that this work contains no material which has been accepted for the award of any other degree or diploma at any university or 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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[1] Xiaobo He and Nicholas C.S. Sim (2012). The Effect of Transportation Infrastructure on Growth: The Case of China.

[2] Xiaobo He and Nicholas C.S. Sim (2012). Long-Run Impact of Transportation Infrastructure on Growth: Evidence from China.

[3] Xiaobo He and Nicholas C.S. Sim (2012). Does Economic Growth affect Urbanization? New Evidence from China and the Chinese National Congress.

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1. GENERAL INTRODUCTION

1. Introduction

Prior to 1978, China was a highly centralised economy run by the central government and a closed economy isolated from the rest of the world. In 1978, the government initiated a series of reforms among which fiscal decentralisation and trade liberalisation were fundamental. Following the reforms, the annual growth rate of total factor productivity (TFP) increased from 0.5 percent to 3.8 percent over the period 1952–1978 to 1978–2005. This prolonged strong economic growth has been referred to in the literature as the 'China miracle', to which fiscal decentralisation and trade liberalisation have been identified as contributors. Accompanying the economic growth, as measured by GDP per capita growth, China also experienced a rapid process of urbanisation and rising income inequality during 1978–2008. This thesis looks at the period of Chinese economic reforms over 1978–2008 and the consequences for China's economic growth, urbanisation and income inequality, in which transportation infrastructure plays a pivotal role.

Transportation infrastructure has had, and continues to have important impacts on propelling China's economic development. Improvements to transportation infrastructure reduce trade costs (e.g. commuting and shipping costs) between trading partners, which increases internal trade and generates direct welfare benefits across Chinese cities. The decline of transportation costs also translates into lower costs and higher productivity in exporting sectors. In particular, it stimulates export-oriented industries in coastal regions where physical capital and high-skilled workers agglomerate. Beyond the direct effects, upgraded transportation infrastructure has indirect effects on China's economic development, since it lowers migration costs between rural and urban China, which facilitates the acceleration of the process of urbanisation. For urbanised regions, it is also noteworthy that the differentials between cities in terms of the provision of transportation infrastructure may lead to income inequality. The increasing income inequality in urban China has recently become a major issue debated among policy-makers and academics.

The rising provision of transportation infrastructure is largely benefited from fiscal decentralisation. In general, fiscal decentralisation denotes the transformation of fiscal controls from the central government to lower administrative levels. A rich body of research has looked at fiscal decentralization in China and confirmed its positive influence on economic growth, which echoes the conventional wisdom that decentralisation motivates local governments to deliver region-specific public services.[1] The fiscal reforms in the 1980s and 1990s allowed provincial governments to retain a larger share of local tax revenues and as a consequence, provincial governments became richer and more powerful in terms of government expenditure. Meanwhile, the competition in GDP growth per capita between provinces occurred from the late 1980s, since a good performance in the sense of local economic growth may determine provincial leaders' promotion. Given the fiscal decentralisation and the presence of promotional pressure among provincial leaders, Chinese provinces became more aggressive in expanding government expenditure and targeting a higher rate of annual GDP per capita growth. This leads to an interesting stylised fact in China that the growth of GDP per capita tends to spike in the year of the National Congress of the Communist Party of China (hereafter, the National Congress of the CPC) or the year before it. Since 1977, the Communist Party of China convenes every five years at the National Congress in the capital city of Beijing to discuss internal party matters in which appointments of provincial and central leaders are the most important matters, and to ratify national development objectives such as economic growth targets. This unique political environment and its potential cyclical influence on economic growth provides us with a good

[1] See Shen et al. (2012) for a detailed historical background of China's fiscal decentralisation.

opportunity to implement a quasi-natural experiment which analyses China's economic growth over the period 1978–2008.

Among many contributors to the GDP per capita growth, recent studies have shed light on the importance of transportation infrastructure. In the context of China, the impact of the increasing density of transportation infrastructure, as measured by length of highways and railroads per square kilometre, on annual economic growth has not yet been accurately quantified. This thesis investigates this short-run effect which is closely related to fiscal decentralisation and the cyclical pattern of government expenditure in China. While this short-run effect is often emphasised in the literature, the effect of the increasing density of transportation infrastructure on long-run economic growth is never clear as the causal relationship between these two variables is difficult to identify. This thesis provides a new perspective, by quantifying the causal impact of changes in the initial level of transportation infrastructure stock on long-run GDP per capita growth, i.e. over a 15-year period.

The unprecedented process of urbanisation and rapid economic growth during 1978–2008 in China has raised the question as to whether economic growth causes urbanisation. In the existing literature, scholars often emphasise the causal effect of urbanisation on economic growth but not the opposite relationship. This is because traditionally urbanisation is considered as a contributor to economic growth. Recently, the economic growth–urbanisation nexus has been paid attention to, for instance, Brückner (2012) has looked at the impact of economic growth on urbanisation in sub-Saharan Africa. This thesis attempts to contribute to close the gap by confirming the existence of the causal effect of economic growth on urbanisation using China as a case study.

China began the process of opening up its borders in 1978 and became a key player in global trade, particularly after its accession to the WTO in 2001. While rising trade may contribute to a higher level of national income, it could also cause income disparities in an emerging economy like China,[2] for example, its Gini coefficient reached 42.5 percent in 2005 relative to

[2] See Richardson (1995) for initial thoughts and Harrison et al. (2010) for recent empirical findings.

29.1 percent in 1981 according to the World Development Indicators (World Bank). One stream of studies has indicated the importance of location and accessibility to markets in causing this income inequality.[3] Theoretically, the New Economic Geography (NEG) model provides an insight into income disparities by showing a precise channel through which geographic location has influence on individual wages. This thesis looks at the impact of the access to international markets on income inequality in China. Since urban wage earners are more likely to work in exporting sectors, this thesis focuses on the impact of accessibility to international markets on income inequality among urban wage earners. Linking to the latest literature that uses the Mincer (1974) wage function embedded in a framework of NEG theory, this thesis intends to quantify the effect of an increase in length of transport routes connecting the origin city to the international market (i.e. the nearest seaport) on individual wages in urban China.

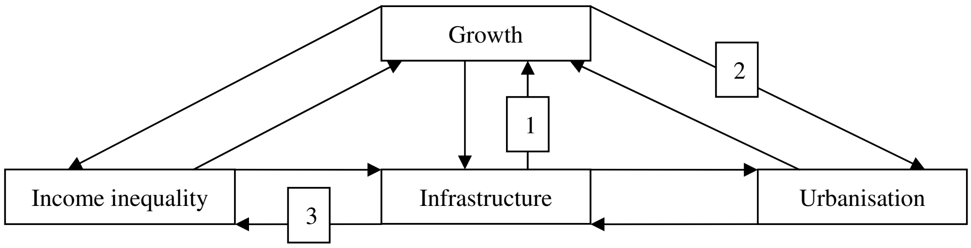
2. Research Questions

In order to visualise the research questions, this section first paints a general picture of the key relationships of interest in the thesis. As can be seen in Figure 1.1, four concepts covered in this thesis are (economic) growth, urbanisation, (transportation) infrastructure, and income inequality. Empirically, due to the presence of two-way causalities, it is not easy to identify the relationships illustrated below. This thesis intends to provide new identification strategies to disentangle the three main causal relationships which are shown in Figure 1.1, numbered 1, 2 and 3.

Changes in the density of transportation infrastructure are essential in the system. This contributes to economic growth, because it can reduce internal trade costs and facilitate production. Furthermore, it may stimulate economic growth through an indirect channel, i.e. urbanisation, because upgrading transportation infrastructure can lower the cost of rural-to-urban

[3] For instance, Benjamin et al. (2005) find some empirical evidence that geographic location perhaps drove spatial income inequality in rural China from 1987 to 2002.

Fig. 1.1: Diagram of Core Concepts in the Thesis



migration and ultimately increase the rate of urbanisation. Last, the uneven distribution of transportation infrastructure may result in income disparities among wage earners, which may potentially hinder further economic growth. Rather than studying all relationships illustrated in Figure 1.1, this thesis concentrates on three major nexuses, i.e. (1) transportation infrastructure to economic growth, (2) economic growth to urbanisation, and (3) transportation infrastructure to income inequality.

This thesis uses a mixture of data. It uses provincial panel data to look at the first and second nexus. The advantage of using provincial panel datasets is that one can eliminate provincial time-invariant unobservable factors that may confound the causal effects of endogenous variables of interest. However, the cost is also obvious that this type of study relies on macro-level data that cannot explicitly capture individual behaviour in economic activities. To provide micro-level evidence, this thesis uses cross-sectional individual income data to analyse the third nexus.

This thesis first explores the research question: "What is the short-run effect of changes in the density of transportation infrastructure on economic growth in China?" Although the contribution of changes in transportation infrastructure to short-run GDP per capita growth has been often mentioned (Esfahani and Ramirez, 2003; Calderón and Chong, 2004; Calderón and Servén, 2005), the causal relationship to date is not yet clear-cut due to the confounding effect that rapid economic growth in turn increases demand for expanding transportation infrastructure. This motivates the exploration in Chapter 3 that uses a national political event — the National Congress of the Communist Party of China to construct instrumental variables to identify the causal effect of changes in the density of transportation infrastructure on economic growth.

Extending the first exploration, this thesis investigates the causal effect of improvement of transportation infrastructure on long-run economic growth. Hence, the second question of interest is: "What is the long-run impact of changes in the density of transportation infrastructure on economic growth in China?" Generally speaking, this is not an easy question to address due to the presence of endogeneity issues. For instance, better initial conditions of transportation infrastructure could be positively correlated with natural resources, local income level, and other unobserved factors that can promote long-run growth, for instance, the tightness of connection between local governments and the central government. To this end, omitted unobservables, such as geographical conditions, social norms, and political environment, may confound the effects running from transportation infrastructure to long-run growth. Since little has been done to date to mitigate the endogeneity bias in this field, Chapter 4 contributes to the literature by proposing a new strategy employing the density of Chinese guilds, as measured by the number of guilds in the Qing dynasty per 10,000 people, to identify exogenous variation in the initial level of provision of the transportation infrastructure.

During 1978–2008, we observed that massive flows of rural-urban migration in China, facilitated by upgraded transportation networks, raised the rate of urbanisation, as measured by local urban population as a share of total local population. Existing studies (Quigley, 1998; Henderson, 2003; Duranton and Puga, 2004; Duranton, 2008) have arrived at a consensus that urbanisation is positively associated with growth, while researchers until recently have paid little attention to the opposite relationship, i.e. the economic growth-urbanisation nexus. Due to the reverse causality, it is not easy to quantify the causal impact of economic growth on urbanisation.[4] Brückner

[4] The potential channels through which rapid economic growth may potentially increase the degree of urbanisation are as follows. First, regions with relatively high rates of GDP per capita growth attract rural migrants, because they often offer higher wages. Second, rapid economic growth usually occurs (especially in developing countries) together with

(2012) finds that income growth did not significantly raise urbanisation in sub-Saharan Africa. By contrast, Henderson (2002) shows economic growth could lead to a higher level of urbanisation based on data from 85 countries over the period 1960–1990. Given these conflicting results above, it is worth identifying the causal effect of economic growth on urbanisation. Using China as a case study, Chapter 5 addresses the question: "Does economic growth affect urbanisation?", and uses instrumental variables to mitigate the reverse effect running from urbanisation to economic growth.

Through the lens of NEG theory (Krugman, 1991; Krugman and Venables, 1995), empirical studies (Redding and Venables, 2004; Hanson, 2005; Head and Mayer, 2006) confirm the impact of increasing market access on nominal wages. Following this stream of literature and recent explorations using Chinese data (Hering and Poncet, 2010; Hou and Emran, 2012; Kamal et al., 2012), Chapter 6 addresses the question: "How does access to international markets affect individual wages?" In the area of income inequality, this is a new topic for China, because scholars usually underscore the aggregated impact of trade openness on national income (Dollar and Kraay, 2004; Wacziarg and Welch, 2008) or address the reason why increased exporting activities promote regional income and GDP per capita growth (Lemoine and Ünal-Kesenci, 2004; Sun and Heshmati, 2010; Jarreau and Poncet, 2012). However, these studies fail to address the fact that there are losses resulting from situations where there is failure to access international markets. Moreover, understanding the impact of access to international markets on urban wage earners is important for Chinese policy-makers, because transportation infrastructure was provided unevenly across regions during 1978–2006 (Chen and Yao, 2011), which generates inter-regional physical differentials of accessibility to international markets.

rising FDI and international trade, which resulted in increased demand for more labour, which in turn results in more people working and living in cities (urban areas).

3. Summary of Core Chapters

The thesis is organised as follows. This chapter states the research questions, presents the motivation for the research, and summarises empirical findings in this thesis. Chapter 2 provides an introductory background of China's economic development, summarises related econometric issues, and highlights the significance of the thesis. Chapters 3 to 6 are core chapters. Chapter 3 and Chapter 4 address the causal effect of changes in the density of transportation infrastructure on both short-run and long-run economic growth. Chapter 5 explores whether economic growth causally affects urbanisation. Chapter 6 quantifies the impact of the provision of transportation infrastructure on income inequality in urban China. Chapter 7 gives concluding remarks and discusses further studies.

Chapter 3 looks at the short-run causal effect of changes in the density of transportation infrastructure on economic growth. It uses the timing of an exogenous event – the National Congress of the Communist Party of China – to construct two-stage least squares (2SLS) estimates of the within-province effect of changes in the density of transportation infrastructure on GDP growth per capita during 1985–2008. It looks at whether the timing of the National Congress is associated with changes in the density of transportation infrastructure. While the ordinary least squares (OLS) estimate is nearly zero, the 2SLS estimate shows that an increase in the density of transportation infrastructure has a statistically significant effect on raising GDP growth per capita. This effect of improvement of transportation infrastructure on growth is robust to the inclusion of additional control variables in the regression, to running separate regressions for coastal and non-coastal provinces, and to utilising four alternative constructions of instrumental variables based on information about the National Congress.

Chapter 4 studies the long-run effect that changes in the provision of transportation infrastructure had on growth using Chinese provincial data during 1978–2008. Because of the endogeneity of transportation infrastructure, Chapter 4 constructs an instrument based on the density of the number of the Chinese guilds in the population, which are associations serving numerous economic and social functions going back to the Qing dynasty, and finds this instrument to be powerful. The instrumental variable estimate shows that changes in the provision of transportation infrastructure has a quantitatively important influence on long-run economic growth, which is strongly robust to a battery of sensitivity tests that bring into the regression different sets of potentially relevant covariates.

Chapter 5 explores the causal link between economic growth and urbanisation. Using a panel dataset of Chinese provinces during 1985–2008, it proposes a new identification strategy to construct instrumental variables estimates of the within-province effect that GDP growth per capita has on the urbanisation rate. This strategy uses the timing of the National Congress of the CPC, which is a five-yearly meeting where national economic policies are debated. Chapter 5 finds that GDP growth per capita is strongly associated with the timing of the National Congress. Using instrumental variables that convey this timing information, 2SLS estimates are used to show whether economic growth has a statistically significant effect on raising the urbanisation rate.

While previous chapters mainly rely on aggregated data, Chapter 6 offers some micro evidence of how the provision of transportation infrastructure affects income inequality in urban China. In Chapter 6, the provision of transportation infrastructure is proxied by length of current transport routes from origin city to its nearest major seaport. Using China Household Income Project Survey (2002) data, Chapter 6 addresses the causal effect of the improvement of transportation infrastructure on urban wage earners. Using historical information, i.e. prefecture-level population density in 1820, to construct instrumental variables for current transport routes, the 2SLS regressions show a statistically significant effect of better transportation infrastructure on individual wages in urban China. This causal effect remains robust to various sensitivity tests which bring relevant covariates such as current labour market structure, historical factor endowments, and initial population development into the regression.

2. BACKGROUND

1. Introduction

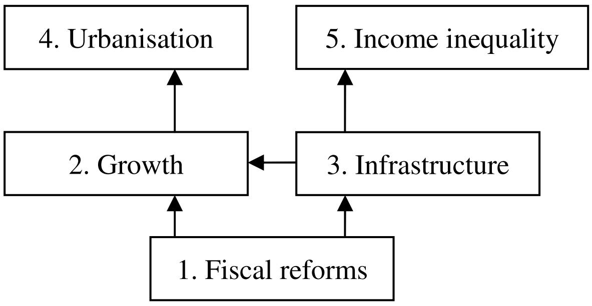
This thesis analyses China's economic growth, urbanisation and income inequality in which transportation infrastructure played an important role during 1978–2008. This chapter provides the background of China's economic development, reviews the related literature, and summarises the significance of the core chapters (i.e. Chapters 3 to 6).

As illustrated in Figure 2.1, section 2 revisits China's economic development after 1978. Section 2 summarises five development issues, i.e. 1) fiscal reforms; 2) (economic) growth; 3) (transportation) infrastructure; 4) urbanisation and 5) income inequality. The fiscal reforms, which began in the 1980s, were fundamental institutional changes. These reforms were positively associated with rapid economic growth and significant improvement of transportation infrastructure.[5] The remaining three linkages, i.e. transportation infrastructure to economic growth (3 to 2), economic growth to urbanisation (2 to 4) and transportation infrastructure to income inequality (3 to 5), have been already introduced in Chapter 1 and will be elaborated on in four core chapters.

Section 3 reviews the related studies in terms of econometric issues. Section 4 highlights the significance of the core chapters. Methodologically, this thesis contributes to the literature by providing several new identification strategies, which rely on both China's unique political environment and rich historical datasets. In particular, to mitigate endogeneity bias, this thesis explores the area of employing historical information as instrumental variables.

[5] The relationships are visualised in Figure 2.1, namely, fiscal reforms to economic growth (1 to 2) and fiscal reforms to transportation infrastructure (1 to 3).

Fig. 2.1: China's Development Issues Revisited



2. Background of China's Economic Development

The great expansion of the Chinese economy attracts much attention from academics, however, no simple factor can explain the unprecedented China miracle, whereby real GDP per capita rose from USD 145.5 to USD 2426.3 between 1975 and 2010. To understand why China could achieve a consistently high rate of GDP per capita growth during 1978–2008, it is necessary to look first at China's development pattern after 1978.

This section introduces the fiscal reforms which propelled China's economic development and drove its rapid economic growth during 1978–2008. The latest fiscal reform initiated in 1994 allowed the provincial governments to raise the regional GDP per capita growth through expanding government expenditure. This decentralisation reform contributed to increasing the provision of transportation infrastructure — the central theme of this thesis. In addition, this section delineates China's economic growth, development of transportation infrastructure, rapid process of urbanisation and urban income inequality.

2.1 Fiscal Reforms

In order to demystify China's economic growth and development by understanding the economic history and fundamental institutions, Table 2.1 outlines the evolution of fiscal decentralisation and institutional changes in the major development phases. In addition, this chapter illustrates the hierarchy of Chinese governments in Figure 2.2. The highest authority of the nation is the central government, while the sub-national administrative units constitute provinces, prefectures, counties (or cities) and townships (or villages).

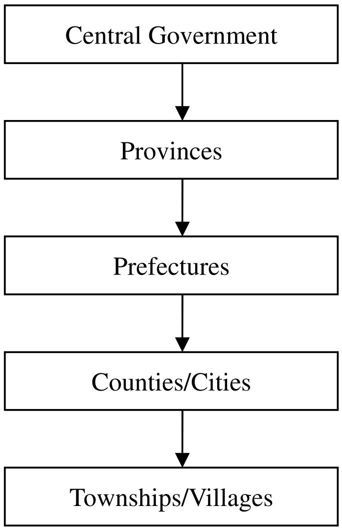
Tab. 2.1: Fiscal Decentralisation (Percent) and Institutional Changes (1953–2005)

Note: All information is obtained from Xu (2011). HRS denotes *Household Responsibility System* initiated in 1979 and completed in 1984. The HRS allocated the collective agricultural land to rural households, giving them relative autonomy over land use, and allocated them to contract land, machinery and other physical capital from collective organizations.

The People's Republic of China which was founded in 1949 started its first Five-Year Plan in 1953 when a transplantation of the Soviet model had been completed.[6] Initially, the central authority tightly controlled taxation and government spending so that only 17 percent of revenue went to local government accounts and 26 percent of expenditure was used for sub-national items. After two high-cost campaigns, the Great Leap Forward (1958–

[6] The Five-Year Plan was borrowed from the Soviet model which emphasised that the process of economic development should be designed and monitored by the central government only. For instance, each Five-Year Plan would announce some key economic targets like the GDP level, the level of agricultural outputs and the rate of GDP per capita growth, among others.

Fig. 2.2: Structure of Government



1961) and the Cultural Revolution (1966–1976), which encouraged regional competition in over-fulfilling centrally-planned targets, local governments shared more than 80 percent of total tax revenue and more than a half of total government expenditure by the late 1970s.[7] In 1980,[8] the central authority started the first fiscal reform. During 1980–1993, the so-called 'fiscal contract system' was implemented. Under such a system, provincial governments shared their revenues with the central government according to those predetermined schemes.[9] In other words, the provincial governments remitted 'contracted' revenues to the central government.

Starting in 1994, the 'fiscal contract system' was replaced by the 'fiscal sharing rule' which aimed to increase central tax revenue. The 'fiscal sharing rule' introduced the tax assignment, which specified the way revenues were shared between sub-national governments and the central government. As illustrated in Table 2.1, the proportion of sub-national revenue to national revenue shrank from 78.0 percent in 1993 to 44.3 percent in 1994.

[7] See Xu (2011) which summarises the Chinese political institutions and revisits major economic and political reforms after 1949.

[8] This was two years after the official economic liberalisation announced by the central government in 1978.

[9] Detailed phases of 'fiscal contract system' are discussed in Shen et al. (2012).

An interesting finding from Table 2.1 is that the ratio of sub-national expenditure to total expenditure rose from 45.7 percent in 1980 to 74.1 percent in 2005, while the ratio of sub-national revenue to total revenue declined from 75.5 percent to 47.7 percent during the same period. At first glance, this seemed to be incredible. How could sub-national governments achieve this? Jin et al. (2005) and Shen et al. (2012) suggest it was 'extra-budgetary' funding that financed the expansion of government spending. The 'extra-budgetary' funding, as pointed out by Montinola et al. (1995), was a special revenue component which was retained by sub-national governments during 1980–1993.[10] Although the central authority intended to restrict the ability of sub-national governments to increase local coffers through 'extra-budgetary' funds under the 'fiscal sharing rule', the actual proportion of sub-national expenditure to national expenditure increased from 70 percent in 1994 to 74 percent in 2005. In order to find the source for the relatively higher growth of the proportion of sub-national expenditure to total expenditure after 1994, Wong and Bird (2008) investigate the Chinese fiscal system and point out that sub-national governments could still maintain large, under-reported extra-budgetary reserves after 1994 and use these 'secrete' reserves for their own purposes.

The changes in the Chinese fiscal system, which funds to provincial governments, reinforces political and economic powers of those provincial governments, may in turn promote regional economic growth. For example, provincial governments are able to increase the investment on transportation infrastructure under the current 'fiscal sharing rule' without the substantial financial support from the central government. The essential work of this thesis is built on this unique fiscal pattern in China.

[10] Due to loose reporting requirements, provincial governments were able to retain extra-budgetary reserves which in fact had continued to grow after the 1994 fiscal reform (Wong and Bird, 2008).

2.2 Economic Growth

In order to draw a general picture of China's income level and its growth pathway, this section starts with the evolution of China's GDP per capita during 1961–2010. Shown in Table 2.2, China's GDP per capita rose from USD 105.5 in 1961 to USD 2,426.3 in 2010, which was one of the most impressive development stories following the Second World War.[11]

Tab. 2.2: China's GDP Per Capita Level and Annual Growth (1961–2010)

Year	Real GDP per capita (USD)	Annual growth (Percent)
1961	105.5	-26.4
1965	100.1	13.6
1970	122.3	16.1
1975	145.5	6.8
1980	186.4	6.5
1985	289.7	12.0
1990	391.7	2.3
1995	658.0	9.7
2000	949.2	7.5
2005	1464.1	10.6
2010	2426.3	9.9

Note: Data are obtained from the World Development Indicators (World Bank). *Real GDP per capita* is deflated to constant 2000 US dollars. *Annual growth* denotes average yearly growth rate of real GDP per capita.

Figure 2.3 illustrates the trajectory of China's GDP per capita from 1960 to 2011, indicating that it began to gradually rise during 1978–1993 when the 'fiscal contract system' was active, then doubled within less than a decade (1994–2001) during which the 'fiscal sharing rule' was implemented. After its accession to the WTO, China achieved the second 'double' within seven years (2002–2008).

With respect to economic growth in China which is one of the most important variables this thesis looks at, Figure 2.4 plots the annual growth

[11] GDP per capita is deflated to constant 2000 US dollars.

Fig. 2.3: GDP Per Capita in China (1960–2011)

Source: World Development Indicators (World Bank).

rate of GDP per capita during 1961–2011. The first peak after 1978 appeared in 1984 (13.7 percent), when the Household Responsibility System (HRS) had been adopted by 99 percent of the production teams in rural China (Lin, 1992).[12] The HRS was initiated in the late 1970s and completed in 1984, which allocated the collective land to rural households and allowed them to contract other physical capital from village governments. Meanwhile, rural households were also given relative autonomy over land use. More importantly, within the limits imposed by the contract agreements, rural households could dispose the surpluses of agricultural outputs. The HRS reform liberalised the agricultural production since the early 1980s and

[12] The production teams, consisting of households within a village, were organised by the village governments. These teams shared agricultural land and other physical capital which were owned by collective organisations. In other words, a single rural household did not own any agricultural land and facilities.

resulted in a significant growth in agricultural outputs as shown in Lin (1992).

During 1989 to 1990 when radical political changes occurred in the Eastern bloc countries, China's rate of growth also fell to around 2 percent which was the lowest pace since 1978. But the political instability only resulted in a pause of GDP per capita growth, as China surprisingly returned to a 12.8 percent rate of growth in 1992 (the second peak) when the central government officially announced the transformation from a central-planned to a market-based economy. Between the Asian financial crisis (1997–1998) and the latest global financial crisis (2008–2009), China reached its third peak of economic growth after 1978, i.e. 13.6 percent per annum in 2007.

Fig. 2.4: Annual Growth Rate of GDP Per Capita in China (1961–2011)

Source: World Development Indicators (World Bank).

As China has undergone economic development since the 1950s, it is interesting to note that the relative contributions of the determinants of economic growth (e.g. physical capital, human capital and TFP) varied over time. In other words, sometimes one factor might contribute more to economic growth relative to the other two factors. During period of the initial economic prosperity recovering from the Korean War (1950–1953), as can be seen in Table 2.3 (row 1), the TFP grew strongly (4.7 percent). During the Great Leap Forward (1958–1961), the central government emphasised the role of heavy industry by allocating more physical and human capital. This resulted in a relative labour shortage in the other industries and caused a steep decline in productivity. Letting the data speak, the average annual growth of TFP reduced from 4.7 percent (1952–1957) to -1.0 percent (1957–1965). During the Great Leap Forward, physical capital became almost the only engine of economic growth, as physical capital accounted for 93.1 percent of total contribution to GDP growth (see row 2 in Table 2.3).

After 1965, the Cultural Revolution began and led to a 10-year period of chaos during which the peak of disruption to the national economy occurred over the period 1967–1968 (Perkins and Rawski, 2008). Field (1986) reports that the gross value of industrial output shrank from RMB 152.6 billion to RMB 122.3 billion between 1966–1968.[13] As described in Li et al. (2010), "At the onset of the Cultural Revolution, all primary schools in urban China were closed for 2–3 years, and secondary- and tertiary-level institutions were closed for much of the period."

During 1965–1978, two-thirds of economic growth was attributed to physical capital (67.7 percent), which recalled the scenario during the Great Leap Forward. It was the economic reform starting from 1978 that reconfirmed the key position of TFP in China's economic growth. In particular, as summarised in Table 2.3, the TFP kept rising during 1978–2005 and was the strongest contributor to GDP per capita growth relative to physical and human capital for a decade (1985–1995). During the period 1995–2005, although the TFP still grew, China returned to the growth pattern which relied heavily on physical capital accumulation.

Finally, it is worth providing a cross-country comparison displaying China's economic growth relative to other economies. Table 2.4 shows that from the late 1970s, China's economy followed the booming trajectory which

[13] The gross value gross value of industrial output is deflated to 1957 constant prices.

Tab. 2.3: Contributors to GDP Growth and Average Annual Growth of TFP (1952–2005)

	Percentage shares of GDP growth attributable to			
Year	Physical Capital	Human Capital	TFP	TFP growth
1952–1957	12.7	14.9	72.4	4.7
1957–1965	93.1	49.5	-42.6	-1.0
1965–1978	67.7	36.7	-4.4	-0.2
1978–1985	40.6	26.6	32.8	3.2
1985–1990	38.8	21.5	39.7	3.1
1990–1995	33.3	9.5	57.3	6.7
1995–2000	52.7	10.5	36.8	3.2
2000–2005	57.1	10.6	32.3	3.1

Note: Data are obtained from Perkins and Rawski (2008). TFP growth denotes average growth rate of TFP over the periods stated.

Tab. 2.4: Five-Year Average Economic Growth Across Countries (1961–2010)

Year	China	Hong Kong	Japan	Korea	Singapore	EU	US
1961–1965	0.2	10.4	7.9	3.2	4.5	4.1	3.5
1966–1970	4.6	4.7	8.0	8.1	10.7	4.0	2.3
1971–1975	3.6	5.2	3.2	5.4	7.7	2.6	1.8
1976–1980	5.2	8.9	3.5	5.4	7.2	2.6	2.7
1981–1985	9.3	4.2	3.6	6.4	4.3	1.4	2.3
1986–1990	6.3	6.9	4.5	8.6	6.3	2.9	2.2
1991–1995	11.0	3.6	1.1	6.7	5.5	1.2	1.2
1996–2000	7.6	1.1	0.6	3.7	3.1	2.8	3.1
2001–2005	9.1	3.7	1.1	4.0	3.7	1.5	1.5
2006–2010	10.6	3.2	0.4	3.3	3.0	0.5	-0.2

Note: Data are obtained from the World Development Indicators (World Bank). This table provides five-year average growth rates of real GDP per capita.

other East Asian economies (e.g. Hong Kong, Japan, Korea and Singapore) had experienced during the 1960s and the 1970s. Compared with developed economies, China's growth since the late 1970s exceeded the highest growth rate for the US and the EU during the period 1961–2010, as shown in Table 2.4.

2.3 Transportation Infrastructure

China has made huge investments in transportation infrastructure which mainly consisted of highways and railroads in the 1990s and the 2000s, which resulted in a significant increase in the provision of transportation infrastructure. For instance, tracking the evolution of transportation infrastructure in 210 Chinese prefectures during 1962–2010, Baum-Snow and Turner (2012) show that between 1990 and 2010, the length of railroads in a prefecture on average increased from 142.03 to 209.17 kilometres.

For more details, Figure 2.5 illustrates that an average prefecture saw its length of railroads gradually grew from 93.39 to 132.96 kilometres during the pre-reform era (i.e. prior to 1978), then jumped to 207.38 kilometres by 2005, and steadily rose to 209.17 kilometres by 2010. In addition, Figure 2.5 displays that before 1990 there were no express highways between Chinese prefectures. However, the Chinese government earmarked a large-scale of construction of express highways from the 1990s, which resulted in the average length of express highways per prefecture rising to 47.39 kilometres in 1999 and jumping to 222.09 kilometres by 2010.

According to a comprehensive analysis of China's road infrastructure in Bellier and Zhou (2003), the investment focus shifted from low-grade highways towards expressways between 1990 and 2000. Table 2.5 shows that the share of expressway investment rose from 0.1 percent to 28.0 percent between 1990 and 2000; meanwhile, low-grade (Class 4) highways declined from 51.0 percent to 13.5 percent.

Furthermore, Bellier and Zhou (2003) point out that the construction of roads heavily relied on public investment in China. As can been see in Table 2.6, private investment during 1990–2000 accounted for only 10 percent of total public investment in transportation infrastructure over the period 1981–

Fig. 2.5: Average Length of Railroads and Express Highways in China (1962–2010)

NOTE:
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Source: Baum-Snow and Turner (2012).

2000.[14]

A significant expansion of public investment (RMB 805 billion) in Chinese highways during 1996–2000 is shown in Table 2.6, which in part relates to the Asian financial crisis between 1997 and 1998. In the wake of this crisis, the Chinese government encouraged public entities to take medium- and long-term infrastructure loans. As Bellier and Zhou (2003) compute, from 1998 to 2002, 30 percent of public bonds (around RMB 200 billion) issued by the government went to infrastructure. Likewise, a similar policy was implemented as a response to the 2008–2009 global financial crisis. In 2008, the government announced a stimulus package of RMB 1.52 trillion for infrastructure projects. This package included investment

[14] There was a very low level of private investment in highway investment until the early 1990s, as the related laws and regulations for private investment, particularly foreign investment, were not fully established until 1995 (Bellier and Zhou, 2003).

Tab. 2.5: Highway Investments in China (1990 and 2000)

	Investment (Billion RMB)		Share (Percent)	
Highway Type	1990	2000	1990	2000
Expressway	0.1	56	0.1	28.0
Highways				
Class 1	0.02	30	0.3	15.0
Class 2	0.20	60	4.0	30.0
Class 3	0.84	12	16.5	6.0
Class 4	2.60	27	51.0	13.5
Unclassified	1.43	15	28.1	7.5
Total	5.10	200	100	100

Note: Figures are obtained from Bellier and Zhou (2003). RMB denotes the Chinese currency (renminbi).

Tab. 2.6: Public and Private Highway Investments in China (1981–2000)

Revenue Source	Period	Investment (Billion RMB)	Share of Public Investment (Percent)
Public	1981–1989	19	2
Public	1990–1995	138	14
Public	1996–2000	805	84
Total Public	1981–2000	963	100
Private	1990–2000	91	10

Note: Figures are obtained from Bellier and Zhou (2003). RMB denotes the Chinese currency (renminbi).

in road construction and aimed to increase the total highway length by about 40 percent between 2010 and 2020. In short, public investment is the main source of finance for China's transportation infrastructure. Moreover, the government believes that the expanding investment in transportation infrastructure is a sharp weapon against regional or global financial crises.

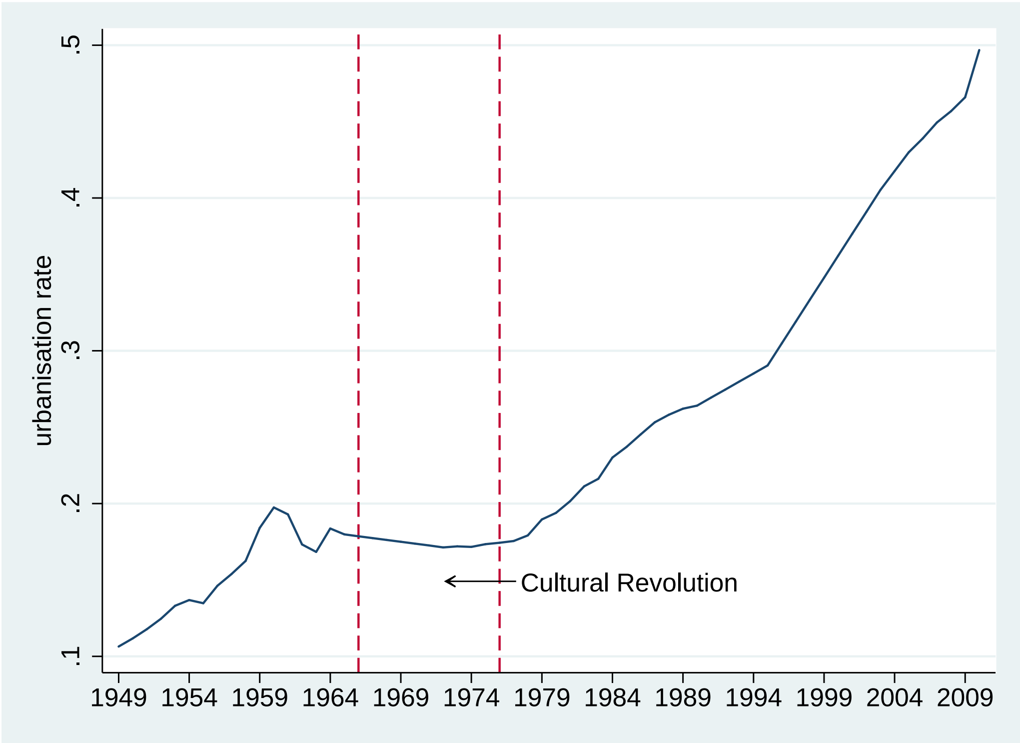
From a long-run perspective, an upgrade in transportation infrastructure may lower costs for migration, and thus raise rural-to-urban migration flows as mentioned in Combes et al. (2013). In addition, Baum-Snow and Turner (2012) and Baum-Snow et al. (2012) reveal the potential link between the development of transportation infrastructure (including roads and railroads) and the evolution of urbanisation in China. In the next section, the issues which relate to the urbanisation process and rural-to-urban migration are carefully reviewed.

2.4 Urbanisation Process, Hukou Reforms and Rural-Urban Migration

According to Henderson (2005), urbanisation is the process by which an economy undergoes the restructure from predominantly agricultural production to manufacturing and services. In China, a series of agricultural reforms (e.g. the HRS reform) significantly raised agricultural productivity in the early 1980s and reduced the demand for rural labour in agricultural production. The labour surplus in rural China, together with the booming of exporting sectors in coastal regions, started the engine of China's urbanisation. Figure 2.6 shows that China's urbanisation rate, as measured by the proportion of urban population to total population, gradually increased from 23.0 percent in 1984 to 28.5 percent in 1994, and jumped to 49.7 percent in 2010.

The procedure of China's urbanisation closely relates to the evolution of *hukou* (household registration) system which partially allowed rural labour to move between regions from 1980 onwards. The *hukou* system was initially established in 1951 to control population movement and labour mobility. On 16 July 1951, the Ministry of Public Security, with State Council Approval, issued "Regulations Governing the Urban Population" (Cheng and Selden, 1994). This document officially denied the Chinese people freedom of residence and movement. Similar restrictions to rural residents were imposed by the central government in 1955 (see Chan and Zhang, 1999). In general, the Chinese people could not move to destinations other than their registered locations for various purposes (e.g. studying, working and marriage, among others), unless their applications for movement were approved by the local

Fig. 2.6: Urbanisation Process in China (1949–2010)



Source: National Bureau of Statistics China (2010) and World Development Indicators (World Bank).

governments. However, this process was difficult and many people could not move as their applications were rejected.

From the early 1980s, the central government gradually implemented various programmes to devolve fiscal and administrative powers to lower-level governments (i.e. counties, townships and villages), so they took over control of migration (Chan and Buckingham, 2008). The local governments tended to have a more relaxed approach to allowing people to leave, which eased the flow of migration from rural areas. Meanwhile, the attitudes of city (destination) governments towards immigrants from rural areas also became more relaxed. Prior to the early 1990s, if migrants from rural areas were found not to have been granted residency (migrated without permission), they would be expelled from that destination and sent back to their origin locations. Rather than expelling migrant workers, the destination governments enacted rules to regulate these new ‘immigrants’ from the early 1990s onwards. For example, in 1995, rural migrants were required to present four documents (i.e. individual identification card, temporary residency, and employment certificate issued by labour bureaus in both the origin and destination locations) in order to ‘legally’ live and work in urban areas (see Cai et al. (2008) for more detailed regulations). The relatively relaxed migration policies during the 1990s had a significantly positive impact on the rapid increase of the urbanisation rate after 1995, which is illustrated in Figure 2.6.

According to Harris and Todaro (1970), migration decisions are usually driven by income differentials between origin and destination locations. This theory may also apply in China. Using Chinese data, a growing body of literature explains the question about why rural labour migrates to urban areas. Relying on household survey data from Sichuan province in 1995, Zhao (1999) argues that the shortage of farmland and the abundance of household labour significantly affected labour migration. This so-called ‘push’ effect implies that due to the reduction in relative marginal income from farming, rural labour begins to leave the countryside. There also exists a source of ‘pull’ effect, that is due to the relatively higher potential income in urban areas. Using data from 29 provinces over two periods (i.e. 1985–1990 and 1990–1995), Poncet (2006) finds that the income difference between destination and origin locations has a statistically significant and quantitatively large effect on migration flows.

Migration *per se* is costly. The costs consist of, for example, transport, temporary unemployment, social security and children’s living and education costs in urban China. Among these costs, the most important one which has a significant impact on migration decisions is transport cost. As transport costs may not always be measured directly, empirical studies often use migration distance to proxy for it. Poncet (2006) shows that migration flows decline significantly with the increase in distance between origin and destination locations. A study of rural migrants using survey data from the Rural Urban Migration in China (RUMiC, 2007), i.e. Zhang and Zhao (2013), estimates the income-distance elasticity, and reports that to induce a migrant to move 1 percent farther away from his origin location, the potential income in the destination location has to increase by roughly 1.5 percent. In other words, based on survey data on rural-to-urban migrants in 15 Chinese cities in 2007, Zhang and Zhao (2013) find that the income-distance elasticity was around 1.5.

Although rural migrants may benefit from potentially higher earnings in urban areas relative to staying in the countryside, their actual wages are lower than they should be. This issue which relates to wage inequality among urban wage earners is documented in the next section.

2.5 Income (Wage) Inequality in Urban China

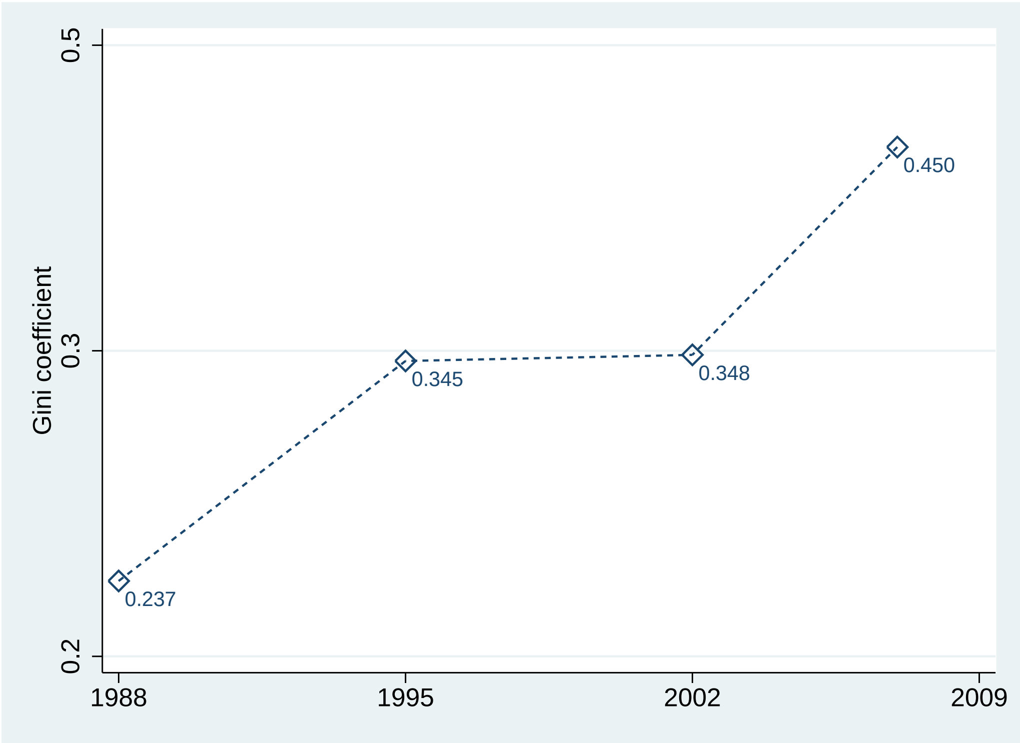
China's labour reforms began in 1983 when the HRS (agricultural) reform was introduced in most rural areas and had the effect of liberalising agricultural labour. After 1983, China started transforming it centrally-planned labour allocation system into a liberalised labour market in urban areas,[15] which led to a mounting wage inequality within the urban labour market as illustrated in this section.

Recent studies such as Appleton et al. (2012) and Xia et al. (2013), use the China Household Income Project Survey (CHIPS) data to delineate the trend of wage inequality during 1988–2007 in urban China.[16] As can be seen in Figure 2.7, the wage inequality (Gini coefficient) rose from 0.237 in 1988 to 0.345 in 1995, remaining relatively stable during 1995 to 2002, and sharply increased to 0.450 by 2007. It is noteworthy that over the period 1988–2007, the Chinese government applied two major programmes, i.e. the retrenchment within SOEs (state-owned enterprises) and the relaxation of controls on rural-urban migration. These measures aimed to restructure the state-owned sectors and liberalise the national labour market, respectively.

[15] See Appleton et al. (2005), which studies the evolution of wage structure during 1988–2002 when China began the liberalisation of its labour market.

[16] CHIPS data contain four waves for 1988, 1995, 2002 and 2007. The surveys were national representative, and samples were randomly drawn from the annual national household income survey of the National Bureau of Statistics of China.

Fig. 2.7: Wage Inequality in Urban China (1988, 1995, 2002 and 2007)



Source: Appleton et al. (2012) and Xia et al. (2013).

Since the non-state sectors expanded rapidly during the late 1980s and the early 1990s, a large proportion of SOEs found that it became more and more difficult to deal with growing losses and labour surplus (Dong and Putterman, 2003). As a response, the Chinese government applied a large-scale labour retrenchment programme in the late 1990s, which aimed to remove the relatively unproductive SOEs and to move former SOE workers to non-state sectors. Some evidence of these changes can be found in Cai et al. (2008), Dong and Xu (2009) and Dong and Pandey (2012). Dong and Xu (2009) show that the number of SOEs fell from 118,000 to 53,489 between 1995 and 2001. Based on the 2002 State-Owned Enterprises Reform Survey,[17] Dong and Pandey (2012) show that the average annual growth rate

[17] It covered 684 enterprises in 11 cities, which provided enterprise-level information during 1995 to 2001.

of output among surveyed SOEs fell from -0.159 in 1996 to -0.201 in 1998. In addition, based on the data from the Labour Statistical Year Book (1999–2005), Cai et al. (2008) report that 27.04 million workers from SOEs were laid off during 1998–2004. As most of laid-off (in Chinese, *xiagang*) workers were more likely to be low-skilled and/or unemployed,[18] they might face a low-income trap in the long run.[19] In summary, the retrenchment within SOEs resulted in a huge number of laid-off workers whose wages were much lower than the average level within the respective occupation. The presence of these low-income workers during the late 1990s and early 2000s could be one of the sources of wage inequality between urban wage earners.

The another factor which contributed to the liberalisation of the Chinese labour market but potentially worsened the wage inequality in urban China is the relaxation of controls on rural-to-urban migration. Various studies find that rural migrants in the destination cities experience low wages (or total income) relative to urban permanent residents. Using Shanghai as a case study, Wang and Zuo (1999) report that in 1995, even though rural migrants worked on average 25 percent longer per week (54 versus 43 hours) than urban workers who were permanent residents, they earned 40 percent less income.[20] Also looking at Shanghai, Meng and Zhang (2001) find that the wage differentials between migrants and non-migrants was 50 percent in 1995.[21] More importantly, Meng and Zhang (2001) indicate that wage differentials between the two groups were largely attributed to discrimination within the market, as they find that 83 percent of the hourly wage differential resulted from unequal payment within a given occupation. For nation-wide evidence, Démurger et al. (2009), based on China Household Income

[18] Cai et al. (2008) indicate that the registered unemployment rate rose from 3.1 percent in 1998 to 4.2 percent in 2004 due to the sudden spike of millions of laid-off workers in the urban labour market.

[19] Due to China's underdeveloped social security system, these laid-off workers were less likely or unlikely to be compensated for unemployment. Also, it was relatively difficult for them to find new jobs, since they were less competitive in the urban labour market.

[20] The data were obtained from the Shanghai Floating Population Survey which was conducted by the Institute of Population Studies at Shanghai Academy of Social Sciences in late 1995.

[21] Meng and Zhang (2001) use data from the Shanghai Floating Population Survey and the Shanghai Residents and Floating Population Survey.

Project Survey (CHIPS, 2002) data, show that urban residents earned 1.3 times higher annual income than long-term rural migrants in 12 surveyed provinces.[22]

To sum up, it is believed that the rising number of two types of workers, namely low-skilled, laid-off workers from former SOEs and rural migrants who are discriminated against in terms of wages, significantly widened the wage gap among urban wage earners after the late 1990s. This seems to be an unavoidable 'cost' of the reshaping of SOEs and the nation-wide liberalisation of the labour force.

3. Econometric Issues

One of the central challenges in empirical studies is endogeneity that is typically caused by omitted variables, measurement errors and simultaneity. For instance, studies that seek to identify causal relationships between infrastructure and economic growth have to solve for the reverse causality. Moreover, in the case of China, measurement errors in national accounting could be another source of endogeneity. This section revisits econometric issues of endogeneity in the literature which closely relate to this thesis.

To mitigate endogeneity bias, existing literature offers several methods, for example, fixed effects estimation, dynamic panel data estimation, the simultaneous equations approach and instrumental variables estimation. Table 2.7 lists major studies which relate to the topics of interest, where the upper panel summarises those studies that primarily investigate the relationship between infrastructure and economic growth,[23] while the lower panel outlines those studies that mainly look at the association between urbanisation and economic growth.

[22] Combes et al. (2013), using 2007 Urban Household Survey data, provide some evidence that the larger the share of migrants in a destination city, the higher the local workers' wages. This could also in part explain the recent rising wage inequality in Chinese cities.

[23] Some studies look at the relationship between infrastructure (stock or investment) and the three measures, i.e. income, consumption and productivity.

Tab. 2.7: Related Econometric Methods

Studies	Methods	Data	Topics
Holtz-Eakin (1994)	FE	US	Public Capital and Productivity
Holtz-Eakin and Schwartz (1995)	FE	US	Infrastructure and Economic Growth
Garcia-Mila et al. (1996)	FE	US	Public Capital and Productivity
Démurger (2001)	FE+IV	China	Infrastructure and Economic Growth
Calderón and Chong (2004)	DPD	Cross-country	Infrastructure and Income Distribution
Calderón and Servén (2005)	DPD	Cross-country	Infrastructure and Economic Growth
Esfahani and Ramirez (2003)	SE	Cross-country	Infrastructure and Economic Growth
Chen and Yao (2011)	SE	China	Infrastructure and Consumption
Henderson (2003)	IV+FE	Cross-country	Urbanisation and Economic Growth
Davis and Henderson (2003)	FE/DPD	Cross-country	Income and Urbanisation/Primacy
Deng et al. (2008)	FE	China	Economic Growth and Urban Land
Brückner (2012)	IV+FE	Cross-country	Economic Growth and Urbanisation

Note: *SE* is 'simultaneous equations' approach. *FE* denotes 'fixed effect' estimation. *IV* represents 'instrumental variables' estimation. *DPD* stands for 'dynamic panel data' estimation. In *Topics* column, the former and latter terms denote independent and dependent variables, respectively.

3.1 Infrastructure and Economic Growth

The first method to ameliorate endogeneity is employing fixed effects estimation embedded in a panel data framework. This method is used in early studies based on state-level data in the US, for example, Holtz-Eakin (1994), Holtz-Eakin and Schwartz (1995) and Garcia-Mila et al. (1996). Fixed effect estimations in principle can partial out time-invariant unobservable heterogeneity. By employing this approach, one actually deals with omitted variables (e.g. geographical conditions and cultural norms) which are constant over time. However, although fixed effect estimations are able to purge time-invariant unobservables, they cannot deal with omitted idiosyncratic variables. More importantly, fixed effects estimations cannot avoid the reverse response of GDP per capita growth to changes in infrastructure stock (or investment).

In order to solve the reverse causality which is the main problem in this area, dynamic panel methods and the simultaneous equations approach are often practised. Caselli et al. (1996) first show that a per capita growth equation can be expressed as an autoregression in per capita output levels, which thus can be conveniently estimated by the well-known dynamic panel approach developed in Arellano and Bond (1991). Using cross-country data, Calderón and Chong (2004) and Calderón and Servén (2005) apply this dynamic panel method and find that the improvement of infrastructure stock raises growth per capita and reduces income inequality. The alternative way is to treat reverse causality in a system of simultaneous equations. Esfahani and Ramirez (2003) employ this approach to identify the causal effect of changes in infrastructure on economic growth and indicate that the contribution of infrastructure services to GDP is substantial. A related study using Chinese provincial data and adopting a similar method is Chen and Yao (2011), which shows that the larger share of infrastructure investment in government expenditure lowered household consumption during 1978–2006. Methodologically, the simultaneous equations approach is a sharp weapon in terms of dealing with reverse causality and delineating the mediators that link infrastructure stock with GDP per capita growth. But in practice, it is not easily implementable using Chinese data. This is because standard simultaneous equations models assume that the endogenous and exogenous variables are directly measured and have no measurement error. However, Chinese data may contain significant measurement errors, which invalidates this crucial assumption.

The problem of measurement errors in Chinese data is emphasised by Rawski (2001), Rawski and Xiao (2001), Chow (2006), and Ravallion and Chen (2007), in which researchers claim that the data obtained from the National Bureau of Statistics of China may contain non-negligible measurement errors. If these errors are classical, the OLS estimates will be attenuated. This issue cannot be fully solved by employing fixed effects estimation. Furthermore, the attenuation due to the presence of measurement errors cannot be purged by a standard simultaneous equations approach. Thus, recent empirical studies often adopt instrumental variables to identify the causal relationship between infrastructure and China's regional economic growth, for example, Démurger (2001) and Banerjee et al. (2012).

3.2 Urbanisation and Economic Growth

It is widely accepted that the causality of economic growth and urbanisation runs in both directions. At one end of the discussion, there exists a large body of literature, for instance, Quigley (1998), Henderson (2003), Duranton and Puga (2004), and Duranton (2008), that almost unequivocally emphasises the positive effect that urbanisation has on economic growth. At the other end, the literature pays little attention to the opposite relationship, i.e. economic growth to urbanisation. The reason may be that in urban economics, the endogenous response of economic growth to urbanisation is a complicated econometric issue that usually calls for proper instrumental variables which in practice are often difficult to find. Brückner (2012) is one of the very few studies that successfully finds good instrumental variables in this area. Based on data from sub-Saharan Africa, Brückner (2012) uses rainfall shocks as instruments for economic growth and finds that GDP growth per capita is not a significant cause of urbanisation once the size of the agricultural sector is taken into account in the regression. For China, the most directly related study, i.e. Deng et al. (2008), examines the determinants of urbanisation but does not carefully identify the causal effect of economic growth on urbanisation.

3.3 Market Access and Income Inequality

In the recent studies (see Hering and Poncet, 2010; Hou and Emran, 2012; and Kamal et al., 2012, among others), researchers are interested in the question about how market access drives income inequality. However, given the difficulty of obtaining longitudinal data of regional market accessibility and individual income, one has to solve the major problem of using cross-sectional data, i.e. the problem of omitted variables. In a cross-sectional dataset, unobservables cannot be easily purged by employing fixed effects estimations reviewed in the last section, because the explanatory variable — market access is one of the regional fixed effects. If one intends to include regional dummies in the estimation to eliminate time-invariant heterogeneity, OLS estimates will be quantitatively small and statistically insignificant. However, leaving those unobservable variables in error terms causes standard endogeneity problems.

There exist at least three sources of omitted unobservable variables. First of all, individuals (or households) choose the place to live based on their own abilities which affects their earning potential. Second, the distribution of infrastructure is rarely random. For example, Chen and Yao (2011) address the uneven development of transportation infrastructure across regions over the period 1978–2006. Intuitively, the distribution of highways and railroads is likely to be positively associated with rich natural endowments, higher income levels and future development potential as discussed in Hou and Emran (2012). Last, endowments matter in a broad sense. These endowments can be traditional links between Chinese cities and western trade partners, which were initially built up in the late 19th century. Alternatively, the endowments can be spill-over effects from surrounding domestic markets. For example, a city which is closer to local business centres, e.g. provincial capitals, big cities and transportation hubs, tends to own more endowments which may affect local income. None of the above three factors, i.e. individual unobserved ability, determinants of the provision of transportation infrastructure, and city-level unobserved endowments, can be simply quantified or proxied for. In other words, they are often treated as error terms in empirical studies. To mitigate endogeneity bias like these omitted variables, proper instrumental variables that should be only correlated with market access but independent from individual (household) income are desired in this research area.

4. Significance of Core Chapters

This section compares the four cores chapters with the existing literature, and highlights the primary significance of them in terms of identification strategies.

4.1 Chapters 3-4: Transportation Infrastructure and Economic Growth

What do we already know about the role of transportation infrastructure in economic development? At the heart of this literature, researchers have paid attention to the impacts of changes in transportation infrastructure on income levels and economic growth. An early study (Holtz-Eakin and Schwartz, 1995) using US data for the 1970s and 1980s indicates that an increase in the rate of infrastructure investment only had a negligible impact on productivity growth. By contrast, a rich body of recent studies employing cross-country data paints the opposite picture. For instance, Esfahani and Ramirez (2003) find that infrastructure services substantially contribute to GDP per capita growth. In additional, Calderón and Servén (2005) reveal that changes in infrastructure stock had a positive impact on economic growth and reduced income inequality based on data from more than 100 countries over the period 1960–2000. Using similar data from 1960 to 1997, Calderón and Chong (2004) confirm that better infrastructure lowered income inequality. Calderón and Chong (2004) also show that in developing countries, it was the quantity of infrastructure that played a more important role in inequality reduction relative to the quality of infrastructure. In the case of China, the world's largest developing economy, Démurger (2001) indicates that uneven distribution of transportation infrastructure caused heterogeneous economic growth across Chinese provinces during 1985–1998.

This thesis provides empirical evidence for the causal effects of changes in the density of transportation infrastructure on economic growth in China, which enhances the understanding of the causal relationship between transportation infrastructure and economic growth in developing countries. Based on provincial panel data over the period 1985 to 2008, Chapter 3 uses the timing of the National Congress of the CPC to construct instrument variables to achieve the identification. Unlike Démurger (2001) who uses internal instruments, e.g. lagged trade and FDI, to mitigate endogeneity biases caused by reverse causality, Chapter 3 emphasises the importance of using external instruments, i.e. the timing of the National Congress of the CPC. This is because internal instruments could suffer from weak instrument problems and could overestimate the effect of interest.[24]

Since the causal effect of the expansion of initial transportation infrastructure on long-run economic growth has not been investigated to date, this thesis contributes to the literature by providing a new identification strategy to quantify this effect. Chapter 4 employs the density of ownership of Chinese guilds, as measured by the number of guilds in the Qing dynasty per 10,000 people, to identify exogenous variation in the initial level of provision of transportation infrastructure. Using Chinese provincial panel data over the period 1978 to 2008, Chapter 4 shows that changes in the provision of transportation infrastructure have a substantial influence on long-run economic growth. Methodologically, Chapter 4 is one of the very few studies (e.g. Banerjee et al., 2012, Fang and Zhao, 2009, among others)

[24] The detailed comparison between Démurger (2001) and this research will be provided in Chapter 3.

that use Chinese historical events as instruments. The strong and robust first-stage results shown in Chapter 4 demonstrate that historical events can have quantitatively large impact on contemporary endogenous variables. Intuitively, Chapter 4 indicates that current heterogeneity of the provision of transportation infrastructure may substantially affect regional economic growth in the long run. In short, Chapter 4 is the first exploration to quantify the effect of the provision of initial transportation infrastructure on long-run GDP per capita growth across Chinese provinces, suggesting that policy-makers should pay attention to this province-specific long-run effect.

4.2 Chapter 5: Economic Growth and Urbanisation

To date, it is not yet clear-cut whether economic growth affects urbanisation. Some studies like Fay and Opal (2000) and Poelhekke (2011) show that urbanisation could take place in the absence of growth, citing sub-Saharan Africa and some Latin American countries as notable cases. By contrast, Henderson (2002) shows that economic growth could lead to a higher level of urbanisation based on data from 85 countries over the period 1960–1990. As the existing studies have not arrived at a consensus that economic growth causally raises urbanisation, it is worth identifying this causal relationship using China as a case study.

Chapter 5 proposes a simple empirical strategy which uses the timing of the National Congress of the CPC to identify the exogenous variation in economic growth cyclically during 1985–2008. As this five-yearly national event has been exogenously scheduled, it is independent from the massive rural-to-urban migration which resulted in the rapid process of urbanisation during the period of interest. Using this identification strategy, Chapter 5 finds that economic growth has a statistically significant effect on raising the urbanisation rate.

This is one of the very few studies that attempt to investigate the causal relationship between economic growth and urbanisation. Also, it is the first one that looks at this causal relationship in China. The results shown in

Chapter 5 not only contribute to the empirical literature by providing a new identification scheme, but also have importation policy implications. As increasing urbanisation has raised critical environmental issues in China, from the sustainable development perspective, policy-makers should keep the balance between urbanisation and economic growth. However, this is not easy to manage, because the balancing calls for a recalibration of the GDP per capita growth target which may be detrimental to the local economy from the governments' point of view.

4.3 Chapter 6: Market Access and Income Inequality

Recently, economists have began to look at the relationship between market access and China's labour market (both rural and urban) based on micro data. For instance, Hering and Poncet (2010) estimate the wage equation in a NEG framework, investigating the effect of access to both domestic and international markets on individual wages. They find that the heterogeneous geography of market access has a significant impact on individual differences in economic returns to labour. In addition, Kamal et al. (2012) emphasise that market access affects wages paid to both skilled and unskilled workers. Departing from Hering and Poncet (2010) and Kamal et al. (2012), Hou and Emran (2012) quantify the direct impact of rural households living relatively far away from local business centres and international markets on their consumption. Their findings, relying on CHIPS (1995), show that the better the access to markets, measured as the length of transport routes that connect households and domestic markets (local business centres) and international markets (the nearest seaports), the greater the positive impact on rural consumption, which supplements Hering and Poncet (2010) and Kamal et al. (2012).

Following Hou and Emran (2012), Chapter 6 defines market access as the length of current transport routes from the origin city to its nearest major seaport. Chapter 6 proposes a new identification strategy that uses heterogeneity of inter-prefecture population density in 1820 to identify the effect of accessibility to international markets on individual wages in urban China. Based on CHIPS (2002) data, Chapter 6 finds that the lengths of contemporary transport routes connecting the origin city and its nearest major seaport are significantly affected by differentials in historical population density, which suggests that those instruments that this study constructs successfully capture exogenous variation in access to international markets. Using these instruments, Chapter 6 confirms that an increase in distance from the origin city to international markets (i.e. the nearest seaport) had a negative impact on individual wages in urban China in 2002.

In summary, this study explores the research area of using historical information as instrumental variables to mitigate endogeneity problems of contemporary variables. Moreover, the main finding indicates that an upgrade in transportation infrastructure may have a 'negative' effect in that it may widen the wage gap between urban wage earners. This reminds policy-makers to think of complementary policies, when stimulus packages which propel the development of regional transportation infrastructure are implemented.

3. THE EFFECT OF TRANSPORTATION INFRASTRUCTURE ON GROWTH: THE CASE OF CHINA

To get rich, build roads first. – Chinese proverb

1. Introduction

The concept of 'stimulative infrastructure spending', practised as early as during the Second World War, underlines the belief that policy-makers have that transportation infrastructure is the key for promoting economic growth and development.[25] Today, this confidence in transportation infrastructure appears unabated. For instance, almost 20 percent of World Bank lending in 2007 was allocated to transportation infrastructure projects, more than the share in education, health and social services combined (World Bank, 2007). In China, arguably the most successful transition economy, the central government announced in 2008 the largest ever amount earmarked for infrastructure spending, with a quantum that surpasses the total planned expenditure in public housing, health care and education.[26]

[25] Stimulative infrastructure spending was widespread globally. For instance, it was a campaign tool for former US President Bill Clinton who "has made infrastructure spending a major part of his economic plan" (Munnell, 1992, p.190). It was even implemented to construct roads for leisure in the 1940s in the US. For instance, the 108 mile Skyline Drive atop the Blue Ridge Mountains in the US state of Virginia's Shenandoah National Park was constructed during the Great Depression as a public work relief programme for young, unemployed, unmarried men. Gramlich (1994) surveys the infrastructure literature.

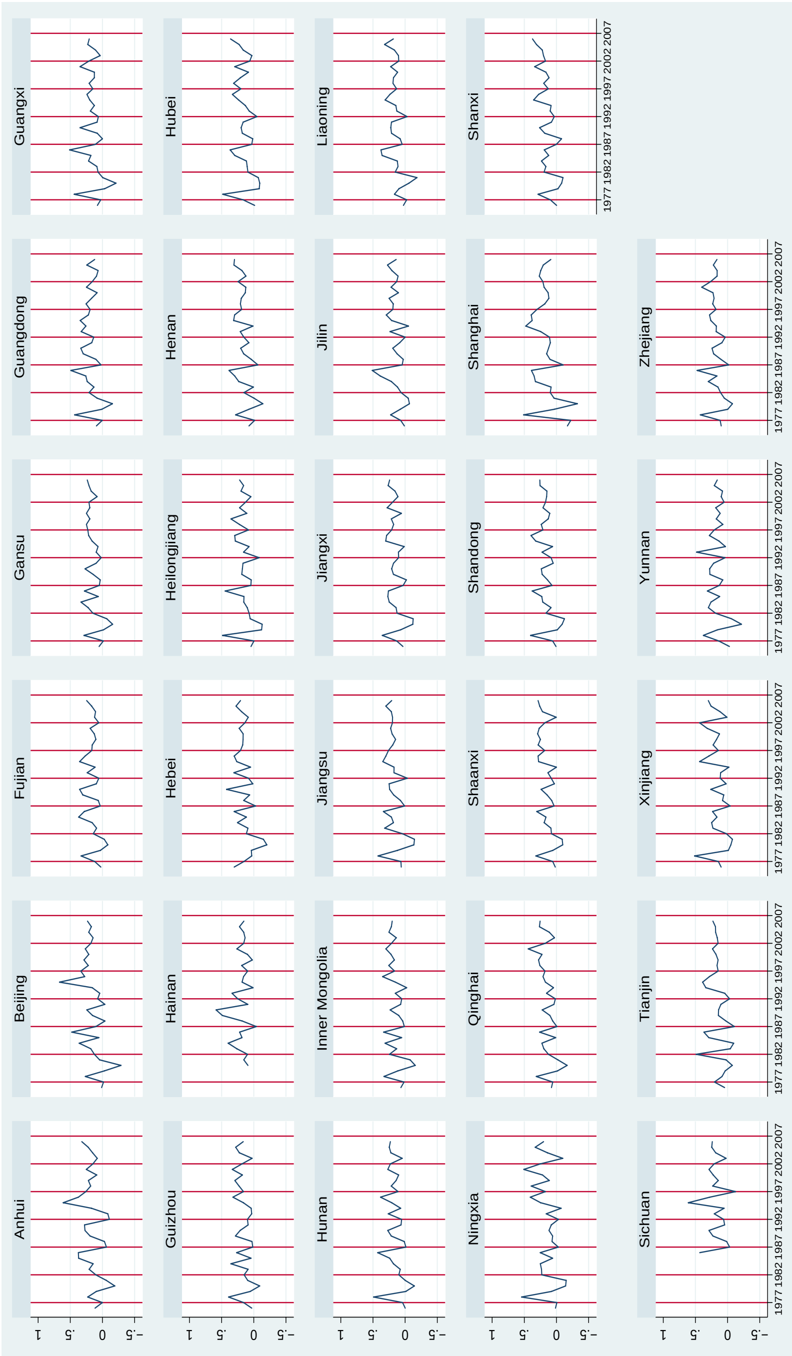
[26] See, for example, Wong (2011). The policy, which was announced in 2008, includes committing 1) RMB 1.52 trillion for infrastructure projects that include road construction and to increase the total highway length by about 40 percent between 2010 and 2020, and 2) RMB 1.41 trillion in 2010 and 2011 for railroad construction and to raise the total operating length by about 33 percent between 2010 and 2015. Note that China's average nominal GDP from 2004–2009 was approximately RMB 26.6 trillion, where RMB 1.52

From the policy perspective, the positive correlation between changes in density of transportation infrastructure (hereafter, changes in transportation infrastructure), as measured by length of railway and highway per squared kilometre area, and economic growth may be viewed as an encouraging empirical regularity. Nevertheless, academics even to date are confronted with the problem of identifying the extent to which this correlation reflects the causal effect on economic growth that is due to changes in transportation infrastructure. Obtaining a consistent estimate of this causal effect is complicated by two issues. First, the data may contain measurement errors, which if they are classical, will attenuate the least-squares estimate towards zero and understate the true contribution of transportation infrastructure towards economic growth.[27] Second, provision of infrastructure can respond endogenously to economic growth, as higher levels of economic growth may in return encourage the expansion of infrastructure services. Ideally, an experiment that randomly distributes infrastructure can avoid reverse causality, however, it is empirically infeasible. Thus, careful analysis of the causal link requires finding an external source of variation in changes in transportation infrastructure as a means of identification, which itself is a significant hurdle to overcome.

trillion and RMB 1.41 trillion were approximately USD 0.23 trillion and USD 0.22 trillion respectively. Sources: *The road to success*, HSBC Emerging Market Report, March 10, 2010; *China infra construction sector*, JP Morgan Asia Pacific Equity Research, 5 January, 2011.

[27] In the case of China which is the focus of this study, the data are obtained from the National Bureau of Statistics of China (NBSC), which according to Rawski (2001), Rawski and Xiao (2001), Chow (2006), and Ravallion and Chen (2007) may contain measurement errors.

Fig. 3.1: Annual Growth Rate of Provincial Government Expenditure, 1976–2006



Note: The figure plots the average of the annual government expenditure growth of 22 provinces, three municipalities and four autonomous regions, less Chongqing municipality and Tibet autonomous region. Data are obtained from the National Bureau of Statistics of China (NBSC). The vertical lines represent the years of the National Congress, which are 1977, 1982, 1987, 1992, 1997,2002 and 2007.

Focusing on the case of China, this chapter seeks to address these issues and contribute to the literature on the causal effect that transportation infrastructure has on economic growth. Employing a provincial panel dataset during 1985–2008, it does so by proposing an identification strategy to construct 2SLS estimates of the within-province causal effects that use the timing of an exogenous event – National Congress of the Communist Party of China (CPC) – as a source of external variation in changes in transportation infrastructure. This strategy relies on the interplay of two institutional features in the Chinese political and fiscal system. For a start, it appeals to the unique Chinese political environment where government interventions for promoting economic development and growth are frequent and influential, and where some of these intervening policies originate from major political events such as the National Congress of the CPC. Since 1977, the CPC convenes every five years at the National Congress in the capital city of Beijing to discuss internal party matters and ratify national development objectives such as economic growth targets.[28] Because the Chinese fiscal system is highly decentralised, the vast majority of responsibilities of accomplishing such national objectives, in particular the implementation of fiscal spending and the provision of infrastructure, are assigned to local governments (Wong, 2011).[29] Therefore, while the congressional event *per se* may not be directly associated with provincial economic growth, the recurring National Congress may engender a cyclical pattern in the expenditure of provincial governments, in particular the expenditure on transportation infrastructure, which in turn may generate the variation in serviceable transportation infrastructure that is useful for identifying its effect on growth.

Figure 3.1 offers some visual evidence that the spending of provincial governments and the timing of the National Congress are linked. Plotting the annual growth rate of provincial government expenditure from 1976

[28] For instance, in the most recent (12th) five-year plan ratified by the National Congress, the central government sets a target of 7 percent of annual economic growth during 2011-2015 with significant improvement in the quality and performance of economic development. See `http://www.chinadaily.com.cn/china/2011npc/2011-03/05/content_12120516.htm`.

[29] In recent times, the local governments have accounted for more than 80 percent of the national budgetary expenditures. See Wong (2011).

Tab. 3.1: Correlation Between Transportation Infrastructure Growth and Government Spending Growth, 1977–2006

	spending (-3)	*spending (-2)*	*spending (-1)*	*spending*
transport growth	-0.0069	0.0511	0.1054**	0.1153***
	[0.8402]	[0.1368]	[0.0021]	[0.0007]

Note: The numbers in the brackets are p-values and the asterisk represents significance levels according to *** p<0.01, ** p<0.05, * p<0.1. This table shows the correlation between the annual growth rate of the density of transportation infrastructure (*transport growth*) and the annual growth rate of provincial government expenditure. *spending* is the contemporaneous annual growth rate of provincial government expenditure, $spending(-k)$ is the growth rate that takes place k year(s) before, i.e. the kth lead. The correlation figures are calculated using data on 22 provinces, three municipalities and four autonomous regions, less Chongqing municipality and Tibet autonomous region, obtained from the National Bureau of Statistics of China.

to 2006, it shows that provincial spending usually peaks a year or two before the National Congress. This could be due to the fact that spending, should it be on infrastructure, may materialise into serviceable infrastructure with a possible delay. Indeed, Table 3.1 shows that spending growth is not only positively correlated with transportation infrastructure growth contemporaneously, but also with its first lag.[30] Since transportation infrastructure could be related to provincial government expenditure, which in turn could be systematically elicited by the National Congress, this relationship potentially allows us to exploit the timing of the National Congress as a source of external variation in transportation infrastructure for identification.

Subjecting the visual evidence to the test, the statistical evidence this chapter gathers confirms that the timing of the National Congress is indeed related to the variation in changes in transportation infrastructure in a peculiar way. For example, letting the data speak, this chapter finds that transportation infrastructure accumulates most significantly around the year of the National Congress rather than on years further away from the event. Besides showing that the timing of the National Congress and increase

[30] Refer to Table 3.8 for a definition of the transportation infrastructure variable.

in transportation infrastructure are potentially linked, this chapter also contributes to the literature in the following aspects. Firstly, only a handful of papers to date had looked at how timing of the National Congress could have causal implications.[31] This chapter uses this information about the National Congress for identification, and thus proposes another avenue to complement existing techniques for pinning down the causal effect of changes in transportation infrastructure in the study of its effect on growth in China. Secondly, this chapter also highlights the important role of transportation infrastructure in channelling the forces from the timing of the National Congress into cyclical variation in economic growth, as this chapter finds that the timing of the National Congress has a positive influence on GDP growth per capita through the accumulation of transportation infrastructure.

The rest of the discussion is organised as follows. Section 2 provides some background on the literature and section 3 presents the data and the summary statistics. The methodology and results are discussed in sections 4 and 5. Section 6 concludes.

2. Related Literature

This work is related to the research agenda, linking back to Aschauer (1989), that looks at the impact of infrastructure on growth.[32] In this literature, identifying the causality of infrastructure is complicated by the endogenous response of infrastructure to growth. One solution is to model this reverse causality together with the main causal relationship using a simultaneous

[31] Piotroski et al. (2010) examine how local and provincial government entities might manipulate the flow of negative financial information into the stock prices of state-controlled firms. They find that state-controlled firms are significantly less likely to experience negative stock price crashes in the congress years and political promotion events. Shen et al. (2008) show that activities in the Chinese initial public offering (IPO) market could be politically influenced, as IPO volumes typically declined after the congress year, only to rise towards a peak in the quarter of the next National Congress.

[32] Aschauer (1989), who brought this topic to the fore, as well as Holtz-Eakin (1988), Munnell (1990) and Rubin (1991), first find the return on public capital in production to be far greater than that on private capital. But this result is hardly plausible, as it would motivate the undertaking of public capital investment by the private sector, which one rarely observes.

equations approach (Esfahani and Ramirez, 2003).[33] Another solution is to ascribe this endogeneity to the presence of fixed effects, hence employ fixed effects estimation[34] or dynamic panel methods (e.g. Calderón and Chong, 2004 and Calderón and Servén, 2005).[35] Nevertheless, even if fixed effects were dealt with, there could still be omitted idiosyncratic variables that are correlated with infrastructure that call for the use of external information to achieve identification.[36]

To ameliorate the issue of endogeneity, some studies have pointed out that since the contribution of output growth towards infrastructure stock would be very small, the endogeneity in infrastructure should not be too serious if infrastructure *stock* and not *flow* were used as the regressor.[37] In this study, infrastructure stock is used as the regressor and a 2SLS approach is adopted as a safeguard.

This work is related to Chen and Fleisher (1996), Fleisher and Chen (1997), Démurger (2001), Fleisher et al. (2010), and Chen and Yao (2011). Chen and Fleisher (1996) and Fleisher and Chen (1997) look at the determinants of GDP growth and TFP among Chinese provinces but the impact of transportation infrastructure is not included in their study. This is undertaken in Fleisher et al. (2010), although the context is mainly on the impact of infrastructure on TFP growth. Using Chinese provincial panel data over the period 1978–2006, Chen and Yao (2011) analyse the implication of increasing the proportion of government budgets for investments in transportation, although unlike this chapter's focus on economic growth,

[33] A simultaneous equations approach is employed by Binswanger et al. (1993), who examine the effects on agricultural output from government's physical infrastructure expenditure.

[34] In earlier studies based on US state-level panel data, Holtz-Eakin (1994), Holtz-Eakin and Schwartz (1995) and Garcia-Mila et al. (1996) find that introducing fixed effects may eliminate the positive effect of infrastructure on growth.

[35] Caselli et al. (1996) show that the per capita growth equation can be expressed as an autoregression in per capita output levels, which can then be estimated using the identification scheme of Arellano and Bond (1991). Calderón and Chong (2004) and Calderón and Servén (2005) employ cross-country panel data and find that infrastructure stock reduces income inequality and increases growth positively.

[36] This could be due to relevant omitted variables or measurement error in the explanatory variable of interest. See Angrist and Pischke (2009) p.225.

[37] See, for example, Estache et al. (2005) and Arnold et al. (2007).

they are primarily concerned with the response of household consumption. Also using Chinese provincial panel data, Démurger (2001) looks at how transportation infrastructure could drive provincial income disparities in China. While Démurger (2001) employs internal instruments, e.g. lagged trade and FDI, this chapter intends to use external instruments which rely on the timing of an exogenous event – the National Congress – as an empirical strategy to estimate the causal effect of transportation infrastructure.

In this regard, this research is also related to a handful of papers that consider the issue of identifying the exogenous variation in changes in transportation infrastructure.[38] Based on Chinese county-level data to study how access to transportation infrastructure may affect growth, Banerjee et al. (2012) use the distance of a county from transport networks that connect historical treaty ports and business centres to construct an exogenous proxy of accessibility to current transportation infrastructure. Li and Li (2010) examine the causal effect on firms' inventory levels by controlling for omitted variables that might affect infrastructure and inventory jointly. Li (2009) looks at the welfare implication of the provision of transport by employing a quasi-natural experiment approach. This work complements these identification schemes by introducing a simple, yet powerful, instrument for transportation infrastructure that draws information from the timing of the National Congress.

[38] See also Fernald (1999), Michaels (2008), Keller and Shiue (2008) and Donaldson (2010). Based on industry-level data for the US, Fernald (1999) identifies the causal effect of roads on US industrial productivity from 1953 to 1989 by examining how the intensity of vehicle use by different industries is linked to their productivity levels. Causality is pinned down if changes in road growth are associated with larger changes in productivity growth in industries that are more vehicle intensive. A difference-in-difference approach to deal with the endogeneity issue is employed by Michaels (2008), who examines the effect of highway construction in the US in the 1950s, and Donaldson (2010), who studies the effect of railroad construction in 19th century India. Keller and Shiue (2008) look at the effect of steam train in 19th century Europe by employing an instrumental variable approach for identification.

3. Data and Variables

The study utilises panel data drawn from the *China Compendium of Statistics*, which is compiled by the Department of Comprehensive Statistics of the National Bureau of Statistics. The year 1985 is chosen to be the starting period of the sample as there are many missing observations on the covariates prior to 1985. The end of sample year in the dataset is 2008.[39] Regional data are available for 31 sub-national administrative units in mainland China,[40] including 22 provinces, four municipalities (Beijing, Shanghai, Tianjin, and Chongqing[41]) and five autonomous regions (Tibet, Xinjiang, Ningxia, Inner Mongolia and Guangxi). The inclusion of the data on municipalities is consistent with Fleisher and Chen (1997) as doing so will help to maximise the use of available information. For exposition sake, this chapter calls each sub-national unit 'province'. The summary statistics are presented in Table 3.2.[42]

The dependent variable is real GDP growth per capita. The control variables include production factors consisting of physical and human capital, and provincial attributes reflecting geographical constraints and economic heterogeneity. As proxies for physical and human capital shares, this chapter uses fixed investment to GDP ratio and secondary school enrolment rate (e.g. Démurger, 2001).[43] In relation to section 4, these variables are grouped and represented collectively as the vector x_{it}, where i is the province index and t is the year index. The additional controls that are considered are,

[39] This chapter sticks to 1985 as the starting year following Démurger (2001).

[40] According to official classification, all regions excluding Hong Kong, Macao and Taiwan are categorised as East (12), Central (9) and West (10). East: Beijing, Tianjin, Shanghai, Shangdong, Hebei, Liaoning, Fujian, Jiangsu, Zhejiang, Guangdong, Guangxi, Hainan. Central: Heilongjiang, Henan, Hunan, Hubei, Inner Mongolia, Jilin, Anhui, Jiangxi, Shanxi. West: Chongqing, Gansu, Guizhou, Ningxia, Qinghai, Shaanxi, Sichuan, Tibet, Xinjiang, Yunnan.

[41] Chongqing was designated a municipality in the year 1997. The other three cities were initially municipalities when the People's Republic of China was established in 1949.

[42] A detailed list of variables is available in Table 3.8.

[43] Because infrastructure is a stock variable and fixed capital formation contains information about infrastructure, using fixed investment to GDP ratio instead ameliorates the collinearity between capital and infrastructure given that the fixed investment ratio is a flow variable and the density of transportation infrastructure, the infrastructure variable, is a stock.

Tab. 3.2: Summary Statistics, 1985–2008

Variables	Obs	Mean	SD	Min.	Max.
GDP growth per capita	667	0.08	0.05	-0.04	0.24
transport	720	0.35	0.28	0.02	2.35
$ln(GDP)_{t-2}$	696	7.08	0.78	5.35	9.31
vector x					
investment	717	0.36	0.12	0.17	0.79
education	730	0.05	0.02	0.001	0.10
vector z					
FDI	673	0.04	0.06	0.0002	0.40
trade	706	0.03	0.07	0.0002	0.50
urbanisation	604	0.37	0.17	0.003	0.88
agricultural labour	721	0.52	0.17	0.05	0.81
state labour	727	0.25	0.15	0.08	0.74
telephone density	717	53.74	162.52	0.01	1,711.01
population density	739	351.10	403.26	1.64	2,224.53
coastal	744	0.29	0.45	0	1
reform	743	0.25	0.40	0	1
coastal×*reform*	743	0.06	0.22	0	1

Note: Section 3 provides a discussion on these variables, particularly the vectors x and z. Variable definitions are provided in Table 3.8.

a coastal dummy, urbanisation rate, population density, telecommunication density, agricultural labour as a fraction of total labour, non-private firm labour fraction, and FDI and trade as ratios over their respective national levels. These variables capture the uneven development and differences in geographic, economic and social characteristics across provinces that are now standard control variables in the literature (e.g. Fleisher and Chen, 1997; Démurger, 2001; Fleisher et al., 2010). Also, a reform dummy to pick up the effects of the institutional reforms and economic decentralisation that took place between 1992 and 1998 is included, so as to disentangle the effect of this policy from the effect of the timing of the National Congress.[44] These additional control variables are grouped and represented as the vector z_{it}.

The key explanatory variable in this chapter is the density of transportation infrastructure, defined as the sum of the length of roads and railroads in kilometres divided by the total land area in square kilometres. This measure of transportation infrastructure is widely adopted by existing studies for China (Démurger, 2001; Fan and Zhang, 2004; Ding and Knight, 2011) and for cross-country analysis (Esfahani and Ramirez, 2003; Calderón and Chong, 2004; Calderón and Servén, 2005).[45] As discussed, a measure related to infrastructure stock, rather than its flow, is preferred on the basis of ameliorating the possibility of endogeneity due to reverse causality from growth. In addition, this study prefers to focus on the causality of infrastructure stock than infrastructure spending for two reasons. Firstly, by focusing on the causal effect of infrastructure spending, the question at hand becomes fundamentally different. Secondly, as spending may be inefficient and wasteful, the expenditure itself may not materialise into intended levels of infrastructure output. In other words, the study of the effects of transportation investment is not the same as the study of the effects of materialised transportation infrastructure, which is the main focus of this study.

[44] This period corresponds to the third phase of China's economic reform towards a more market-oriented and open economy.

[45] It should be mentioned that together with infrastructure stock, Calderón and Chong (2004) also look at the causal effect of infrastructure quality. They find that the causal effect of infrastructure stock is more quantitatively important.

4. Methodology

4.1 The Estimating Equation

In the spirit of the celebrated Barro framework,[46] considered by Chen and Fleisher (1996), Fleisher and Chen (1997) and Démurger (2001) in their study of economic growth in China, the main estimating equation is as follows,

$$g_{it} = c + \phi\, transport_{it} + \beta \ln(y_{it-2}) + \gamma' x_{it} + \rho' z_{it} + \alpha_i + \gamma_t^r + u_{it}, \quad (3.1)$$

where g_{it} represents the average annual growth rate of real GDP per capita for province i at time t, y_{it} represents the level of real GDP per capita, α_i is the province fixed effect that controls for time-invariant permanent differences across provinces and u_{it} is the error term.

The causal variable of interest is $transport_{it}$, the density of transportation infrastructure, where its impact is summarised by ϕ. In order to identify ϕ, it is important to carefully consider the issue of omitted variables that may be correlated with both $transport_{it}$ and g_{it}. To address this issue and to ameliorate the problem of omitted variable bias, $\ln(y_{it-2})$ is included to control for differences in the past condition across provinces. Also, the vector x_{it} is included to control for production factors such as physical and human capital as these factors are inputs in the production process.

To control for the uneven development and differences in geographic, economic and social characteristics across provinces, the inclusion of the vector z_{it} is considered. The vector z_{it}, by soaking up the remaining effects on growth that are not captured by x_{it}, also plays the role of disentangling the possible effects related to other policy changes from the effect of the National Congress on transportation infrastructure. For example, being an aggregate event, not only may the National Congress impact the formation of transportation infrastructure, it may also influence trade policies that might in turn have non-trivial effects on growth. Therefore, without taking

[46] Using data obtained from 98 countries over the period 1965–1985, Barro (1991) investigates what determines GDP per capita growth. The main variables estimated in Barro (1991) are initial level of GDP per capita, human capital, physical capital and government investment.

into account the possible changes in trade policies that are related to the National Congress, the 2SLS estimate may be confounded by the effect that runs from the National Congress to these policy 'shocks', and ultimately to economic growth. In order to identify the link between the timing of the National Congress and transportation infrastructure so as to pin down the effect of changes in transportation infrastructure on economic growth, it is important to partial out these confounding effects. To the extent that these effects are manifested through some measure of provincial trade, which this chapter has included as a component in the vector z_{it}, this may be achievable by controlling for the vector z_{it} in the regression analysis.

To smooth out short term fluctuations, this chapter follows a previous protocol of using averages for continuous variables according to the averaging scheme $(x^*_{it-1}+2x^*_{it}+x^*_{it+1})/4$ for some continuous variable x^*_{it} (e.g. Démurger, 2001). For binary indicators, this study will use the start of the averaging period so that the $t-1$th observation is used for the regression indexed by t. The use of an averaging scheme, as in Chen and Fleisher (1996), Fleisher and Chen (1997) and Démurger (2001), would dampen any extant systemic shock that is not already soaked up by the vectors x_{it} and z_{it}.[47] Hence, this averaging scheme serves as a additional precautionary measure to deal with systemic shocks that affect all the regions identically, from Tibet and Xinjiang autonomous regions in China's deep west to Beijing, Shanghai or Guangdong province in the coastal east, even though the occurrence of such shocks on a regular basis seems unlikely given the immense diversity in culture, religion and governance across these regions. Moreover, these shocks, if they exist, are likely to be due to global effects that are not associated with the timing of the National Congress in a systematic way, in which case any omitted remnant of these shocks (after what x_{it} and z_{it} have absorbed) should not infringe upon the empirical strategy.

To add another layer of safeguard, this chapter includes γ^r_t that represents a separate trend for each of three regions (r) — East, Central and West regions — which is based on the official classification of grouping

[47] This, perhaps, explains why the models of Chen and Fleisher (1996) and Fleisher and Chen (1997) abstract from year fixed effects.

administrative units. Including a trend is important for two related reasons. Firstly, the measure of transportation infrastructure that is used in this paper and elsewhere in the literature contains an increasing trend. This is because its denominator (the area of the province) is fixed while the numerator (transportation infrastructure stock) is rising over time. Secondly, the GDP growth per capita of emerging countries may have an increasing trend. This is the case for most Chinese provinces during the sample period.[48] As a result, the trends might give a misleading impression about how the covariates are related, and therefore must be purged to safeguard against confounding the main causal relationship.

4.2 Instrumental Variables

The identification strategy uses the timing of the National Congress and constructs $Congress$, an indicator variable that is equal to one for the year of the National Congress and zero for the other years, as an instrument for transportation infrastructure. Besides $Congress$, there are reasons why using indicators of the years before the National Congress as additional instruments might be a good strategy from the identification standpoint. Firstly, it is best to let the data speak and take an agnostic stance on how the timing of the National Congress is related to the variation in changes in transportation infrastructure. Secondly, infrastructure could accumulate before the National Congress as construction might commence early. Thirdly, since the 1980s, the five-year plans outlining the national economic goals are drawn in the year before the National Congress.[49] Therefore, $Congress(-1)$, which indicates the year before the National Congress, and $Congress(-2)$, which indicates the two years before it, might potentially help to pick up further variation in transportation infrastructure.

[48] As opposed to emerging countries, the GDP growth per capita of developed countries may fluctuate around some steady state level without exhibiting a trend.

[49] The first Five-Year Plan was implemented for 1953 to 1957. A recent example is the 11th plan (2006-2010), which proposed that GDP per capita, urbanisation rate, and rural net income per capita towards the end of 2010 should reach 19,270 *yuan*, 47 percent, and 4,150 *yuan*, respectively. See Fan (2006).

The identifying assumption in this chapter relies on the premise that provincial economic growth is not directly associated with the National Congress *per se*, but indirectly with the timing of the National Congress as the policy objectives it ratifies are executed by local governments in a decentralised way. That being said, some issues related to exclusion restriction are worth further clarification. Firstly, to foster economic growth, local officials may engage in other 'growth enhancing' activities besides investment in transportation infrastructure.[50] While data at a more micro-level are not available, the issue will be taken care of insofar as the effects of these activities are manifested through the determinants of economic growth, such as fixed investment and education, that the estimating equation has already included as control variables. Secondly, provincial leaders of different backgrounds might adopt different development strategies, which are influenced by attitudes and ambitions that are not observable. However, this chapter holds on to the view that attitudes and ambitions *per se* should not directly contribute to growth, but indirectly through the economic activities that are influenced by these unobserved characteristics. Therefore, this unobserved heterogeneity, if it is not already taken care of by fixed effects, should not pose an issue as long as the effects of such concomitant economic activities are captured by the control variables in the model.[51] That said, section 5.4 checks for the sensitivity of the estimation results to the inclusion of certain attributes of local leaders as additional controls and finds that the results remain robust. Finally, the identification strategy is based on the timing of the National Congress, which is an aggregate event. Its effect may therefore be confounded by other unobserved shocks such as policy changes that are not related to the formation of transportation infrastructure but nevertheless are non-trivial for economic growth. To address this issue, this chapter includes not just the vector x_{it} in the estimating equation, but also

[50] For instance, local governments may provide easier loans to particular sectors or directly subsidise local state-owned monopolistic firms (Shen et al., 2012).

[51] For instance, while there are different industrial development strategies adopted by provincial leaders, these activities may be captured more conventionally by the other control variables. As an example, the 2008 Olympic Games in Beijing involves the construction of stadiums and relevant facilities, which involves fixed capital formation that is included as a control variable in the estimating equation.

considers the inclusion of the large z_{it} vector in an attempt to soak up these unobserved shocks and to partial out any effects that may confound the link that goes from the timing of the National Congress to transportation infrastructure, and ultimately to growth.

As a model-based assessment of instrument validity, this study will employ the overidentifying restrictions test. Rejecting the test implies that one or more instruments are invalid, or the model is mis-specified, or both. But it does not distinguish which condition or if both conditions are violated. This study will also check for weak instruments as they would cause the true standard errors to be understated.[52] To do so, this study will report the first stage F-statistic, motivated by the rule-of-thumb on adequate instrument strength if it is greater than 10. This study will also report the Kleibergen and Paap (KP) (2006) Wald statistic for further evidence on instrument weakness. The KP statistic will be evaluated against a critical value, adopted from Stock and Yogo (2005), that 15 percent is the maximal rejection rate the researcher is willing to tolerate if the true rejection rate is 5 percent.[53] Observing a KP statistic that exceeds this critical value implies that the maximal rejection rate is smaller than 15 percent, hence the actual size of the test is between the 5 percent and 15 percent levels. Last but not least, standard errors are clustered for each province.

5. Empirical Results

In all regressions, the vector x_{it} is included to control for physical and human capital inputs into the production process. This study also takes into account the time-invariant permanent differences by including province fixed effects while controlling for region-specific time trends. To check for the sensitivity of the estimation results to omitted variables, the baseline regressions juxtapose

[52] For instance, the congress instruments resemble instruments of political cycles, reminiscent of Levitt (1997) who considers electoral cycles to identify the causal impact of the number of police officers on crime, although these instruments are later found to be weak (Murray, 2006).

[53] This follows from the suggestion of Stock et al. (2002).

the estimates that are based on omitting versus including the vector z_{it}. Since the main interest is to estimate the effect of transportation infrastructure, the estimated effects of other control variables are suppressed for the sake of presentation.

5.1 Baseline Results

Table 3.3 summarises the baseline results from the OLS and 2SLS regressions. While the OLS regression is unidentified, it nonetheless provides a useful starting point for investigating the direction of bias in the estimate of how transportation infrastructure affects economic growth. Column (1) shows that the OLS estimate of the response of growth to transportation infrastructure is very close to zero. If the premise that transportation infrastructure is growth enhancing, this weak association suggests at first sight that the OLS estimate is downward biased. This bias, however, does not appear to be due to omitted variables, given that the OLS estimate remains stubbornly close to zero even when the vector z_{it}, which encompasses both macroeconomic and policy-related variables, is included in the regression (see column (2)). Instead, it is symptomatic of measurement errors in the data, which come from NBSC. According to Rawski (2001), Rawski and Xiao (2001), Chow (2006) and Ravallion and Chen (2007), data from NBSC may contain measurement errors. If these measurement errors are classical, the least squares estimates will be attenuated, which may explain why the OLS estimates are nearly zero.

To address the issues of measurement errors and reverse causality, column (3) reports the 2SLS estimates of both first and second stage regressions. The first stage regression in column (3) confirms that transportation infrastructure is substantially influenced by the year of the National Congress and the years before it. Moreover, the positive effect on transportation infrastructure among the congress instruments is strongest for $Congress$ but weakest for $Congress(-2)$, suggesting that transportation infrastructure accumulates the most around the year of the National Congress. Concerning

Tab. 3.3: Baseline Regressions

	(1)	(2)	(3)	(4)
	OLS		2SLS	
	Dependent Variable: *growth* (2nd Stage)			
transport	0.027*	0.026	0.295***	0.217***
	(0.014)	(0.024)	(0.076)	(0.061)
	Dependent Variable: *transport* (1st Stage)			
Congress			0.052***	0.057***
			(0.016)	(0.012)
Congress (-1)			0.051***	0.047***
			(0.013)	(0.011)
Congress (-2)			0.028**	0.017*
			(0.011)	(0.010)
First-Stage (F-stat)			43.41	55.51
Hansen J (p-value)			0.28	0.61
Weak IV (F-stat)			7.51	12.53
Weak IV critical value			4.46	4.46
N	656	501	656	501
x vector included?	Yes	Yes	Yes	Yes
z vector included?	No	Yes	No	Yes

Note: The numbers in parentheses are robust standard errors and the asterisk represents significance levels according to *** p<0.01, ** p<0.05, * p<0.1. Columns (1)-(2) are estimated by fixed effects OLS regression and columns (3)-(4) by fixed effects 2SLS regression. The vectors x and z are outlined in section 4.1. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 15 percent is the maximal rejection rate if the true rejection rate is 5 percent. Region-specific time trends are included in columns (1)-(4). Variable definitions are provided in Table 3.8.

identification, the first stage F-statistic in column (3) is well above the Staiger and Stock (1997) rule-of-thumb threshold of 10, suggesting that the congress instruments are powerful.

Given that the instruments are strong, the second stage regression shows that the effect of transportation infrastructure on growth is both quantitatively large and statistically significant. Unlike the tenuous infrastructure-growth relationship reflected by the OLS estimates, column (3) shows that a one standard deviation increase in the density of transportation infrastructure accounts for an 8.3 percentage point increase in GDP growth per capita on average.[54] This strong effect is not an artefact of omitted variables and policy changes that may interfere with the strategy of using the timing of the National Congress for identification. For instance, as a robustness check, column (4) shows that including the vector z_{it} does not eliminate the substantial effect that the timing of the National Congress (especially the variable $Congress$) has on transportation infrastructure, nor does it drive away the significant contribution of transportation infrastructure towards growth, where a one standard deviation increase in transport density, *ceteris paribus*, has the effect of raising GDP growth per capita by more than 6 percentage points on average.

The congress instruments are significant drivers of the variation in transportation infrastructure with a total impact of 0.121 (column (4)) to 0.131 (column (3)) reported in the first stage regressions. Therefore, through the transportation infrastructure channel, the indirect impact of the total congress effect on growth is non-trivial, where the total effect from the timing of the National Congress is associated with a 2.63 (column (4)) to 3.86 (column (3)) percentage point increase in GDP growth per capita on the year of the National Congress.[55] This implies that through the formation of transportation infrastructure, the timing of the National

[54] One standard deviation in transportation infrastructure is 0.28. The coefficient on transportation infrastructure in column (3) is 0.295. Therefore, the "8.3 percentage points" result that is reported in the text is derived from $100 \times 0.295 \times 0.28$.

[55] Focusing on column (4), the figure 2.63 is computed based on $100 \times 0.217 \times (0.057 + 0.047 + 0.017) = 2.63$, where $(0.057 + 0.047 + 0.017)$ captures the total response of transportation infrastructure to the three congress instruments.

Congress may generate cyclical increases in provincial economic growth, an empirical regularity of separate interest. Much of this increase in growth can be attributed to the information arising from the year of the National Congress and the year before it, as the effects of $Congress$ and $Congress(-1)$ on transportation infrastructure are much larger than the effect of $Congress(-2)$.

Columns (3)-(4) report the p-value of the overidentifying restrictions test. The Hansen J statistics with p-values of 0.28 and 0.61 imply that the overidentifying restrictions test is not rejected, hence supporting both the model specification and the validity of instruments. The fact that the p-value of the Hansen J in column (4) is 0.61 and is much greater than the p-value of 0.28 in column (3) suggests that a model that controls for the vector z_{it} would be preferred. As mentioned, the weakness of instruments would cause the true standard errors to be understated and distort the size of the hypothesis test. To evaluate weak instruments, columns (3)-(4) also report the KP statistic and the critical value corresponding to a 15 percent maximal size for a 5 percent hypothesis test. Against a critical value of 4.36, the KP statistics of 7.51 and 12.53 in columns (3) and (4), respectively, suggest again that the congress instruments are strong and the size distortion would be mild.

5.2 Coastal versus Non-Coastal Regions

The coastal and non-coastal regions in China differ not only in terms of geographical characteristics, but also in terms of how their economies are structured, and in the distribution of key production factors such as physical and human capital, FDI and trade, all of which contribute to income and productivity gaps between these regions (e.g. Chen and Fleisher, 1996; Fleisher and Chen, 1997; Fleisher et al., 2010). Through separate regressions for coastal and non-coastal regions, this study may investigate if the positive influence of the congress instruments on transportation infrastructure, as well as the positive effect of transportation infrastructure on growth, remain present when due considerations are made with respect to the heterogeneity across coastal and non-coastal regions in China.[56]

Columns (1) and (2) of Table 3.4 report the 2SLS estimates based on the sample of coastal provinces, and columns (3) and (4) report the same for non-coastal provinces. In the first stage regression, this chapter finds yet again that the timing of the National Congress has a large impact on transportation infrastructure. For the coastal region, the total effect of the congress instruments on transportation infrastructure ranges from 0.156 when z_{it} is controlled (column (2)) to 0.174 when z_{it} is omitted (column (1)). For the non-coastal region, columns (3)-(4) show that the total congress effect in the first stage regression, although smaller, remains non-trivial. While the timing of the National Congress is an important determinant of transportation infrastructure for both coastal and non-coastal regions, the larger impact of the National Congress with respect to the coastal region is perhaps reflective of the fact that governments in the coastal region have been more responsive to the National Congress, or that their efforts to accumulate infrastructure have been more successful than governments in the non-coastal region.

From the second stage regressions pertaining to coastal and non-coastal regions (see columns (1)-(4) of Table 3.4), it is evident that the contribution of transportation infrastructure towards growth is robust. Nonetheless, there are regional disparities in the response of growth to transportation infrastructure. For instance, column (2) reports a coefficient of 0.192 on transportation infrastructure for the coastal region whereas column (4) reports a coefficient of 0.239 for the non-coastal region, where both estimates are statistically significant at the 1 percent level. This implies that controlling for z_{it}, a one standard deviation increase in transport density, *ceteris paribus*, has an effect of raising GDP growth per capita on average by 5.4 percentage points in the coastal region and 6.7 percentage points in the non-coastal region. Since transportation infrastructure is relatively less developed in the

[56] To simplify matters, this study includes a common regional trend for each coastal and non-coastal region. For the non-coastal regions, this study could use separate trends for Central and West regions. As it turns out, the results are not sensitive to using two separate regional trends or a common trend.

Tab. 3.4: 2SLS Regressions for Coastal and Non-Coastal Regions

	(1)	(2)	(3)	(4)
	Coastal		Non-Coastal	
	Dependent Variable: *growth* (2nd Stage)			
transport	0.228**	0.192**	0.367***	0.239***
	(0.098)	(0.088)	(0.119)	(0.081)
	Dependent Variable: *transport* (1st Stage)			
Congress	0.073**	0.078***	0.040***	0.049***
	(0.035)	(0.027)	(0.015)	(0.013)
Congress (-1)	0.064**	0.056**	0.042***	0.046***
	(0.028)	(0.026)	(0.014)	(0.012)
Congress (-2)	0.037	0.022	0.021*	0.018*
	(0.025)	(0.027)	(0.012)	(0.010)
First Stage (F-stat)	29.51	47.82	31.24	26.21
Hansen J (p-value)	0.89	0.92	0.20	0.71
Weak IV (F-stat)	2.88	3.72	4.55	8.91
Weak IV critical value	4.36	4.36	4.36	4.36
N	198	124	458	377
x vector included?	Yes	Yes	Yes	Yes
z vector included?	No	Yes	No	Yes

Note: The numbers in parentheses are robust standard errors and the asterisk represents significance levels according to *** p<0.01, ** p<0.05, * p<0.1. Columns (1)-(4) are estimated by fixed effects 2SLS regression. The vectors x and z are outlined in section 4.1. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 15 percent is the maximal rejection rate if the true rejection rate is 5 percent. Region-specific time trends are included. Variable definitions are provided in Table 3.8.

inland areas, this suggests that the return to transportation infrastructure in terms of growth would be larger when infrastructure is scarce. The stronger positive effect of transportation infrastructure observed for the non-coastal region also suggests that transportation infrastructure can help to narrow the income gap between the wealthier coastal provinces and their less affluent non-coastal neighbours.

5.3 Attributes of Provincial Leaders

This section conducts a sensitivity test that is motivated by the consideration that provincial leaders might adopt different development strategies based on their own attributes. Chen et al. (2005) and Li and Zhou (2005) find that provincial secretaries of the CPC and provincial governors are evaluated based on certain criteria such as the annual growth rate and five-year average provincial GDP per capita. If personal attributes of provincial leaders can affect policy outcomes in their regions, these attributes may interact with the timing of the National Congress to influence economic growth. Consequently, this might violate the exclusion restriction required of the congress instruments, an indication of which would be fragility of the baseline estimates when the attributes of local leaders are introduced as additional controls. Even though this is not an infallible procedure, the sensitivity check reported below concurs that the baseline results are robust, which offers some limited support that exploiting the timing of the National Congress is a reasonable strategy from the estimation standpoint.

To control for the personal characteristics of local leaders, this study forms vectors x^{SEC} and x^{GOV} that contain the attributes of two key sorts of provincial leaders, the provincial CPC secretary (x^{SEC}) and the provincial governor (x^{GOV}). Drawing from the study of Chen et al. (2005) and Li and Zhou (2005), this study constructs variables of personal characteristics that are related to the tenure, age (including its square), education and past working experience of the secretary or governor. The tenure is defined as the kth year of one's current assignment in either a CPC secretary or a provincial governor position. The education variable is a binary variable that is equal to one if a leader is an alumnus of a choice university in China, which is a way of extracting information about the ambition and personal network of a local leader.[57] Following Li and Zhou (2005), this study also considers the implication of working experience by constructing a binary variable that is equal to one if a leader has past experience or is currently holding a joint appointment in the central government. Li and Zhou (2005) find that having connections with the central government may increase the promotional chances of local leaders, which may in turn influence the type of development strategies they choose to pursue for their local regions.

Table 3.5 reports the estimation results based on the regression that controls for x^{SEC} (column (1)), x^{GOV} (column (2)), or both (column (3)). For the sake of conciseness, this study suppresses the estimated coefficients on the extra controls, some of which are statistically significant, and focuses on what is essential – whether the baseline estimates are robust.[58] Table 3.5 shows that the estimated coefficient on transport density across columns (1)–(3) ranges from 0.222 to 0.240. These estimates are clearly closer to the baseline estimate of 0.217 (see column (4) of Table 3.3) than the OLS estimate which is nearly zero. Therefore, these results show that the baseline estimates are robust to the inclusion of the attributes of provincial leaders as additional controls, despite the fact that these attributes may affect the efficacy of managing and implementing policies including those ratified by the National Congress.

5.4 Alternative Constructions of Instrumental Variables

As a further robustness check on the effect of transportation infrastructure on growth, this study considers several alternative constructions of instrumental variables, which are motivated by one caveat with respect to using $Congress$,

[57] The choice universities are Peking University, Tsinghua University, Fudan University, Jiaotong University and Renmin University. This study distinguishes between local leaders who are graduates from choice versus non-choice universities instead of considering whether these leaders have or haven not acquired a university degree, since a significant majority of local leaders are university graduates.

[58] Adding characteristics of provincial leaders into the regression, this study finds that the tenure and connection of provincial CPC secretaries are statistically significant but the characteristics of the provincial governors are not individually statistically significant. Details are available in Appendix A (Table 8.1).

Tab. 3.5: Attributes of Provincial Leaders As Additional Controls

	(1)	(2)	(3)
	Dependent Variable: *growth* (2nd Stage)		
transport	0.233***	0.222***	0.240***
	(0.062)	(0.061)	(0.063)
	Dependent Variable: *transport* (1st Stage)		
Congress	0.056***	0.057***	0.056***
	(0.012)	(0.012)	(0.012)
Congress (-1)	0.046***	0.047***	0.045***
	(0.010)	(0.011)	(0.010)
Congress (-2)	0.018*	0.019*	0.019*
	(0.010)	(0.010)	(0.010)
First-Stage (F-stat)	46.60	46.78	40.811
Hansen J (p-value)	0.51	0.66	0.56
Weak IV (F-stat)	12.51	12.52	12.28
Weak IV critical value	4.36	4.36	4.36
N	501	501	501
x vector included?	Yes	Yes	Yes
z vector included?	Yes	Yes	Yes
x^{SEC} vector included?	Yes	No	Yes
x^{GOV} vector included?	No	Yes	Yes

Note: The numbers in parentheses are robust standard errors and the asterisk represents significance levels according to *** p<0.01, ** p<0.05, * p<0.1. Columns (1)-(3) are estimated by fixed effects 2SLS regression. The vectors x and z are outlined in section 4.1. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. The additional control variables included in the regressions are x^{SEC}, x^{GOV} and z. The vectors x^{SEC} and x^{GOV} consist of attributes – *age*, square of *age*, *tenure*, *education* and *central connection* – on the provincial secretary and provincial governor respectively. Column (1) and column (2) control for x^{SEC} and x^{GOV} respectively, and column (3) controls for both. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 15 percent is the maximal rejection rate if the true rejection rate is 5 percent. Region-specific time trends are included in columns (1)-(4). Variable definitions are provided in Table 3.8.

$Congress(-1)$ and $Congress(-2)$ as instruments. Specifically, the economic consequences of the National Congress, while it is an aggregate event, may not be uniform across all provinces. Therefore, it is important to construct an instrument that draws information from the timing of the National Congress in a way that allows the effect of the National Congress to be province-specific.

To construct such alternative instruments, this chapter first constructs a so-called intensity function, related to the timing of the National Congress, that is indexed by time only. The intensity function increases in magnitude, and thus becomes more intense so to speak, the closer that the period t is to the next National Congress. Taking an agnostic approach on how the intensity function should look like, this chapter considers two possible constructions. Letting k_t denote the k number of years that period t is before the next National Congress, where k_t takes a value of either 4, 3, 2, 1, or 0, the first function, which is called the linear intensity function, is defined to be

$$f(k_t) = 5 - k_t.$$

For instance, if t coincides with the year of the National congress, k_t is equal to zero and the intensity function has the maximum value of 5. This chapter also considers a second construction, which this study calls the convex intensity function, defined as

$$g(k_t) = 1/(1 + k_t).$$

This is a convex intensity function because as k_t decreases, the function g increases at an increasing rate. In order to obtain an instrument that contains variation across both time and provinces, this study interacts the intensity function, f or g, with a variable that exhibits provincial variation. This study considers two such variables, which are linked to the National Congress as well.

The first variable is *seats share*, defined as the number of congressional seats of a province divided by the total number of seats in the National Congress. This variable captures differences in political power across provinces. Thus, the effect of the National Congress may be more important for provinces that are relatively more powerful in the sense that is described by *seats share*. Since information about the number of congressional seats is only available since 2007, this study constructs *seats share* using 2007 data provided by *Xinhua Net*, which would be reasonable if the relative political power of each province did not vary too much over the sample period. The second variable is *lagged spending*, which is the lagged government expenditure. As discussed in section 1, the variation in government expenditure appears to be related to the timing of the National Congress. Since the variation in lagged government spending is also related to the formation of transportation infrastructure (as serviceable infrastructure materialises from investments with a delay), the impact of the National Congress on transportation infrastructure might be more evident in provinces with higher levels of lagged government spending.

Controlling for z_{it} throughout, Table 3.6 revisits the 2SLS regressions in Table 3.3 by employing four alternative sets of instruments. Each instrument set is produced by interacting either the f or g intensity function with *seats share* or *lagged spending*. Regardless of how the instruments are constructed, Table 3.6 shows that the 2SLS estimates of the effect of transportation infrastructure on growth are both quantitatively large and statistically significant, with first stage F-statistics that are even larger than the baseline case (compare Table 3.6 with column (4) of Table 3.3). These second stage estimates are also very similar whether or not the linear or convex intensity function is used in the computation, implying that the shape of the intensity function is not crucial. Furthermore, the range of the new estimates, from 0.195 (column (1)) to 0.266 (column (2)), also contains the baseline estimate of 0.217 (see column (4) of Table 3.3). Therefore, despite using four different instrumental variable definitions, this study finds that the estimated effects of transportation infrastructure in Table 3.6 are very similar to the baseline estimates in Table 3.3, hence offering some evidence on the robustness of the results.

Tab. 3.6: IV Regressions Using Alternative Instruments

	(1)	(2)	(3)	(4)
	Linear Intensity		Convex Intensity	
	Dependent Variable: *growth* (2nd Stage)			
transport	0.195***	0.266***	0.196***	0.258***
	(0.063)	(0.075)	(0.071)	(0.091)
	Dependent Variable: *transport* (1st Stage)			
seats share×intensity	0.457***		1.996***	
	(0.089)		(0.486)	
lagged spending×intensity		0.086***		0.350***
		(0.017)		(0.087)
First Stage (F-stat)	64.29	62.61	62.93	61.06
Weak IV (F-stat)	26.19	25.93	16.91	16.01
Weak IV critical value	8.96	8.96	8.96	8.96
N	501	500	501	500
x and z vectors included?	Yes	Yes	Yes	Yes

Note: The numbers in parentheses are robust standard errors and the asterisk represents significance levels according to *** p<0.01, ** p<0.05, * p<0.1. Columns (1)-(4) are estimated by fixed effects IV regression. The vectors x and z are outlined in section 4.1. The instruments in columns (1)-(2) are constructed by interacting the linear intensity function with seats share and lagged proportion of local government spending to GDP defined in section 6.1, respectively. The instruments in columns (3)-(4) are constructed by interacting the convex intensity function with seats share and lagged government spending share, respectively. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 15 percent is the maximal rejection rate if the true rejection rate is 5 percent. Region-specific time trends are included in columns (1)-(4). Variable definitions are provided in Table 3.8.

Tab. 3.7: IV Regressions Using Alternative Instruments For Coastal and Non-Coastal Regions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Linear Intensity				Convex Intensity			
	Coastal		Non-Coastal		Coastal		Non-Coastal	
	Dependent Variable: *growth* (2nd Stage)							
transport	0.180*	0.205**	0.200***	0.270***	0.193**	0.195**	0.188**	0.253**
	(0.094)	(0.094)	(0.073)	(0.096)	(0.097)	(0.093)	(0.081)	(0.117)
	Dependent Variable: *transport* (1st Stage)							
seats share×*intensity*	0.503***		0.513***		2.325***		2.229**	
	(0.162)		(0.107)		(0.857)		(0.612)	
lagged spending×*intensity*		0.195***		0.069***		0.924**		0.284***
		(0.065)		(0.017)		(0.351)		(0.086)
First Stage (F-stat)	51.85	50.07	30.20	27.71	49.99	47.53	29.51	27.18
Weak IV (F-stat)	9.69	9.12	22.95	17.72	7.36	6.92	13.26	10.89
Weak IV critical value	8.96	8.96	8.96	8.96	8.96	8.96	8.96	8.96
N	124	124	377	376	124	124	377	376
x and z vectors included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The numbers in parentheses are robust standard errors and the asterisk represents significance levels according to *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Columns (1)-(8) are estimated by fixed effects IV regression. The vectors x and z are outlined in section 4.1. The instruments in columns (1)-(4) are constructed by interacting the linear intensity function with seats share and lagged proportion of local government spending to GDP defined in section 6.1, respectively. The instruments in columns (5)-(8) are constructed by interacting the convex intensity function with seats share and lagged government spending share, respectively. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 15 percent is the maximal rejection rate if the true rejection rate is 5 percent. Region-specific time trends are controlled. Variable definitions are provided in the Table 3.8.

The robustness of the effect of transportation infrastructure is further supported by its quantitative and statistical significance in the regressions for both coastal and non-coastal regions, reported in Table 3.7, where the four alternative instruments are considered. Again, the new estimates in Table 3.7 turn out to be similar in magnitude to the baseline estimates pertaining to the coastal and inland provinces in Table 3.4. Take the coastal regression as an example. The baseline estimate of 0.192 in the second stage regression (see column (2) of Table 3.4) is very similar to the estimates of 0.193 and 0.195 that are based on the convex intensity function (see columns (5)-(6) of Table 3.7). The similarity between the baseline and new estimates reiterates the resilience of the results to different constructions of instrumental variables that utilise information from the National Congress.

5.5 Further Discussion

The study of whether the transportation infrastructure and growth relationship is causal is of first order importance. One of the most influential papers looking at this relationship for China is Démurger (2001), whose fixed effects 2SLS estimates provide some early indication that this causal effect may be non-trivial. In her paper, she finds that the increase in GDP growth per capita following a 0.1 increase in transport density ranges from 339 to 456 basis points.[59] Compared to these findings, the conclusions in this chapter are more modest. For instance, column (4) of Table 3.3 suggests that a 0.1 increase in transport density would only raise GDP growth per capita by 217 basis points on average. Therefore, this implies that the causal effect of transportation infrastructure, while is important for economic growth, may not be as large as previously found in the literature. On the other hand, this chapter's findings are tempered by the county-level study of Banerjee et al.

[59] In Model (2) in Table 2 of Démurger (2001), the coefficient on *transport* and $transport^2$ is 0.754 and −1.121 respectively. Using the average transport density of 0.2655 during 1985–1998 and omitting the coefficient on $transport \times pop.density$, the marginal effect of transport density on growth for the 'average' province is $0.754 - 1.121\overline{transport} = 0.754 - (1.121 \times 0.2655) = 0.4564$. Therefore, if transport density increases by 0.1, the yearly GDP growth per capita would increase by approximately 456 basis points on average. Similarly, based on Model (4) in Table 2 of her paper, a similar computation leads to a marginal effect of 0.3389.

(2012), who find that a county's proximity to transportation networks does not have a statistically significant effect on its economic growth. Overall, even though Banerjee et al. (2012) do not consider transport density as the main causal variable, their finding of a weak effect of accessibility to transportation networks on growth in contrast with the strong results of Démurger (2001) shows that there is some way to go in reaching a consensus on what the causal relationship between transportation infrastructure and economic growth might be with respect to China.

6. Conclusion

Focusing on China, this chapter proposes a new identification strategy that exploits the timing of the National Congress to identify the within-province effect that transportation infrastructure has on growth. Letting the data speak, it finds that transportation infrastructure is most strongly influenced around the year of the National Congress and the set of congress instruments constructed, which are associated with the timing of the National Congress, generates significant response in transportation infrastructure.

The main empirical results are presented as follows. The OLS estimate of the within-province effect of transportation infrastructure on growth is tenuous at best, a possible reflection of the overpowering influence of attenuation bias due to measurement errors in the data. By contrast, the 2SLS estimate paints an opposite picture. With the density of transportation infrastructure as the main causal variable, the 2SLS estimate shows that an increase in the density of transportation infrastructure, *ceteris paribus*, has an effect of raising GDP growth per capita by more than 6 percentage points on average. This effect is robust to the inclusion of a large number of additional control variables in the regression, as these variables are included to eliminate any bias that may arise from omitting potentially relevant variables, and to soak up the effects of other unobserved shocks such as policy changes that may coincide with the National Congress but are not related to the formation of transportation infrastructure. It is also robust to running separate regressions for coastal and non-coastal provinces as these regions differ not only in geographical characteristics, but also in how their economies are structured; as well as to utilising four alternative constructions of instrumental variables that allow for an aggregate event such as the National Congress to have province-specific effects on transportation infrastructure. Therefore, taking a broader perspective, the resilience of the main causal estimate that emerges from these robustness checks underscores the positive contribution that transportation infrastructure has made to the economic development of China.

Echoing the Chinese adage '*To get rich, build roads first*', this study provides some evidence that the positive association between transportation infrastructure and economic growth is causal, therefore affirming the positive role that transportation infrastructure has played in the economic development and transition of China. With respect to the magnitude of this causal effect, this study shows a more moderate result than that which has been reported in the seminal work in this area, i.e. Démurger (2001), implying that the economic returns to the improvement of transportation infrastructure may be diminishing over a longer period of time.

Although the short-run causal effect of the changes in transportation infrastructure on economic growth is carefully analysed in this chapter, one may still wonder what is the role of transportation infrastructure in China's long-run GDP per capita growth. Thus, Chapter 4 will explore this problem by proposing a new identification strategy to mitigate endogeneity issues, and quantify the casual effect of the improvement of transportation infrastructure on long-run economic growth.

Tab. 3.8: List of Variables

GDP growth per capita	the annual growth rate of real GDP per capita
transport	length of railway and highway (km) ÷ regional area (km^2)
ln(GDP)	logarithm of real GDP per capita
vector x	
investment	total fixed investment (flow) ÷ total nominal GDP
education	secondary school enrolment ÷ population
vector z	
FDI	local nominal FDI (USD) ÷ national nominal FDI (USD)
trade	local nominal total trade (USD) ÷ national nominal total trade (USD)
urbanisation	urban population ÷ total population
agricultural labour	agricultural labour ÷ local employed labour
state labour	labour employed in state and collective firms ÷ local employed labour
population density	regional total population ÷ regional area (km^2)
telephone density	telephone subscribers ÷ regional area (km^2)
coastal	dummy=1 if provinces are located in coastal regions*
reform	dummy=1 if year is between 1992 and 1998
coastal×reform	coastal dummy multiplied by reform dummy

Note: *The coastal regions are Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian and Guangdong.

4. LONG-RUN IMPACT OF TRANSPORTATION INFRASTRUCTURE ON GROWTH: EVIDENCE FROM CHINA

1. Introduction

In development economics, the contribution of transportation infrastructure to economic growth is a key topic that captivates much attention among academics and policy-makers alike.[60] This issue is especially relevant to China where behind its impressive growth trajectory in recent years is the rapid expansion of modern transportation infrastructure. Even as recently as 2008, the Chinese central government earmarked the largest ever infrastructure spending surpassing the total planned expenditure in public housing, health care and education, which underscored the confidence in infrastructure that the government had as a way of securing the country's economic future. From the policy perspective, transportation infrastructure is a key focal point because of its potential benefits for economic development. For instance, access to transportation helps to facilitate the flow of human capital and draw workers to places where economic opportunities are more abundant. It also helps to connect different regions through trade, enabling them to specialise in their core economic strengths that are important for fostering local economic development.[61] Even though transportation

[60] For instance, almost 20 percent of World Bank lending in 2007 was allocated to transportation infrastructure projects, more than the share in education, health and social services combined (World Bank, 2007).

[61] Donaldson (2010) documents a strong positive link between economic development and the transition from autarky to trade among regions in colonial India, where this transition was facilitated by the construction of railroads that reduced inter-regional trade costs during the 19th century. As he explains, before the advent of railroads, bullocks that travel no more than 30 kilometres a day were the main source of transport for India's

infrastructure appears to be important for the economy in the early stage of economic development, a study of its causal effect is by no means straightforward, primarily because of the problem of reverse causality where higher levels of economic growth may in turn encourage the expansion of infrastructure services. In the related literature that spans more than two decades, this is arguably the most challenging problem to deal with and one that is a subject of intense interest even to this day.

Based on provincial level data (1978–2008), this chapter seeks to answer that question: "What is the long-run impact of changes in the density of transportation infrastructure on economic growth in China?" Because transportation infrastructure is an endogenous determinant of economic growth, OLS regressions are fundamentally unidentified and better estimation strategies are therefore vital to address this research question. While instrumental variable estimation has been used to cut through the problem of endogeneity (e.g. Banerjee et al., 2012), the focus on long-run growth raises a formidable challenge in finding a suitable instrument for transportation infrastructure. Specifically, most of the variation in the data that the regression draws upon comes from cross-section datasets, since long-run economic growth is constructed by averaging the annual growth rate of GDP per capita over a significant period of time and this reduces one's ability to utilise much of the time variation in the data. In order to obtain a reasonably exogenous instrument for transportation infrastructure, a venture into history for the instrument search appears necessary. This chapter proposes an instrument that is related to the presence of Chinese guilds, which were forms of corporate collective action that first came about during the Ming dynasty (1368–1644) and flourished towards the end of the Qing dynasty (1644–1911). Literally translated in Chinese as 'trade-line association' (Quan, 1934) and known by the populace throughout China by a generic designation, 'mutual help association', the guild was an association that was involved in any form of craft, merchant and trade (Moll-

commodity trade. In contrast, trains during that time could travel 20 times faster and at much lower freight rates per unit distance travelled. Therefore, the construction of railroads in colonial India had led to a dramatic reduction in trade costs, encouraging inter-regional trade that helps to foster economic development.

Murata, 2008). The Chinese guilds served numerous important economic and social functions such as the provision of hospitality and entertainment services, training of skilled crafts and tradesmen, and the development of educational and municipal services. The presence of Chinese guilds is an important indicator of past infrastructure provision, as these guilds represent the integration of economic and social activities.[62] Therefore, information about the Chinese guilds could be used to construct a candidate instrument insofar as modern infrastructure (1978–2008) is linked with past (1911) infrastructure.

In the literature, the endogenous response of infrastructure to economic growth is a significant obstacle to overcome in any empirical analysis, especially since it is infeasible to 'randomly distribute' infrastructure as one would in an ideal experiment. Hence, the identification of the effect of changes in transportation infrastructure on economic growth and development has been a topic of intense interest among academics where various solutions have been proposed to partially address the confounding influence due to its endogenous nature. This chapter relates to this stream of work that considers the issue of identifying the exogenous variation in transportation infrastructure in the context of China.[63] For instance, based on Chinese provincial panel data over the period 1985–1998, Démurger (2001) looks at how changes in transportation infrastructure could drive provincial income disparities in China, employing internal instruments, e.g. lagged trade and FDI. Using Chinese county-level data, Banerjee et al. (2012) study the causal effect of changes in transportation infrastructure by constructing an instrument that is based on information about a county's distance from

[62] See Appendix B for more details.

[63] There are related studies on other countries as well. For instance, based on industry-level data for the US, Fernald (1999) identifies the causal effect of the provision of roads on US industrial productivity from 1953 to 1989 by examining how the intensity of vehicle use by different industries is linked to their productivity levels. Causality is pinned down if changes the increase in the provision of roads is associated with larger changes in productivity growth in industries that are more vehicle intensive. A difference-in-difference approach to deal with the endogeneity issue is employed by Michaels (2008), who examines the effect of highway construction in the US in the 1950s. Keller and Shiue (2008) look at the effect of steam trains in 19th century Europe by employing an instrumental variable approach for identification.

main transportation networks that link up cities in the past. While the existing studies of China's transportation infrastructure mainly investigate its short-run effect on economic growth, this chapter complements the literature and Chapter 3 by proposing a new instrument for transportation infrastructure and by focusing on its long-run economic implication.

Using data from 1978–2008, this chapter splits this sample into two halves of similar size and constructs long-run growth for each time period, based on the average annual growth during 1978–1993 and 1994–2008. By splitting the sample so as to obtain a two-period panel, one can eliminate province fixed effects that represent all time-invariant permanent differences while still focusing on the impact that transportation infrastructure has on long-run GDP growth per capita. Controlling for province fixed effects is paramount because of the immense diversity in culture, religion, geographic characteristics and governance that one observes, for example, from Tibet and Xinjiang in China's deep west to the more developed areas in the coastal east, and this diversity could confound the relationship between infrastructure and economic growth. Nevertheless, OLS regression may still be unidentified, because unlike instrumental variable (IV) regression, it cannot be used to address the issue of reverse causality that confounds the causal effect of transportation infrastructure.

The first stage regression reveals that the density of guilds, defined as the number of guilds per 10,000 people, is a powerful instrument for transportation infrastructure. The IV estimate offers evidence that the expansion of transportation infrastructure is beneficial for long-run GDP growth per capita. This is in stark contrast to the OLS estimates that suggest that the effect of transportation infrastructure on growth is not (statistically) significantly different from zero. The strong benefits of transportation infrastructure are robust to a battery of sensitivity tests. These tests bring into four covariates the regression that are potentially relevant to economic growth,[64] and the robustness that emerges from the sensitivity tests underscores the significant role that transportation infrastructure has

[64] These covariates consist of the urbanisation rate, openness, public employment share and agricultural labour share.

played in propelling the long-term economic development of China.

The remainder of this chapter is organised as follows. Section 2 describes the data, variables and the methodology. Section 3 presents the empirical results as well as the results from the robustness checks. Section 4 concludes.

2. Data and Methodology

The main dataset is obtained from the China Compendium of Statistics, which is compiled by the Department of Comprehensive Statistics at the National Bureau of Statistics of China. There are 31 sub-national administrative units in mainland China,[65] including 22 provinces, four municipalities (Beijing, Shanghai, Tianjin and Chongqing) and five autonomous regions (Tibet, Xinjiang, Ningxia, Inner Mongolia and Guangxi).[66] But due to missing data, this chapter excludes information about Hainan and Tibet and uses data for the remaining 29 administrative units. For ease of discussion, each administrative unit is henceforth referred to as a 'province'. The summary statistics are reported in Table 4.1.[67]

The dataset spans from 1978 to 2008. This study splits the sample into two approximately equal halves corresponding to the periods 1978–1993 and 1994–2008 as this helps to construct long-run economic growth and employ panel data estimation at the same time. By splitting this way and constructing a set of two-period panel data, one may eliminate province fixed effects that represent all time-invariant permanent differences across provinces. Controlling for province fixed effects is crucial because the differences in culture, religion, geographic characteristics and governance across regions in China could confound the relationship between transportation infrastructure and economic growth. Therefore, by using a two-period panel,

[65] They are Anhui, Beijing, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Hebei, Heilongjiang, Henan, Hunan, Hubei, Inner Mongolia, Jiangsu, Jiangxi, Jilin, Liaoning, Ningxia, Qinghai, Shanghai, Shandong, Shanxi, Shaanxi, Sichuan, Tianjin, Tibet, Xinjiang, Yunnan and Zhejiang, excluding Hong Kong, Macao and Taiwan.

[66] Chongqing was designated a municipality in the year 1997. The other three cities were initially municipalities when the People's Republic of China was established in 1949.

[67] Table 4.6 provides the definitions of the variables used in this chapter.

Tab. 4.1: Summary Statistics (1978–2008)

Variable	Obs	Mean	SD	Min.	Max.
non-time-averaged variables					
$transport^s$	58	0.248	0.181	0.016	0.987
$\Delta transport^s$	29	0.076	0.086	0.001	0.304
guilds	29	0.029	0.071	0	0.302
lnpop 1953	29	7.279	0.913	5.018	8.502
lnGDP 1953	27	4.915	0.544	4.065	6.324
service 1953	29	0.230	0.082	0.093	0.418
railway 1911	29	0.003	0.006	0	0.021
time-averaged variables					
$\Delta growth^a$	29	0.029	0.020	-0.012	0.064
$\Delta education^a$	29	0.005	0.009	-0.005	0.038
$\Delta investment^a$	29	0.156	0.054	0.056	0.292
$\Delta urban^a$	24	0.124	0.100	-0.130	0.415
$\Delta trade^a$	29	0.003	0.003	0.0002	0.013
$\Delta state^a$	29	-0.081	0.064	-0.236	-0.019
$\Delta agriculture^a$	29	-0.131	0.070	-0.248	0.024

Note: Definitions can be found in the Table 4.6. The subscript s denotes the starting level for each sample period (i.e. 1978 or 1994). The subscript a indicates an average value for each sample period (1978–1993 or 1994–2008). Δ is the difference between sample period 2 (1994–2008) and sample period 1 (1978–1993).

one may formulate a model for long-run growth that also purges province fixed effects.

Letting $t = 1, 2$ denote the first and second periods respectively (i.e. 1978–1993 and 1994–2008), this chapter defines long-run economic growth as the average annual GDP growth rate per capita within each time period. Specifically, the long-run economic growth of province i at period t, denoted as $growth^a_{it}$, is the average annual growth rate of real GDP per capita of i over the entire sub-sample corresponding to $t = 1$ (i.e. 1978–1993) or $t = 2$ (i.e. 1994–2008). The main objective of this chapter is to study the effect that varying the initial level of the density of transportation infrastructure has on long-run average GDP growth per capita. In term of estimation, the main causal variable is $transport^s_{it}$, the start of the period measure of transportation density, defined as the total length of railways and highways in kilometres over the total provincial area in squared kilometres. For instance, for $t = 1$, $transport^s_{it}$ is the density of transportation infrastructure in 1978. The focus on transportation infrastructure at the beginning of each period as the main causal variable allows the study of its impact on long-run economic growth from that point (i.e 1978 or 1994) onwards. Therefore, the main estimating equation of this chapter relates $growth^a_{it}$ to $transport^s_{it}$ as,

$$growth^a_{it} = c + \alpha\, transport^s_{it} + \beta' X^a_{it} + \mu_i + \epsilon_{it}, \tag{4.1}$$

where c is a general intercept term and μ_i represents province i's fixed effect. The variable ϵ_{it} represents any province i's unconditioned variable that may affect its long-run growth rate, e.g. for $t = 1$, it represents any unconditioned factor that may affect the average annual growth rate during 1978–1993.

The estimation of α might be complicated by omitted variables that are possibly related to both transportation infrastructure and economic growth. To this end, this study also considers the inclusion of a vector X^a_{it} that represents other potentially relevant control variables. These variables are introduced into equation (4.1) to also serve another purpose: to evaluate the robustness of the estimate of the effect of the initial level of the density of transportation infrastructure as summarised by the parameter α. In the baseline regressions, the vector X^a_{it} contains two variables, namely, the average annual fixed investment formation to GDP ratio and a measure of human capital proxied by the teacher to student ratio at secondary schools, both of which are standard determinants of economic growth.[68] In the

[68] This study uses secondary school teacher-student ratio as a proxy for human capital. Other studies have considered proxies such as the number of secondary school students and the ratio of secondary school students to total population (e.g. Barro, 1991, Li and Huang, 2009). Given data limitations, researchers have pointed out that the average class size of secondary schools is the best possible measure of human capital as it reflects the average quality of education across provinces. For instance, Glass and Smith (1979), Glass et al. (1982), and Angrist and Lavy (1999) show that reducing the class size could lead to better student performance in standardised tests.

robustness checks, the vector X_{it}^{a} is expanded to include information related to the urbanisation rate, trade openness, the size of the public sector, and the size of the agricultural sector, all of which are potentially related to transportation infrastructure and growth as discussed further in section 3.2.

To eliminate the fixed effects, this study estimates equation (4.1) in first difference taken across the two periods indexed by $t = 2$ and $t = 1$. In first difference, the estimating equation is given by,[69]

$$\Delta growth_{it}^{a} = \alpha \Delta transport_{it}^{s} + \beta' \Delta X_{it}^{a} + \Delta \epsilon_{it}, \tag{4.2}$$

where the causal effect of transportation infrastructure on long-run growth, i.e. α, can be estimated by examining the effect that $\Delta transport_{it}^{s}$ has on $\Delta growth_{it}^{a}$. While equation (4.2) purges the province fixed effects, OLS regression may still be unidentified as it does not take into account the endogenous response of transportation infrastructure to (potential) economic growth. For instance, transportation infrastructure can respond endogenously to GDP per capita growth as higher levels of economic growth may in turn cause the expansion of infrastructure services. Indeed, the inadequacy of eliminating fixed effects as a way of dealing with the endogeneity of transportation infrastructure can be inferred from earlier studies based on the US state-level panel data where Holtz-Eakin (1994), Holtz-Eakin and Schwartz (1995) and Garcia-Mila et al. (1996) find that introducing fixed effects may eliminate the positive effect of infrastructure on growth. As can be seen in section 3.1, this is echoed in this study as the OLS estimate after purging fixed effects is nearly zero. In order to obtain consistent estimates of α, this calls for the use of IV estimation, which in the context of equation (4.2), requires an instrument for $\Delta transport_{it}^{s}$.

The instrument proposed in this chapter uses historical information related to the Chinese guilds. There is a large body of literature in geography and anthropology that discusses how the Chinese guilds were associated with the early urban structure in China prior to 1911 (e.g. Rowe, 1984).

[69] In a two-period panel dataset, the first difference estimator is the same as the within-province estimator.

The Chinese guilds (explained in Appendix B) were forms of corporate collective action that flourished towards the end of Qing dynasty (1644-1991). During its heyday, the guilds provided a wide range of economic and social services that were intertwined with day-to-day living, such as the matching of skilled workers with employers, providing a meeting place for merchants and their buyers, as well as offering hospitality services in the form of hotels, restaurants and entertainment centres. The guilds were also involved in the training of skilled crafts and tradesmen (Golas, 1977; Moll-Murata, 2008) and in the provision of educational and municipal services such as elementary schooling to guild members, firefighting, policing and the maintenance of streets and bridges for local residents (Rowe, 1992).

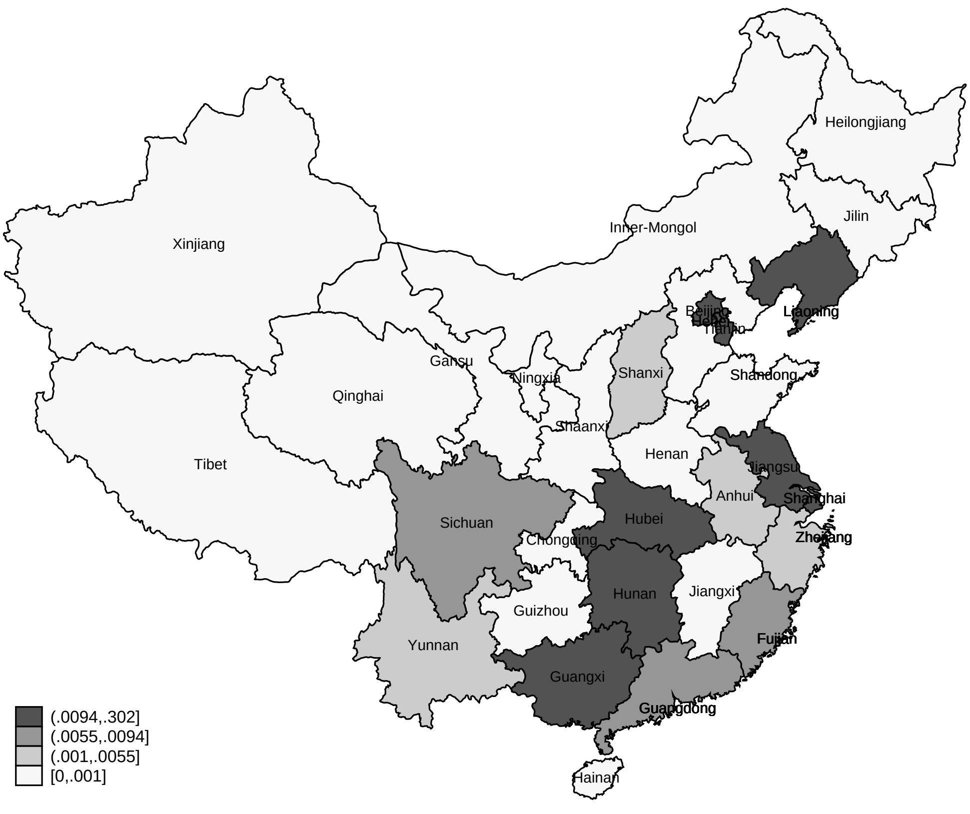
The presence of Chinese guilds thus offers some insight into the importance of business and social networks, as well as an indirect indication of the extent of infrastructure development that existed in the past. This is reminiscent of the concept of 'central place' from 'central place theory' in the anthropology literature, which is a theory of location for retail trade that is discussed in Skinner (1977). It is believed that the industrialisation and trade agglomerations were more likely to occur in the places that guilds were flourished, as central place models point out that major centres (or cities) primarily serve and support their surroundings, including smaller centres and rural hinterlands Wang (1999). According to the central place theory, it is not surprising that guilds agglomerated to the regions that were more likely to develop towards large centres (modern cities) and demand for more transportation infrastructure.

Using this historical information, one can construct a measure of the density of guilds, defined by the number of guilds in 1911 per 10,000 local inhabitants,[70] as an instrument for $\Delta transport^{s}_{it}$. The number of guilds that existed in the year 1911 is obtained from Moll-Murata (2008). Figure 4.1 plots the distribution of guilds density across China defined by current (2008) provincial boundaries. It shows that the guilds are more concentrated in the

[70] Historical population in 1911 is not available to construct the guilds density variable, so instead this chapter uses historical population data in 1933 that is documented by *Zhongguo tu di ren kou, zu dian zhi du zhi tong ji fen xi* (National Bureau of Statistics of Republic of China, 1978).

eastern coastal regions (Liaoning, Jiangsu and Shanghai) and central Yangtze river regions (Hubei and Hunan). If the guilds were more densely located in historical infrastructure hubs, and if historical infrastructure were correlated with modern infrastructure (1978–2008), then information about the Chinese guilds could be linked with the transportation infrastructure variable. It is this rationale that leads this study to explore the use of the density of guilds as an instrument, which turns out to be especially powerful for $\Delta transport^{s}_{it}$.

Fig. 4.1: The Distribution of Guilds Density in 1911



Note: The number of guilds were collected from Moll-Murata (2008). Mainland China does not include Taiwan, Hong Kong and Macao. The four colours represent the different quartiles.

3. Empirical Results

3.1 OLS and IV Results

Table 4.2 summarises the baseline results from OLS regressions. While the OLS regression is unidentified, it nonetheless provides a useful starting point for investigating the direction of bias in the estimate of how transportation infrastructure affects economic growth. Controlling for province fixed effects, column (1) of Table 4.3 shows that the OLS estimate of the response of economic growth to transportation infrastructure is not statistically significantly different from zero. This weakness in the OLS estimate is perhaps symptomatic of a deeper problem that goes beyond the issue of omitted variables as it cannot be resolved by the introduction of possibly relevant covariates into the regression. For instance, columns (2)-(4) control for education and physical investment, which could be linked to both transportation infrastructure and economic growth, and show that the OLS estimates of the impact of the initial level of the density of transportation infrastructure on long-run economic growth remain stubbornly close to zero. If the premise that transportation infrastructure enhances economic growth holds, the weakness of the OLS estimate suggests the possibility that it is downward biased. This problem may be due to measurement error in the data of the National Bureau of Statistics of China, which has already been highlighted by Rawski (2001), Rawski and Xiao (2001), Chow (2006), and Ravallion and Chen (2007). If this measurement error were classical, the least squares estimates would be attenuated. Together with the problem of reverse causality, the presence of measurement errors will confound the causal relationship and this requires the use of an instrument for transportation infrastructure in order to obtain consistent estimates of its effect on growth.

To this end, Table 4.3 reports the IV estimates using the density of guilds as an instrument for transportation infrastructure. In the simplest regression specification with province fixed effects purged, the first stage result in column (1) shows that the density of guilds is a statistically significant explanatory variable for transportation infrastructure. It is also an especially powerful instrument, as column (1) shows that the first stage

Tab. 4.2: OLS Regressions (1978–2008)

	(1)	(2)	(3)	(4)
	Dependent Variable: $\Delta growth^a$			
$\Delta transport^s$	0.002	0.007	-0.003	0.004
	(0.042)	(0.041)	(0.046)	(0.045)
$\Delta education^a$		0.348		0.310
		(0.437)		(0.483)
$\Delta investment^a$			0.036	0.014
			(0.074)	(0.082)
Province fixed effects eliminated?	Yes	Yes	Yes	Yes
Number of provinces	29	29	29	29
Number of observations	58	58	58	58

Note: Robust standard errors in parentheses, ***p< 0.01, **p< 0.05, *p< 0.1. The subscript *s* denotes the starting level for each sample period (i.e. 1978 or 1994). The subscript *a* indicates an average value for each sample period (1978–1993 or 1994–2008). Δ is the difference between sample period 2 (1994–2008) and sample period 1 (1978–1993).

F-statistic well exceeds the Staiger and Stock (1997) rule-of-thumb threshold of 10. Moreover, the Kleibergen and Paap (2006) Wald statistic also comfortably exceeds the critical value associated with the statement that 10 percent is the maximal rejection rate tolerated if the true rejection rate is 5 percent, which suggests that guilds density does not suffer from the weak instrument problem.[71] Besides column (1), columns (2)-(4) show that including the education and fixed capital investment variables will not weaken the explanatory power of guilds density, since the first stage F-statistics and Kleibergen-Paap Wald statistics across the columns all exceed the required threshold for instrument strength. Interestingly, regardless of regression specification, the coefficients on *guilds* in Table 4.3 all vary within a narrow

[71] This study evaluates the KP statistic against the critical value, adopted from Stock and Yogo (2005), that 10 percent is the maximal rejection rate the researcher is willing to tolerate if the true rejection rate is 5 percent. Observing a KP statistic that exceeds this critical value implies that the maximal rejection rate is smaller than 10 percent, hence the actual size of the test is closer to 5 percent.

interval around 0.8, an early indication of the robustness of the regressions.

Tab. 4.3: IV Regressions (1978–2008)

	(1)	(2)	(3)	(4)
	Dependent Variable: $\Delta growth^a$ (2nd Stage)			
$\Delta transport^s$	0.108***	0.125***	0.108***	0.127***
	(0.031)	(0.036)	(0.030)	(0.039)
$\Delta education^a$		0.522		0.651
		(0.487)		(0.490)
$\Delta investment^a$			-0.003	-0.052
			(0.081)	(0.097)
	Dependent Variable: $\Delta transport^s$ (1st Stage)			
guilds	0.809**	0.807***	0.821***	0.790***
	(0.085)	(0.078)	(0.069)	(0.077)
$\Delta education^a$		-0.059		-1.252
		(1.546)		(0.923)
$\Delta investment^a$			0.400	0.478
			(0.381)	(0.406)
First Stage (F-stat)	91.04	53.63	81.43	44.76
Weak IV (F-stat)	91.04	107.04	143.36	105.72
Weak IV critical value	16.38	16.38	16.38	16.38
Province fixed effects eliminated?	Yes	Yes	Yes	Yes
Number of provinces	29	29	29	29
Number of observations	58	58	58	58

Note: Robust standard errors in parentheses, ***p< 0.01, **p< 0.05, *p< 0.1. The subscript s denotes the starting level for each sample period (i.e. 1978 or 1994). The subscript a indicates an average value for each sample period (1978–1993 or 1994–2008). Δ is the difference between sample period 2 (1994–2008) and sample period 1 (1978–1993). *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock and Yogo (2005) critical value to evaluate that 10 percent is the maximal rejection rate if the true rejection rate is 5 percent.

Given that the instrument is strong, the second stage regression in column

(1) of Table 4.3 shows that the impact of transportation infrastructure on long-run economic growth, i.e. the estimate of α, is both statistically significant and quantitatively large. Unlike the OLS estimates that are not significantly different from zero, column (1) reports that a one standard deviation improvement in the initial level of the density of transportation infrastructure raises the long-run average growth of GDP per capita by about 1.95 percentage points.[72] This estimated effect of transportation infrastructure on long-run growth is not confounded by permanent differences across provinces such as the heterogeneity in the local culture, religion, institutions and geography, as province fixed effects have already been eliminated. At first pass, it does not appear to be confounded by omitted variables, since the effect of transportation infrastructure remains strong even after the introduction of the education and fixed investment variables into the regression.

3.2 Robustness Checks

Table 4.4 reports a battery of robustness checks to evaluate the sensitivity of the baseline IV estimates to the inclusion of potentially relevant omitted variables in the long-run growth regression.[73] The first robustness check includes the average provincial urbanisation rate in the baseline model, as the urban economics literature has found that urbanisation may be an important determinant of economic growth.[74] When controlling for information about the urbanisation rate, column (1) of Table 4.4 shows that the effect of transportation infrastructure on long-run growth remains robust. The new,

[72] One standard deviation of $transport^s$ is 0.181. Therefore, the 1.95 percentage point increase reported here is derived based on 0.181×0.108×100=1.95.

[73] As the growth regression of (4.2) considers the time-averaged of economic growth as the dependent variable, the robustness checks introduces additional covariates into the regression that are expressed as time-averages as well. The intuition is that the error term in (4.2) is the time-averaged of the unobservables during each time block (i.e. 1978–1993 or 1994–2008), hence the information drawn out from the error term should have a time-averaged expression.

[74] See Quigley (1998), Henderson (2003), Duranton and Puga (2004), Duranton (2008), among others.

statistically significant coefficient of 0.085 on transportation infrastructure, unlike the OLS estimates, shows that transportation infrastructure is an important determinant of long-run growth. The first stage regression in this robustness check also re-emphasises the sharpness of guilds density as an instrument, where its effect on transportation infrastructure is similar to the baseline estimates and the first stage F-statistic is much greater than the rule-of-thumb threshold of 10.

Tab. 4.4: Robustness Checks

	(1)	(2)	(3)	(4)
	Dependent Variable: $\Delta growth^a$ (2nd Stage)			
$\Delta transport^s$	0.085***	0.135***	0.097***	0.105***
	(0.029)	(0.052)	(0.030)	(0.034)
$\Delta education^a$	0.378	0.368	0.764**	0.426
	(0.459)	(0.492)	(0.328)	(0.436)
$\Delta investment^a$	-0.021	-0.107	-0.008	-0.002
	(0.089)	(0.078)	(0.075)	(0.079)
$\Delta urban^a$	-0.044			
	(0.042)			
$\Delta trade^a$		-3.514***		
		(0.928)		
$\Delta state^a$			-0.151***	
			(0.053)	
$\Delta agriculture^a$				0.116**
				(0.048)
	Dependent Variable: $\Delta transport^s$ (1st Stage)			
guilds	0.907***	0.773***	0.827***	0.823***
	(0.086)	(0.100)	(0.073)	(0.079)
$\Delta education^a$	-0.647	-0.454	-1.490*	-0.878
	(0.476)	(0.858)	(0.871)	(0.965)
$\Delta investment^a$	0.056	0.620	0.432	0.405
	(0.165)	(0.365)	(0.409)	(0.412)
$\Delta urban^a$	0.114			
	(0.100)			
$\Delta trade^a$		9.619***		
		(2.380)		
$\Delta state^a$			0.240*	
			(0.136)	
$\Delta agriculture^a$				-0.035
				(0.159)

Tab. 4.4: Robustness Checks (continued)	(1)	(2)	(3)	(4)
First Stage (F-stat)	33.49	22.80	45.42	41.57
Weak IV (F-stat)	111.55	59.78	129.73	109.74
Weak IV critical value	16.38	16.38	16.38	16.38
Province fixed effects eliminated?	Yes	Yes	Yes	Yes
Number of provinces	24	29	29	29
Number of observations	48	58	58	58

Note: Robust standard errors in parentheses, ***p< 0.01, **p< 0.05, *p< 0.1. The subscript s denotes the starting level for each sample period (i.e. 1978 or 1994). The subscript a indicates an average value for each sample period (1978–1993 or 1994–2008). Δ is the difference between sample period 2 (1994–2008) and sample period 1 (1978–1993). *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 10 percent is the maximal rejection rate if the true rejection rate is 5 percent.

The second robustness check looks at the inclusion of trade openness that is defined by the time-averaged ratio of trade over GDP. Various studies have pointed out that trade openness could have a positive influence on growth. For instance, using a variety of openness measures, Harrison (1996) studies the effect of openness on economic growth among developing countries and finds that greater openness is associated with higher economic growth. In addition, Dollar and Kraay (2004) show that economic growth can be stimulated by positive changes in trade and conclude that greater involvement in trade is associated with faster economic growth. Given that trade may be facilitated by transportation infrastructure networks, the extent of trade openness may be reflective of the development of past and present infrastructure so that trade openness itself could be a non-trivial omitted variable in the growth regression. Indeed, column (2) of Table 4.4 confirms this intuition by showing that trade openness is a statistically significant control variable in both first and second stage regressions. Nevertheless, despite its importance, trade openness neither drives out the effectiveness of the density of guilds as an instrument nor diminishes the contribution of transportation infrastructure to long-run economic growth. In fact, the coefficient on transportation infrastructure is 0.135, which as compared to the baseline IV estimates in Table 4.3, is even further away from the OLS estimates that hover closely around zero.

The final two robustness checks examine the implication of controlling for China's labour market structure in the growth regression. Two factors are considered here. First, the more important the public sector is for a province, the more slowly its economy may grow, given that the public sector that includes state-owned and collective enterprises may have operated inefficiently in China during 1978–2008. Second, a province that is economically more dependent on the agricultural sector may grow at a faster rate than provinces that are already more industrialised, just because provinces where the rural sector is more pervasive have greater potential for industrialisation and catch-up. Columns (3) and (4) control for the size of the public sector and agricultural sector respectively. Both of these variables enter into the second stage regression with strong statistical significance and expected signs, where the effect of the size of the public sector on economic growth is negative while the effect of the size of the agricultural sector is positive. Importantly, even though the size of the public and agricultural sectors are important determinants of long-run economic growth, the effect of transportation infrastructure on economic growth in both cases remain close to the baseline IV estimates.

To sum up, the sensitivity tests in Table 4.4 show that the estimated effect of transportation on long-run economic growth is robust, in the sense that transportation infrastructure is an important determinant for long-run growth, as opposed to the OLS estimates that suggest that transportation infrastructure and long-run economic growth are unrelated. Overall, taking the baseline IV results into account, this chapter finds that a one standard deviation increase in transport infrastructure is associated with a 1.54 (column (1) of Table 4.4) to 2.44 (column (2) of Table 4.4) percentage point increase in long-run yearly growth on average.[75] In all the robustness

[75] One standard deviation of $transport^s$ is 0.181. Therefore, the 1.54 to 2.44 percentage point increase reported in Table 4.4 is derived based on 0.181×0.085×100=1.54 and

checks, the effect of the density of guilds on the initial level of transportation infrastructure also remains similar to the baseline IV estimates and this provides some ratification of the use of the density of guilds as an estimation strategy in this study.

3.3 Alternative Instruments

Can other candidate instruments be used in this study? At first glance, it appears that other historical information, for instance, about past population size, GDP, and the extant transportation infrastructure during historical times, could be used to construct an instrument for the transportation infrastructure variable. Therefore, one might wonder if there is a need to zero in on the use of the density of guilds as an estimation strategy. The following discussion briefly shows that while modern transportation infrastructure might be linked to history in many ways, the density of guilds is unique in its explanatory power for transportation infrastructure as compared to other plausible instruments based on historical information. In other words, among plausible instruments for transportation infrastructure based on different historical information, the density of guilds turns out to be the best, although this does not imply that the density of guilds is the only available instrument for the study of transportation infrastructure on long-run economic growth. That being said, this finding highlights the fact that locating a suitable historical information for the construction of the instrument for transportation infrastructure turns out to be more challenging than it might be expected.

To provide some evidence in support of the density of guilds as an instrument for transportation infrastructure, Table 4.5 shows the estimation results that are obtained using four alternative (historical) instruments.[76] The first alternative instrument is the log of provincial population in 1953.

$0.181 \times 0.135 \times 100 = 2.44$.

[76] This study gathers the data of historical population, GDP, and size of service sector from the China Compendium of Statistics. Railway density in 1911 is calculated based on Ma (1983).

This is the year when the first population census was conducted since the founding of the People's Republic of China. The rationale of using past population as an instrument is based on the idea that past population is likely to be related to past levels of transportation infrastructure, and in turn the level of modern transportation infrastructure that needs to be instrumented here.[77] The second alternative instrument is the log of real GDP per capita in 1953, which reflects an initial economic condition. If wealthier provinces also have better infrastructure, then past information about the wealth of a province would be related to its past levels of infrastructure, hence using a measure of past wealth such as the log of real GDP per capita as an instrument might work. The third alternative instrument is the ratio of service sector GDP to total GDP in 1953. In a way, this variable might have a similar effect on transportation infrastructure as the density of guilds, considering that the Chinese guilds were historically service providers. Finally, the fourth alternative instrument is the density of railroads in 1911.[78] Since the transportation infrastructure variable captures the density of roads and railways combined, the density of historical railroads might be informative about transportation infrastructure given that some of these historical railway lines have been upgraded into the railway lines that are in operation today.

Table 4.5 shows that the log of real GDP per capital in 1953 and the density of railroads in 1911 are statistically significant determinants of transportation infrastructure. However, in the first stage regression, the log of population in 1953 and the size of the service sector in 1953 turn out to be statistically insignificant. As compared to guilds density, all the four

[77] Furthermore, alluding to the 19th century US as an example, the initial population may be positively associated with the expanding demand for the construction of railroads as Fogel (1962) has argued.

[78] Based on information such as railway track lengths, the years when construction started, the years when tracks opened, and the locations of origin and terminal stations of both main and spur lines provided by Ma (1983), it is possible to obtain the total lengths of railroads that existed in 1911, which this study then assigns to each province according to contemporary provincial boundaries provided by *Google Maps* for the calculation of the density historical railway. In the calculation, this study eliminates the spur lines that were reported as dismantled, where the various reasons for the dismantling are discussed in Ma (1983).

Tab. 4.5: The Use of Alternative Instrumental Variables

	(1)	(2)	(3)	(4)
	Dependent Variable: $\Delta growth^a$ (2nd Stage)			
$\Delta transport^s$	10.411	0.249	0.275	0.168
	(219.267)	(0.154)	(0.274)	(0.114)
	Dependent Variable: $\Delta transport^s$ (1st Stage)			
lnpop 1953	-0.001			
	(0.016)			
lnGDP 1953		0.066*		
		(0.035)		
service 1953			0.301	
			(0.313)	
railway 1911				8.01*
				(0.420)
First Stage (F-stat)	0.00	3.56	0.92	3.64
Weak IV (F-stat)	0.00	3.56	0.92	3.64
Weak IV critical value	16.38	16.38	16.38	16.38
Province fixed effects eliminated?	Yes	Yes	Yes	Yes
Number of provinces	29	27	29	29
Number of observations	58	54	58	58

Note: Robust standard errors in parentheses, ***p< 0.01, **p< 0.05, *p< 0.1. The subscript s denotes the starting level for each sample period (i.e. 1978 or 1994). The subscript a indicates an average value for each sample period (1978–1993 or 1994–2008). Δ is the difference between sample period 2 (1994–2008) and sample period 1 (1978–1993). *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 10 percent is the maximal rejection rate if the true rejection rate is 5 percent.

alternative instruments are weak. For instance, the first stage F-statistics in Table 4.5 are much smaller than the rule-of-thumb threshold of 10, and very small compared to the baseline first stage F-statistic of 91.04 when guilds density is the instrument (see column (1) of Table 4.3). The weakness of the alternative instruments is also highlighted by the weak Kleibergen-Paap Wald statistics in Table 4.5, all of which are far from exceeding the required critical value of 16.38. Therefore, not all historical information is alike. In the case of identifying the effect of transportation infrastructure on long-run economic growth, the density of guilds turns out to be an especially powerful instrument while the other instruments that appear to be related to transportation infrastructure at the early stage of economic development turn out to be weak or even irrelevant.

4. Conclusion

This chapter studies the effect that transportation infrastructure has on long-run growth. By splitting the available dataset into two periods, one can eliminate any time-invariant determinants of economic growth that may confound the main causal relationship of interest. Nevertheless, as there is no guarantee that purging the province fixed effects will adequately address the issue that transportation infrastructure is endogenous, a main contribution of this chapter is to propose an instrument that draws information from the presence of Chinese guilds, using the insight that the guilds were central places of economic and social activities as far back as the Qing dynasty.

Letting the data speak, this chapter finds that the density of guilds is an especially powerful instrument for the initial level of the density of transportation infrastructure, much more so than instruments that are constructed using other historical information related to past population, income, and transportation infrastructure. While the OLS estimates of the effect of transportation infrastructure on long-run economic growth are very close to zero, the IV estimates show that transportation infrastructure is an important determinant of long-run growth, where a one standard deviation increase in the initial level of the density of transport infrastructure is associated with a 1.54 to 2.44 percentage point increase in the long-run growth (approximately a 15-year period) on average. More importantly, the strong causal effect of transportation infrastructure is highly robust in a battery of sensitivity tests where four potentially relevant determinants of growth – urbanisation, openness, share of agricultural labour, and share of public sectoral labour – are included in the regression.

The finding of the causal link between the initial level of transportation infrastructure and long-run growth in China complements the literature that mainly focuses on the short-run effect of transportation infrastructure. For instance, Démurger (2001) studies the effect of the improvement of transportation infrastructure on three-year averages of GDP per capita growth using Chinese provincial panel data (1985–1998). This chapter extends the exploration in Chapter 3 which has investigated the short-run causal effect of transportation infrastructure on yearly GDP growth per capita among Chinese provinces over the period 1985–2008. It is worth noting that the size of the long-run effect reported in this chapter is not directly comparable with the magnitude of the short-run effect estimated in Chapter 3. This is because it captures an average effect of the improvement of initial level of transportation infrastructure on a 15-year average of economic growth rather than an effect of annual changes in transportation infrastructure on yearly economic growth. Overall, this thesis confirms that the increasing provision of transportation infrastructure significantly causes both short-run (a one-year period) and long-run (a 15-year period) GDP per capita growth, highlighting the importance of transportation infrastructure in China's regional economic development.

For the study of the long-run implications of transportation infrastructure, the use of the density of guilds as its instrument is not restricted to the context of economic growth. It would also be interesting, for instance, to examine the effect of transportation infrastructure on the long-run evolution of income inequality (e.g. Calderón and Chong, 2004 and Calderón and Servén, 2005).[79] Because transportation infrastructure reduces trade costs as shown in Donaldson (2010), it can help provinces that are lagging behind to catch up with their wealthier counterparts.[80]

[79] Calderón and Chong (2004) and Calderón and Servén (2005) study the impact of infrastructure on inequality using cross-country data and find that infrastructure stock affects income inequality negatively.

[80] Although this thesis will not elaborate on the theme of the long-run evolution of income inequality, Chapter 6 provides some micro-evidence which is related to the question about

Tab. 4.6: List of Variables

Variable	Definition
guilds	number of guilds (1911) per 10,000 people (1933)
growth	real GDP per capita annual growth rate
transport	length of railway and highway (km)/regional area (km^2)
education	secondary school teacher-student ratio
investment	fixed investment formation/GDP
trade	(import+export)/GDP
urban	urban registered residents/provincial population
state	state-owned enterprises employed labour/ local employed labour
agriculture	agricultural labour/local employed labour
lnpop 1953	the logarithm of population in 1953
lnGDP 1953	the logarithm of real GDP per capita in 1953
service 1953	service sector GDP/total GDP
railway 1911	length of railway (km)/regional area (km^2) in 1911

how the varying levels of transportation infrastructure result in income disparities among urban wage earners in China.

5. DOES ECONOMIC GROWTH AFFECT URBANISATION? NEW EVIDENCE FROM CHINA AND THE CHINESE NATIONAL CONGRESS

1. Introduction

At the heart of economic development and urban economics, the relationship between economic growth and the rate of urbanisation is a topic that has captivated much attention in both academic and policy arenas.[81] This discussion is especially germane to China given that one of the most striking facts about its recent development experience is the massive expansion of its urban population. For example, Figure 2.6 (Chapter 2) shows that China's urbanisation rate, measured as the percentage of population living in urban areas as defined by the NBSC, rose slowly starting from its founding year of 1949, fluctuated during the Great Famine (1959–1961) and the Great Cultural Revolution (1966–1976), and embarked upon an impressive upward trajectory from 1978 onwards. In conjunction with this spectacular rise in the rate of urbanisation, China has also seen an unprecedented rate of economic growth that has averaged roughly 9 percent over the period 1978–2008, touching 14 percent at various times (Holz, 2008). While existing research has largely focused on the extent to which urbanisation contributes to growth, where the case of China has been scrutinised (e.g. Zheng et al., 2009; Tian et al., 2010; Wei and Hao, 2010), the literature has recently paid

[81] It is widely accepted that the causality of economic growth and urbanisation runs in both directions. At one end of the discussion, there exists a large body of literature that almost unequivocally emphasises the positive effect that urbanisation has on economic growth (e.g. Quigley, 1998; Henderson, 2003; Duranton and Puga, 2004; Duranton, 2008). At the other end, the literature offers some evidence that economic growth attracts migration from rural to urban regions, which contributes to further development of urban areas (e.g. Zhang and Song, 2003).

more attention to the opposite relationship — the causal effect of economic growth on urbanisation.[82]

Unquestionably, many factors could contribute to how urbanisation evolves, and economic growth is not alone in this function. Nonetheless, while it has been acknowledged that economic growth may affect urbanisation in non-trivial ways (Davis and Henderson, 2003; Brückner, 2012), the fundamental question of whether this effect exists, let alone how strong it is, is difficult to answer objectively based on the somewhat limited empirical evidence from academic research.

The confirmation of the presence of a causal link between economic growth and urbanisation in China can enhance the understanding of China's economic growth as explored in previous chapters. Unlike Chapter 3 and Chapter 4 which focus on the determinants of economic growth, this chapter analyses the causal effect of economic growth on a key macro variable, i.e. urbanisation. In other words, this chapter investigates economic growth in terms of its contribution to China's broad economic development.

There are two methodological issues to be dealt with in this study. The first issue is the problem of reverse causality that runs from urbanisation to economic growth. In the literature, instrumental variable estimation has been utilised to cut through this complication (e.g. Brückner, 2012), but in the context of China, existing research has offered little guidance on how to obtain such an instrument to achieve identification. The second issue is the possibility of measurement errors in the data. Given that the data come from the National Bureau of Statistics of China (NBSC), measurement errors could be present as Rawski (2001), Rawski and Xiao (2001), and Chow (2006) have forewarned. These measurement errors may attenuate the least-squares estimate towards zero and cause the OLS regression to understate the true effect of economic growth.

Inspecting the data, Figure 5.1 shows that provincial economic growth and provincial government spending contain a cyclical feature that appears

[82] The literature has not arrived at a consensus on the extent to which growth affects urbanisation. For example, Brückner (2012) finds that income growth does not significantly raise urbanisation in sub-Saharan Africa conditional on changes in the share of agricultural value added, while Henderson (2002) comes to the opposite conclusion.

to be related to the timing of the National Congress. Specifically, a peak of provincial GDP growth per capita usually appears near the year of the National Congress in a systematic way, and is preceded by spikes of provincial government spending.[83] Investigating this visual evidence suggesting the link between the timing of the National Congress and economic growth, the statistical evidence shown in section 3 confirms that the timing of the National Congress is a quantitatively important source of influence on GDP growth per capita of provinces. In other words, letting the data speak, this chapter finds the instruments capturing information about the timing of the National Congress to be powerful. To check whether this strong effect is contaminated by time-related omitted variables such as plausibly systemic shocks or time trends, this chapter controls for year dummies associated with macroeconomic events and time trends in the regressions to eliminate these potentially confounding influences.

Using the timing of the National Congress of the CPC, this study constructs instrumental variables to estimate the within-province effect that GDP growth per capita has on the urbanisation rate. This strategy relies on the interplay of two institutional features in the Chinese political and fiscal system. For a start, it appeals to the unique Chinese political environment where government policies for promoting economic development and growth are ratified during major political events such as the National Congress of the CPC. Since 1977, the CPC convenes every five years at the National Congress in the capital city of Beijing to discuss internal party matters and national development objectives such as economic growth targets.[84] However, while these national policies are ratified at the National Congress, the decentralisation of the Chinese fiscal system means that the responsibility

[83] A panel Granger causality test is conducted to evaluate the ability of government spending to forecast GDP growth per capita, and vice versa. Generally, the test reveals that government spending *Granger causes* GDP growth per capita, but not the other way around. This suggests a possible situation where congress-driven government spending contributes to the variation in economic growth.

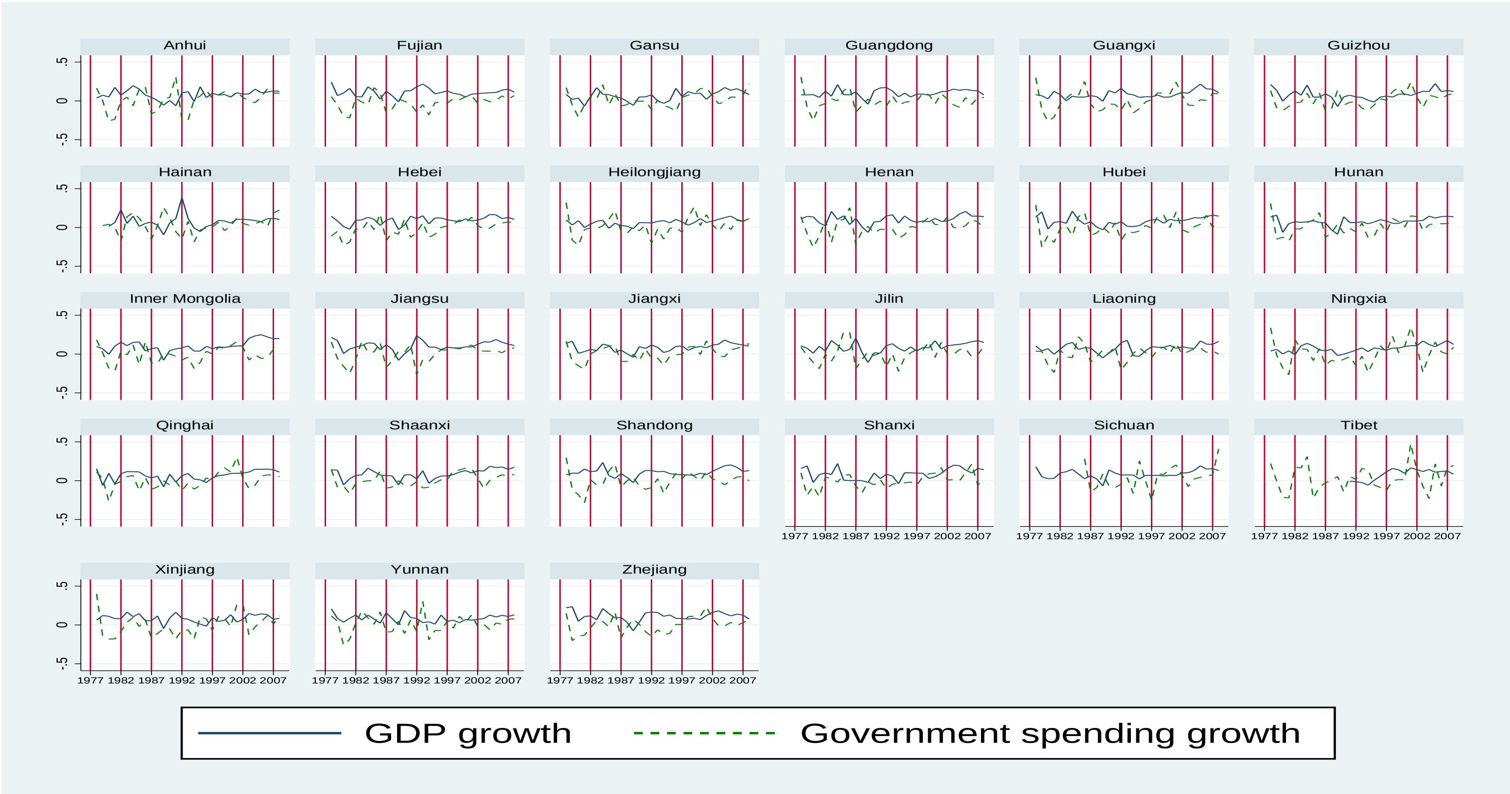
[84] For instance, a key objective of the most recent (12th) five-year plan of the central government involves setting a target of 7 percent of annual economic growth during 2011-2015. See `http://www.chinadaily.com.cn/china/2011npc/2011-03/05/content_12120516.htm`.

of implementing them rest, not on the central government, but on local governments (Wong, 2011).[85] Therefore, the recurring National Congress may engender a cyclical pattern in policy-related expenditure by provincial governments, and in turn produce cyclical peaks in provincial economic growth that is useful for estimating its effect on urbanisation.

The main result of this work underscores the importance of addressing the confounding issues related to the work. For example, this chapter finds that the OLS estimate of the impact of growth on urbanisation is stubbornly close to zero, despite the introduction of additional covariates and province fixed effects in the hope of capturing the 'deep determinants' of urbanisation and ameliorating the extent of omitted variable bias. While the OLS estimates are tenuous at best, a possible reflection of the overpowering influence of attenuation bias due to measurement errors in the data, the 2SLS estimate suggests that growth is an important factor of urbanisation. The magnitude of this effect is strongly robust in a battery of sensitivity tests and not once in these robustness checks was its statistical significance driven out. Therefore, it is safe to conclude that economic growth does affect urbanisation in China.

[85] In recent times, the local governments have accounted for more than 80 percent of the national budgetary expenditures. See Wong (2011).

Fig. 5.1: Annual Growth Rate of Provincial GDP Per Capita and Provincial Government Expenditure Share (1977–2008)



Source: National Bureau of Statistics of China (NBSC).
Note: The figure plots the GDP growth per capita and the growth rate of government spending share to local GDP of 22 provinces and five autonomous regions during 1978–2008. Data are obtained from the National Bureau of Statistics of China (NBSC). The vertical lines represent the years when the National Congress is held, i.e. 1977, 1982, 1987, 1992, 1997, 2002 and 2007.

This chapter is related to the literature that focuses on identifying the causal effect of income levels and growth on urbanisation.[86] In a cross-country study, Davis and Henderson (2003) use lagged covariates as instruments in a first-difference framework to show that higher income levels contribute to the acceleration of urbanisation. For countries in sub-Saharan Africa, Brückner (2012) uses rainfall-driven variation in economic growth to study its impact on urbanisation,[87] but his identification strategy is not applicable in this study as precipitation does not have a statistically significant effect on the GDP growth per capita of Chinese provinces.[88] Using a county-level fixed effects model for China, Deng et al. (2008) examine the causes of urbanisation but abstract from an in-depth focus on the issue of identification. This is critical as the fixed effects estimator cannot handle the identification issues of this chapter in an adequate way.

While there is some evidence that economic growth affects urbanisation, the literature remains divided on the existence of such a causal link. For instance, Zhang and Song (2003) provide some indirect evidence by way of Granger causality tests to show that economic growth *Granger causes* (positively) rural-to-urban migration but not vice versa,[89] while in a study of Brazilian cities, da Mata et al. (2007) find the existence of an incremental effect of a city's income per capita on its population level. However, Fay

[86] The literature goes back to Harris and Todaro (1970) who suggest that the process of urbanisation could implicitly be driven by economic growth. This is because economic growth often transpires into an expanding rural-urban income gap, which encourages rural-urban migration and increases the incidence of urbanisation. See also Henderson (1986) and Becker and Morrison (1999). Davis and Henderson (2003) and Henderson and Wang (2007) consider how institutions, such as the extent of democratisation and the fiscal decentralisation, may redistribute the concentration of urbanisation away from primary cities and help smaller cities to compete more freely for firms and human capital.

[87] Brückner (2012) finds that GDP growth per capita is not a significant cause of urbanisation once the size of the agricultural sector, which captures the consequence of sectoral shifts driven by economic development, is taken into account in the regression.

[88] The evidence is provided in section 3.3 (the fifth robustness check). This, perhaps, underscores the fact that the key driver of growth in China from the mid-1980s onwards comes primarily from the rainfall-insensitive manufacturing sector rather than rainfall-sensitive agricultural sector.

[89] Even though Granger causality is not true causality, the fact that economic growth *Granger causes* rural-urban migration may, though not necessarily, imply that a causal effect exists.

and Opal (2000) and Poelhekke (2011) present some intriguing evidence that urbanisation could take place in the absence of growth, citing sub-Saharan African and some Latin American countries as notable cases.[90] This contrasting evidence suggests that addressing the basic question of whether economic growth affects urbanisation may not be as straightforward as it seems.

The rest of the chapter is organised as follows. Section 2 outlines the data and the methodology. Section 3 presents the main empirical results and the sensitivity checks. Section 4 concludes.

2. Data and Methodology

2.1 Data

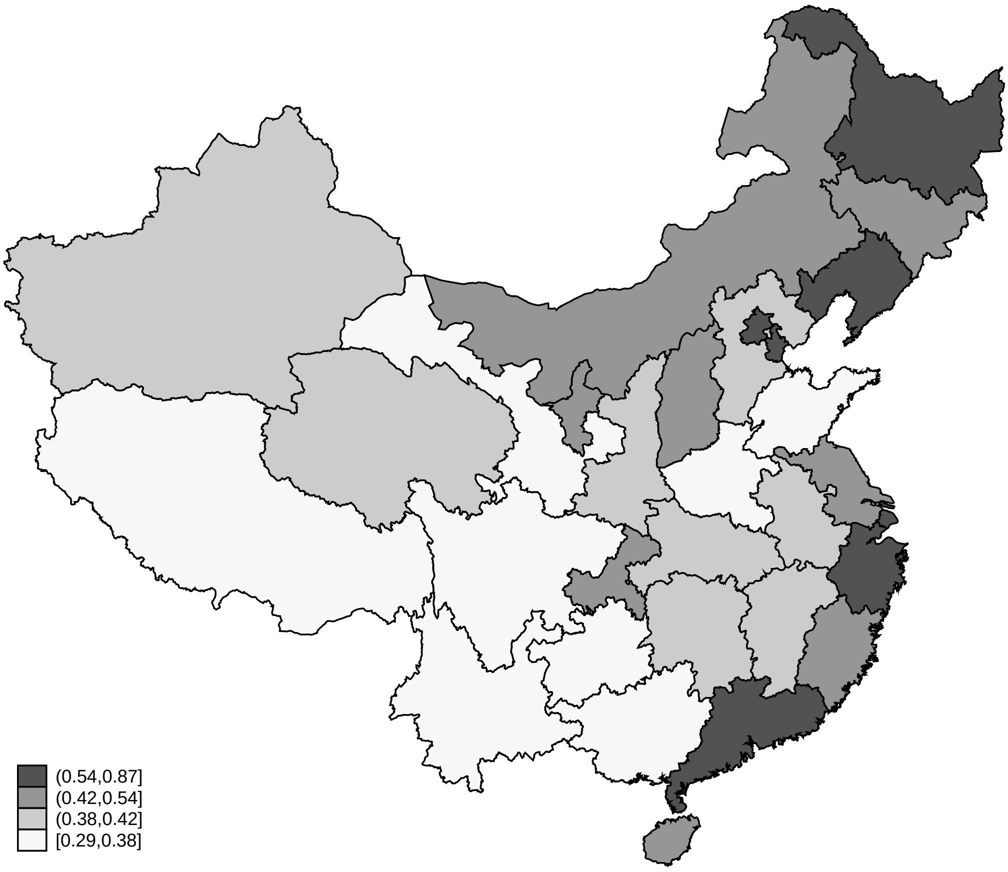
This study utilises panel data from 1985 to 2008 that are drawn from the *China Compendium of Statistics*, which is compiled by the Department of Comprehensive Statistics of the National Bureau of Statistics of China. This dataset is available for 31 sub-national administrative units in mainland China,[91] which consist of 22 provinces, four municipalities (Beijing, Shanghai, Tianjin and Chongqing[92]) and five autonomous regions (Tibet, Xinjiang, Ningxia, Inner Mongolia and Guangxi). This study excludes municipalities in the dataset as they are highly urbanised, and includes information on the 22 provinces and five autonomous regions only. The heterogeneity in the extent of urbanisation across these regions is shown in Figure 5.2. The variables in this study are listed in Table 5.10 and their summary statistics

[90] For instance, Bolivia's urban dwellers grew more than twice as fast as national total population during 1980–1985, however, its manufacturing sector declined around 5 percent per annum (Poelhekke, 2011).

[91] According to official classification, all regions excluding Hong Kong, Macao and Taiwan are categorised as East (12 administrative units), Central (9) and West (10). East: Beijing, Tianjin, Shanghai, Shangdong, Hebei, Liaoning, Fujian, Jiangsu, Zhejiang, Guangdong, Guangxi, Hainan. Central: Heilongjiang, Henan, Hunan, Hubei, Inner Mongolia, Jilin, Anhui, Jiangxi, Shanxi. West: Chongqing, Gansu, Guizhou, Ningxia, Qinghai, Shaanxi, Sichuan, Tibet, Xinjiang, Yunnan.

[92] Chongqing was designated a municipality in 1997. The other three cities were designated municipalities when the People's Republic of China was established in 1949.

Fig. 5.2: Regional Differences in the Urbanisation Rate (2008)



Source: National Bureau of Statistics of China (NBSC).
Note: The four quartiles of the urbanisation rate are represented by shades from white to dark grey, where the darker shaded regions have higher rates of urbanisation.

are reported in Table 5.1.

2.2 Methodology

The dependent variable of interest is the change in the urbanisation rate, where the urbanisation rate is defined as the proportion of urban population to total population for each sub-national unit, i.e. province or autonomous region. The causal variable of interest is the annual growth rate of real GDP

Tab. 5.1: Summary Statistics of Pooled Data, 1985–2008

Variables	Obs	Mean	SD	Min.	Max.
$\Delta urban$	593	0.009	0.050	-0.076	0.139
growth	593	0.086	0.058	-0.108	0.386
government expenditure share	593	0.158	0.107	0.049	0.961
government expenditure growth	593	0.188	0.108	-0.158	0.744
agricultural labour	593	0.549	0.125	0.192	0.818
state labour	593	0.224	0.113	0.082	0.607
grain per capita	593	0.390	0.154	0.130	1.105
wage growth	593	0.080	0.072	-0.132	0.414
population density	593	0.240	0.186	0.002	0.748
rainfall	593	75.794	41.930	9.461	183.952

Note: Variable definitions are provided in Table 5.10.

per capita.[93] Calling each sub-national unit in the study 'province' for sake of simplicity, the main estimating equation of this chapter looks at the causal relationship between GDP growth per capita ($growth_{it}$) for province i at time t and the change in the urbanisation rate ($\Delta urban_{it}$) as follows,

$$\Delta urban_{it} = c + \phi growth_{it} + \beta' \mathbf{z}_{it} + \mu_i + \gamma_t + \psi_r trend + u_{it}. \qquad (5.1)$$

The parameter c is the common intercept term across all provinces. The variable μ_i is the province fixed effect that represents permanent time-invariant differences across provinces, such as differences in institutional, cultural and geographical characteristics. The variable γ_t represents systemic shocks that have identical effects on urbanisation across provinces. Admittedly, such identical effects on urbanisation may seem quite far fetched at first glance, considering the great economic, cultural and geographic diversity in China that spans from the sparsely populated Tibet in the west where pastoralism is still an important way of life, to the densely populated coastal east where the

[93] For the sake of presentation, the rest of the chapter does not multiply the growth variables by 100 as doing so would lead to many decimal places in the main estimated coefficient, i.e. ϕ of equation (1), thus cluttering up the tables of results.

country's most important economic centres are found. Nevertheless, to be conservative, this study uses a focused approach to include year dummies that capture what might plausibly be shocks to urbanisation that have identical effects across provinces. These year dummies capture four nation-wide events that are contained in the sample period. The first event is the revolution in the Eastern bloc countries that some argue contributed to a brief moment of political instability and economic slowdown in China during 1989–1990.[94] The next three events are the Asian financial crisis of 1997–1998, the dot-com bubble of 2000 and the global financial crisis that started in 2007. While these global events may bear on urbanisation across China, their effects are unlikely to be identical across provinces (e.g. western regions such as Xinjiang and Tibet are less exposed to international economic fluctuations relative to the coastal provinces). However, because the main estimation will be utilising the timing of an aggregate event, namely the National Congress, as an estimation strategy, it is advisable to err on the side of caution by partialling out these potentially systemic effects on urbanisation even if they are indeed absent.

As an additional layer of safeguard, this study introduces a region-specific trend ψ_r for region r based on the official grouping of administrative units into East, Central and West regions.[95] This study uses region-specific trends instead of a single national trend because the national trend is nested in the model if the effect ψ_r is the same for each region r. That aside, the time trend is used to capture the trending effect of urbanisation that may either be due to omitted trending variables or policies that cause the trend to occur. For instance, over the last two decades, the *hukou* — a household registration system aimed at controlling the movement of people from rural to urban areas – was gradually relaxed. Therefore, over time, the relaxation of the *hukou* system will cause urbanisation rate to rise even controlling for the effect of economic growth. Because the flow of rural workers into urban regions might

[94] For instance, Naughton (2008) addresses the political economy of China's economic transition, and outlines the major political events during the last 30 years that include the student protests that took place in 1989. Perkins and Rawski (2008) show that the 1989 event is associated with a major drop in TFP. They also point out that during 1989–1990, the expansion of private enterprises paused.

[95] Please refer to section 3 for further details.

occur at a different pace across different regions in China, partialling out the time trend at the regional level provides an extra safeguard to address this issue as well as helping eliminate any correlation between GDP growth per capita and the urbanisation rate that may be driven by trends, possibly caused by other external factors.

To identify the effect of $growth_{it}$, i.e. ϕ, it is also important to consider the pitfall of leaving out variables that are possibly correlated with $growth_{it}$ and $\Delta urban_{it}$. To address its consequence transpiring as omitted variable bias, this chapter includes two additional sets of covariates in the regression framework.

The set of covariates is represented by the vector $\mathbf{z}_{it}$, which consists of an economic reform dummy that is equal to one for the years 1992 to 1998. This reform dummy reflects the institutional transition and economic decentralisation that took place during the third phase of China's economic reform from 1992 to 1998. Since the reform is potentially correlated with both economic growth and the rate of urbanisation, it would be prudent to partial out its effect as has been done elsewhere in the literature.[96] The vector $\mathbf{z}_{it}$ also consists of the interaction between the reform dummy and a coastal indicator variable. Through this interaction term, one may capture the heterogeneous effect of the economic reform on urbanisation from coastal to inland regions, since the rates of urbanisation are vastly different across China as Figure 5.2 suggests.[97]

2.3 Instrumental Variables

Even if the issue of omitted variables is taken care of, OLS regression would still be inconsistent as it does not handle the problem of reverse causality that runs from urbanisation to growth as well as the issue of measurement errors

[96] This economic reform dummy is considered as a control variable in the study of China's economic growth. See, for example, Démurger (2001).

[97] For example, the coastal position of provinces may be linked to better climates than comparable inland regions and to factors that are supportive of a wider range of economic activities such as trade and FDI, all of which are amenable to the process of urbanisation and help foster the development of urban areas in the coastal provinces. See also Li (2011).

that will attenuate the estimates towards zero. To this end, this chapter uses the timing of the National Congress as an attempt to achieve identification.

The National Congress of the CPC is the country's most important public political event led by the General Secretary, senior party leaders and grassroots members. While the National Congress was held even before the establishment of China as the People's Republic,[98] it was not until 1977 that the meeting took place at five-yearly intervals. During the National Congress, both internal party matters, such as promoting, demoting and turning over senior party and provincial leaders, and national economic objectives are discussed. The key economic objectives ratified by the National Congress often include specific growth targets for the country, where it is incumbent upon local governments to ensure that these targets are met.[99] Incentive-wise, the ranking of provincial GDP growth has become an important measure for assessing the performance of local leaders, who could be promoted for exceeding growth expectations or even dismissed for poor performance.[100] Therefore, even though the decentralisation of the Chinese fiscal system meant that the responsibility of implementing these policies rests, not on the central government, but on local governments, a system of incentives is in place to encourage the local leaders to work towards fulfilling the country's economic ambitions.

Because of the decentralised fiscal system, an aggregate event as the National Congress could have implications for provincial economic growth. To capture the effect of the National Congress, this study constructs an instrument, $Congress$, which is a binary indicator that is equal to one in the year of the National Congress and zero in other years. Besides $Congress$, there are reasons why using indicators of the years before the National Congress as additional instruments might be preferable from the

[98] The first National Congress was held in 1921, and the People's Republic of China was founded in 1949.

[99] For example, in the 11th Five-Year Plan (2005-2010) the national gross GDP was targeted to achieve RMB 26.1 trillion with an average 7.5 percent growth over a five-year period (Fan, 2006).

[100] For instance, Chen et al. (2005), Li and Zhou (2005) and Wu (2010) showed that a higher economic growth rate during the five-year tenure of officials and larger growth differentials between current and previous leaders would raise promotional chances.

identification standpoint. Firstly, it is best to let the data speak and take an agnostic stance on how the timing of the National Congress is linked to growth. Secondly, it may take time for growth-enhancing policies to achieve their intended outcomes, so that the effect of the National Congress on growth might be more apparent towards the latter part of the five-year meetings cycle, that is, just before the next meeting takes place.[101] Therefore, this study also utilises $Congress(-1)$, which indicates the year before the National Congress, and $Congress(-2)$, which indicates two years before it, as additional instruments for growth together with $Congress$.

2.4 Further Remarks

Before concluding this section, some remarks are in order. Firstly, for the congress instruments to be valid, they must be correlated with economic growth but uncorrelated with the omitted determinants of the urbanisation rate, captured collectively by u_{it} in (5.1). While the first assumption can be verified, the second assumption — the exclusionary restriction — cannot be tested without overidentification. Therefore, utilising additional information about the timing of the National Congress through $Congress(-1)$ and $Congress(-2)$ will be helpful for the purpose of implementing the overidentifying restrictions test.

Secondly, exclusion restriction requires that the congress dummies affect urbanisation only through economic growth. In other words, it precludes the existence of a direct effect that the timing of the National Congress might have on the urbanisation rate. Since the congress dummies capture "cycles", the exclusion restriction is tantamount to asserting that people do not flow into urban areas in a cyclical manner, and not for the particular reason that

[101] In addition, the recent fiscal decentralisation has provided local leaders with further degrees of flexibility to increase public expenditure for the stimulation of GDP growth (Zhang and Zou, 1998; Jin et al., 2005). Therefore, given that GDP growth is a key performance metric when assessing local leaders, who may use the National Congress to seek promotion to the central government (e.g. Blanchard and Shleifer, 2001; Li and Zhou, 2005), the evaluation of local leaders using a GDP-based benchmark may encourage them to stimulate GDP growth prior to the event.

the National Congress is held that year. No doubt, the National Congress may ratify policies to encourage urbanisation by relaxing the *hukou* system, but the implication of relaxing the restriction on human flow into urban areas is likely to produce a trending, not cyclical, effect on urbanisation that the time trend in the regression will capture.

Thirdly, the first stage equation where growth is regressed on the excluded congress instruments (among other controls) does not have to be causal. That is, the instruments do not have to be uncorrelated with the error term in the first stage (economic growth) equation. Instead, they have to be orthogonal to the error term in the second stage (urbanisation) equation for the purpose of identification. Because the timing of the National Congress is exogenous, one can rule out such correlation that is due to the reverse causal effect of urbanisation on the instruments. Nonetheless, this does not guarantee that the instruments used in this study are uncorrelated with all omitted determinants of urbanisation, which are consolidated by the second stage error term. While not an infallible response to this issue, one could examine whether the causal estimates are sensitive to the inclusion of potential factors of urbanisation that are initially omitted from the urbanisation equation. Guided by the literature, this study gathers a set of additional regression covariates to perform a battery of robustness checks in section 3.3. If the estimation strategy is not robust, the baseline result would be fragile when these covariates are added to the regression, but this is not the case as section 3.3 demonstrates.

3. Empirical Results

3.1 OLS Estimates

Table 5.2 summarises the estimation results from OLS regression. Even though the OLS regression is unidentified, it provides a useful starting point for investigating the extent of the estimation issues that could confound the causal effect of growth on urbanisation. For instance, the positive reverse causation that runs from urbanisation could lead to overestimating the causal effect of growth, which is the focus of this chapter. On the other hand, measurement errors in the data could have an attenuation effect that counteracts this upward bias arising from reverse causality. If the effect of measurement error is powerful enough, OLS regression may understate the true contribution of growth to urbanisation, producing results that would bound the instrumental variable estimates from below.

Tab. 5.2: OLS Regressions

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: $\Delta urban$				
growth	0.046**	0.045*	0.045**	0.074**	0.095**
	(0.021)	(0.024)	(0.021)	(0.035)	(0.046)
$\mathbf{z}_{it}$ included?	No	Yes	Yes	Yes	Yes
μ_i included?	No	No	Yes	Yes	Yes
γ_t included?	No	No	No	Yes	Yes
Regional time trend included?	No	No	No	No	Yes
N	593	593	593	593	593

Note: The numbers in parentheses are robust standard errors. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. Definitions of the variables are provided in Table 5.10.

In the simplest pooled regression model, column (1) shows that the OLS estimate of the slope coefficient is nearly zero. This weakness of the OLS estimate reflects a deeper issue that goes beyond the problem of omitted variable bias, since it cannot be overcome by the introduction of additional covariates. For instance, column (2) includes the vector $\mathbf{z}_{it}$ consisting of the economic reform dummy and its interaction with a coastal indicator variable. Despite including these additional covariates, the OLS estimates of the effect of growth on urbanisation remain very close to the simple pooled regression estimate in column (1). Moreover, as columns (3)-(5) show, the OLS estimates remain stubbornly close to zero even after controlling for province fixed effects, year dummies that capture possible systemic shocks to urbanisation, and region-specific time trends. This implies that identification cannot be achieved by mere inclusion of additional control variables. If the positive reverse causal effect of urbanisation on growth holds, the weak OLS estimates indicate that measurement errors could be a more severe issue than reverse causality, as this weakness is symptomatic of the situation where the attenuation bias due to measurement errors is stronger than the upward bias from reverse causality. Given that the data come from the NBSC, where Rawski (2001), Rawski and Xiao (2001), Chow (2006), and Ravallion and Chen (2007) have raised questions about the quality of the Bureau's data, the concern about measurement errors may well be justified.

3.2 2SLS Estimates

Instrumental variables can be used to circumvent the methodological challenges related to reverse causality and measurement errors. Using the timing of the National Congress as an estimation strategy, column (1) of Table 5.3 reports the findings from 2SLS regression of the model that controls for the economic reform dummy and its interaction with a coastal dummy, the province fixed effect, the crisis dummy, and region-specific time trends. In other words, it reports the 2SLS counterpart of the OLS estimates in column (5) of Table 5.2. Column (1) of Table 5.3 shows that the congress instruments are powerful, where the first stage F-statistic well exceeds the Staiger and Stock (1997) rule-of-thumb threshold of 10. *Congress* has the largest effect among the congress instruments, and this effect tapers off to 0.002 with respect to $Congress(-1)$, then to 0.026 with respect to $Congress(-2)$. The positive link between the congress instruments and growth is consistent with Figure 5.1 that shows that the annual growth rate of provincial GDP per capita is systematically related to the years when the National Congress has taken place.

Given that the instruments are strong, the second stage regression in column (1) shows that the impact of economic growth on the urbanisation rate, i.e. the estimate of ϕ, is both statistically significant and quantitatively large. Unlike the tenuous OLS estimates, column (1) in Table 5.3 shows the

Tab. 5.3: 2SLS Regressions

	(1)	(2)	(3)
	Panel A. Dependent Variable:		
	$\Delta urban$	$\Delta urban$ $(t+1)$	$\Delta urban$ $(t+2)$
growth	0.452**	-0.235	0.286
	(0.191)	(0.290)	(0.182)
	Panel B. Dependent Variable: *growth*		
Congress	0.025***	0.021***	0.023***
	(0.008)	(0.008)	(0.008)
Congress (-1)	0.002	-0.004	-0.004
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.019***	0.015**	0.015**
	(0.007)	(0.007)	(0.007)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Regional time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	50.77	44.37	40.15
Hansen J (p-value)	0.26	0.86	0.57
N	593	571	549

Note: The numbers in parentheses are robust standard errors. Column (1) estimates the baseline estimating equation of (5.1). Columns (2)-(3) re-estimate the model by regressing $\Delta urban$ at period $t+1$ and $t+2$ on the period t control variables of (5.1). The variable μ_i represents province fixed effect, and γ_t captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

2SLS regression yields a much larger estimate of the within-province effect of growth on urbanisation, where a 1 percentage point increase in GDP growth per capita raises the change in the urbanisation rate by 0.452 percentage points on average. The larger 2SLS estimate of the effect of growth is indicative of the overpowering influence of measurement errors, since if the effect of reverse causality were dominant, it would cause an upward bias in the OLS estimate instead of a downward bias that is observed here. There is no evidence that the quantitative significance of the 2SLS estimate is an unintended consequence of model misspecification and questionable instruments validity, as the overidentifying restriction test in column (1) is not rejected at standard significance levels. While there is a positive link in the contemporaneous sense between GDP growth per capita and the change in the urbanisation rate, one does not observe a statistically significant lagged effect of growth on urbanisation. For instance, columns (2)-(3) consider the impact of the period t GDP growth per capita on the change in the urbanisation rate in periods $t+1$ and $t+2$ and show that the coefficient of GDP growth per capita is statistically insignificant in both cases. This implies that growth has no lagged effect on urbanisation, and that the relationship between growth and urbanisation is more transient than persistent in nature.[102]

3.3 Robustness Checks

This section conducts robustness checks to evaluate the sensitivity of the baseline estimate in column (1) of Table 5.3. They are carried out by including in the baseline regression five sets of covariates that are potentially relevant to urbanisation in various aspects.

The first robustness check is motivated by the concern that provincial leaders might adopt different development and urbanisation strategies based on their personal background.[103] To address this issue, this study controls

[102] To save space, this chapter has omitted the events dummies from the tables. The full results are available in Table 8.3 of Appendix C. As it turns out, except for the 1989–1990 revolution following the collapse of communism in the Eastern bloc countries, the macroeconomic events related to the Asian financial crisis, dot-com bubble and the global financial crisis do not have a statistically significant effect on urbanisation, although they are statistically significant negative determinants of growth.

[103] Chen et al. (2005) and Li and Zhou (2005) argue that provincial secretaries of the CPC and provincial governors are evaluated based on certain criteria such as the annual

for the personal characteristics and attributes of two key provincial leaders – the provincial CPC secretary and the provincial governor. Drawing from the study of Chen et al. (2005) and Li and Zhou (2005), this study constructs variables of personal characteristics that are related to the tenure, age (including its square), education and professional connections of the provincial secretary or governor. The tenure is defined as the kth year of one's current assignment in either a CPC secretary or a provincial governor position. The education variable is a binary variable that is equal to one if a leader is an alumnus of a choice university in China, which is a way of extracting information about the ambition and personal network of a local leader.[104] The professional connection variable is a binary variable that is equal to one if a leader has past experience or is currently holding a joint-appointment in the central government.[105] Table 5.4 shows that the baseline estimate of the coefficient on growth, which is 0.452 (see column (1) of Table 5.3), remains identical up to two decimal places after controlling for the attributes of the provincial governor or secretary. This implies that the attributes of provincial leaders are not particularly important in influencing the economic growth-urbanisation relationship, despite the fact that the implementation of national policies rest largely on provincial governments and its efficacy may depend on the leaders' characteristics.

The second robustness check considers the implication of including the provincial expenditure growth and the expenditure share of provincial GDP into the baseline model. This is an important exercise as policies originating from the National Congress may be related to the expenditure of provincial governments, which may in turn affect the rate of urbanisation.[106] As it turns

growth rate and five-year average provincial GDP per capita.

[104] The choice universities are Peking University, Tsinghua University, Fudan University, Jiaotong University and Renmin University. This study distinguishes local leaders who are graduates from choice versus non-choice universities instead of considering whether these leaders do or do not have a university degree, since a significant majority of local leaders are university graduates.

[105] For instance, Li and Zhou (2005) find that having connections with the central government may increase the promotional opportunities of local leaders, which may in turn influence the type of development strategies they choose to pursue for their local regions.

[106] For instance, Becker and Morrison (1988) find that government expenditure and urban

Tab. 5.4: Robustness Check 1 – Attributes of Provincial Leaders

	(1)	(2)	(3)
	Panel A. Dependent Variable: $\Delta urban$		
growth	0.456**	0.450**	0.454**
	(0.186)	(0.191)	(0.187)
	Attributes of provincial CPC secretaries		
age	-0.000		0.001
	(0.007)		(0.007)
age squared	0.000		-0.000
	(0.000)		(0.000)
tenure	-0.001		-0.001
	(0.001)		(0.001)
university	0.005		0.006
	(0.007)		(0.008)
central connection	0.007		0.008
	(0.007)		(0.007)
	Attributes of provincial governors		
age		-0.008	-0.007
		(0.007)	(0.007)
age squared		0.000	0.000
		(0.000)	(0.000)
tenure		0.000	0.001
		(0.001)	(0.001)
university		0.001	0.002
		(0.005)	(0.006)
central connection		0.007	0.007
		(0.009)	(0.009)
	Panel B. Dependent Variable: *growth*		
Congress	0.025***	0.026***	0.025***
	(0.008)	(0.008)	(0.007)
Congress (-1)	0.000	-0.000	-0.001
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.020***	0.019***	0.019***
	(0.007)	(0.007)	(0.007)

	Attributes of provincial CPC secretaries		
age	0.006		0.009
	(0.008)		(0.008)
age squared	-0.000		-0.000
	(0.000)		(0.000)
tenure	0.002*		0.002*
	(0.001)		(0.001)
university	0.007		0.008
	(0.006)		(0.006)
central connection	-0.010**		-0.011**
	(0.005)		(0.005)
	Attributes of provincial governors		
age		-0.005	-0.009
		(0.007)	(0.007)
age squared		0.000	0.000
		(0.000)	(0.000)
tenure		0.001	0.000
		(0.001)	(0.001)
university		-0.010*	-0.011*
		(0.006)	(0.006)
central connection		-0.017***	-0.017***
		(0.006)	(0.006)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Regional time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	41.17	38.50	32.92
Hansen J (p-value)	0.26	0.25	0.24
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ_t captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

out, Table 5.5 shows that the effect of growth on urbanisation remains highly robust. Even upon including the expenditure growth (column (1)), or the expenditure share of GDP (column (2)), or both (column (3)), the estimate of ϕ ranges tightly from 0.456 to 0.482, which is close to the baseline estimate of 0.452. Also interesting is the observation that the first stage regression is robust. In Panel B, the coefficients on the congress instruments in Table 5.5 are very similar to the baseline estimates with first stage F-statistics that are much greater than 10, suggesting that using the expenditure variables as controls has not weakened the power of the congress instruments.

The third robustness check considers whether the transition of China's labour market may confound the growth-urbanisation relationship. As Henderson (2005) argues, the process of urbanisation is usually accompanied by shifts in importance away from the agricultural sector and towards the manufacturing and services sectors. In the case of China, structural changes in the labour market following the liberalisation of the Chinese economy may affect not only the rural labour force but also reduce the share of labour employed in state-owned and collective enterprises. Thus, the third robustness check controls for the share of the labour force in the agricultural sector and the share of the labour force in public and state-owned enterprises in this exercise. Column (3) of Table 5.6 shows that urbanisation is negatively related to the size of the agricultural and public sector, confirming that provinces with larger agricultural and public sectors would also urbanise at a much slower pace.[107] Importantly, Table 5.6 shows that the effect of growth on urbanisation remains highly resilient when the labour share variables are included as controls. The same is true for the first stage regression in Table 5.6, where the estimated coefficients on the congress instruments are largely unaffected.

Related to the third robustness check, the fourth robustness check addresses the question of whether the share of the agricultural labour force is a suitable variable for capturing the size of the agricultural sector. After

population are positively correlated. Brückner (2012) also considered the inclusion of government expenditure as a further robustness check.

[107] A similar result is also found in Brückner (2012) for the case of sub-Saharan Africa.

Tab. 5.5: Robustness Check 2 – Government Expenditure

	(1)	(2)	(3)
	Panel A. Dependent Variable: Δ*urban*		
growth	0.456**	0.478**	0.482**
	(0.192)	(0.205)	(0.208)
government expenditure share	0.002		-0.008
	(0.042)		(0.051)
government expenditure growth		0.007	0.008
		(0.018)	(0.020)
	Panel B. Dependent Variable: *growth*		
Congress	0.025***	0.027***	0.026***
	(0.008)	(0.008)	(0.009)
Congress (-1)	-0.000	-0.001	-0.001
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.019***	0.018**	0.018**
	(0.007)	(0.007)	(0.007)
government expenditure share	0.078		0.060
	(0.065)		(0.068)
government expenditure growth		0.025	0.018
		(0.024)	(0.025)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Regional time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	47.28	47.72	44.59
Hansen J (p-value)	0.26	0.22	0.22
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ_t captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

Tab. 5.6: Robustness Check 3 – Labour Force Characteristics

	(1)	(2)	(3)
	Panel A. Dependent Variable: $\Delta urban$		
growth	0.461**	0.457**	0.451**
	(0.192)	(0.191)	(0.188)
agricultural labour	-0.076		-0.110**
	(0.049)		(0.053)
state labour		0.017	-0.061
		(0.047)	(0.047)
	Panel B. Dependent Variable: *growth*		
Congress	0.026***	0.026***	0.026***
	(0.008)	(0.008)	(0.008)
Congress (-1)	0.000	0.000	0.000
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.019***	0.019***	0.019***
	(0.007)	(0.007)	(0.007)
agricultural labour	-0.005		0.005
	(0.040)		(0.053)
state labour		0.014	0.017
		(0.047)	(0.062)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Regional time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	47.75	47.61	44.84
Hansen J (p-value)	0.28	0.26	0.30
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ_t captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

all, the size of the agricultural labour force may be more closely related to rural population than the size of the agricultural sector *per se*. To this end, the fourth robustness check employs a measure of agricultural output, grain per capita, as a proxy for the size of the agricultural sector. Besides controlling for grain per capita, it also considers the growth rate of real urban wage as a possible confounder. The reason is that urban wage growth may encourage rural-to-urban migration, and at the same time, could be correlated with economic growth. When controlling for grain per capita, column (1) of Table 5.7 shows that the estimated causal effect of growth is identical to the baseline estimate of 0.452. The robustness of this effect is not compromised when controlling for urban wage growth, or grain per capita and urban wage growth simultaneously.

The fifth robustness check introduces population density and provincial rainfall variation into the estimating equation, both of which could be related to urbanisation.[108] For example, Deng et al. (2008) find that the level of population is associated with the size of the urban core area, and Barrios et al. (2006) show that climatic change, as proxied by rainfall, is an important determinant of rural-urban migration in sub-Saharan Africa.[109] Concerning rainfall, although it has been used as an instrument for output, income and growth, the estimation strategy of constructing instruments using rainfall data are not implementable in this study as the effect of rainfall on growth across provinces in China is statistically insignificant.[110] That said, while

[108] This study uses rainfall data from the *Terrestrial Air Temperature and Precipitation: Monthly and Annual Time Series (1900 - 2008)*. `http://climate.geog.udel.edu/~climate/html_pages/download.html`. Table 5.8 only focuses on the effect of contemporary precipitation on urbanisation. The potential impacts of quadratic rainfall and lagged rainfall on urbanisation are carefully investigated in Table 8.4 of Appendix C.

[109] Deng et al. (2008) find that a 1 percent increase in population would raise the urban core area (hectares) by 0.186 percent. See also Brückner (2012) who uses the level of population as an additional control variable in his sensitivity checks.

[110] The omitted results are available in Table 8.5 of Appendix C. Furthermore, it is important to note that rainfall may be correlated with unobserved determinants of urbanisation. For instance, there is a large body of literature in climatology that shows that urbanisation can affect rainfall patterns. Since urbanisation may cause variations in rainfall in return, this may raise questions on the validity of using rainfall to construct instrumental variables for growth for the study of its impact on urbanisation.

Tab. 5.7: Robustness Check 4 – Agricultural Output and Urban Wage Growth

	(1)	(2)	(3)
	Panel A. Dependent Variable: $\Delta urban$		
growth	0.452**	0.479**	0.477**
	(0.189)	(0.189)	(0.188)
grain per capita	-0.014		-0.013
	(0.030)		(0.030)
wage growth		-0.041	-0.040
		(0.031)	(0.030)
	Panel B. Dependent Variable: *growth*		
Congress	0.026***	0.024***	0.024***
	(0.008)	(0.008)	(0.008)
Congress (-1)	-0.000	-0.002	-0.002
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.019***	0.020***	0.020***
	(0.007)	(0.007)	(0.007)
grain per capita	0.055**		0.049*
	(0.028)		(0.027)
wage growth		0.097**	0.093**
		(0.044)	(0.044)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Regional time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	48.00	48.60	46.21
Hansen J (p-value)	0.27	0.33	0.34
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ_t captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

Tab. 5.8: Robustness Check 5 – Population Density and Rainfall

	(1)	(2)	(3)
	Panel A. Dependent Variable: $\Delta urban$		
growth	0.455**	0.458**	0.464**
	(0.192)	(0.188)	(0.189)
population density	0.183		0.188
	(0.175)		(0.166)
rainfall		-0.00004	-0.0001
		(0.0002)	(0.0002)
	Panel B. Dependent Variable: *growth*		
Congress	0.026***	0.025***	0.025***
	(0.008)	(0.008)	(0.008)
Congress (-1)	0.000	0.000	0.000
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.019***	0.019***	0.019***
	(0.007)	(0.007)	(0.007)
population density	-0.177		-0.180
	(0.120)		(0.121)
rainfall		0.000	0.000
		(0.013)	(0.000)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Regional time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	47.25	47.35	44.20
Hansen J (p-value)	0.24	0.26	0.24
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ_t captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

Tab. 5.9: Robustness Check 6 – Alternative Forms of Time Trend

	(1)	(2)	(3)
	Panel A. Dependent Variable: $\Delta urban$		
growth	0.412**	0.453**	0.416**
	(0.205)	(0.192)	(0.205)
	Panel B. Dependent Variable: *growth*		
Congress	0.027***	0.025***	0.026***
	(0.007)	(0.008)	(0.008)
Congress (-1)	0.001	0.002	0.001
	(0.004)	(0.005)	(0.005)
Congress (-2)	0.014**	0.019***	0.014**
	(0.007)	(0.008)	(0.007)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Regional time trend included?	Yes	No	No
Quadratic regional time trend included?	Yes	No	No
National time trend included?	No	Yes	Yes
Quadratic national time trend included?	No	No	Yes
First-Stage (F-stat)	43.42	58.84	55.73
Hansen J (p-value)	0.24	0.26	0.24
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ_t captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

the effect of rainfall on growth in China may be weak at best, rainfall could affect urbanisation in China through rural-urban migration.[111] As with the previous robustness checks, Table 5.8 shows that the estimated effect of growth on urbanisation is nearly identical to the baseline estimate, and the same can be said about the estimated effect of the congress instruments. For instance, adding rainfall into the regression, defined by the average annual precipitation (mm), column (2) shows that the estimated incremental impact of growth on urbanisation is nearly identical to the baseline estimate. With respect to the congress instruments, Table 5.8 shows that these variables are not only statistically significant for growth, the magnitude of their effects are also highly robust.

The sixth robustness check, reported in Table 5.9, explores how sensitive the baseline results are to various specifications of the time trend. First, it includes the square of the region-specific time trend to capture any non-linear trending effect (column (1)). Second, it replaces the region-specific time trends used in (5.1) with a single national time trend (column (2)). Finally, it controls for the national time trend and its square (column (3)). As Table 5.9 shows, the estimation outcomes are not sensitive to the choice of region-specific versus national time trend. Furthermore, adding the squared trend only reduces the effect of growth on urbanisation slightly without driving out its statistical significance.

Overall, the sensitivity tests provide compelling evidence that the estimate of the effect of growth is robust, which offers some support for the 'congress cycles' estimation strategy used here. Furthermore, the estimated effect of the timing of the National Congress is highly resilient. For instance, while the baseline estimate of the coefficient on *Congress* is 0.025, the estimates of this coefficient range from 0.024 to 0.027 across the sensitivity tests. Likewise, the estimates of the effect of *Congress(-2)* in the robustness checks vary in a narrow vicinity around the baseline estimate.

[111] Barrios et al. (2006) show that climatic change, as proxied by rainfall, is an important determinant of rural-urban migration in sub-Saharan Africa.

4. Conclusion

The combination of rapid urbanisation and an impressive record of economic growth is a striking feature in the development experience of China. However, concrete empirical evidence on whether economic growth affects urbanisation in China, let alone how strong this causal effect could be, is limited. The weak OLS estimates of the effect of economic growth, which remain tenuous despite eliminating a host of confounders that include province fixed effects, remind us that addressing a question as fundamental as whether economic growth affects urbanisation may not be straightforward.

Due to the complexity of endogeneity issues, current empirical studies have not arrived at a consensus as to whether economic growth causally raises urbanisation. For example, Brückner (2012) finds that economic growth did not significantly raise urbanisation in sub-Saharan Africa. By contrast, Henderson (2002) shows economic growth could lead to a higher level of urbanisation based on data from 85 countries. While the objective of this chapter is a more modest one than to bring this debate to a close, the robustness of the findings based on 2SLS estimates offers relatively concrete evidence that economic growth matters for urbanisation, particularly for the case of China where there are policy implications. For instance, four potential crises – diminishing land resources, water and energy shortages, overpopulation and weakening environmental sustainability – are on the cusp of reaching the tipping point following the rapid rate of urbanisation in China.[112] But these problems are not straightforward to address, as the observation that urbanisation in China is so strongly driven by economic growth beyond the effects of rainfall, government expenditure, labour force composition, and population growth – factors of urbanisation emphasised previously in the literature[113] – suggests that slowing down the rate of urbanisation would be difficult without relaxing some growth targets, and

[112] See, for example, the article "Too Big, Too Fast" by Jianhua Feng in the Beijing Review, http://www.bjreview.cn/EN/En-2005/05-43-e/china-4.htm.

[113] See, for example, Mohan (1984), Becker and Morrison (1988), Zhang and Song (2003), Henderson (2005), Barrios et al. (2006) and Brückner (2012). This finding has been verified in the robustness checks in section 3.3.

that maintaining an environmentally sustainable rate of urbanisation while achieving high economic growth may be a difficult balancing act from the policy perspective.[114]

This chapter makes two contributions relating to both identification strategy and policy implications. First, because the study of the impact of economic growth on urbanisation must insulate itself from reverse causality and because of measurement errors, this chapter proposes a new but simple estimation strategy that uses the timing of the National Congress to estimate the within-province causal effect that growth has on urbanisation. The robust first-stage results in sections 3.2 and 3.3 have shown a close relationship between economic growth and the timing of the National Congress that is not confounded by systemic macroeconomic events and time trends. Therefore, this work offers a new way to think about identifying the independent variation in economic growth in the context of China, which is useful for the study of its causal implication.

Second, this study sheds light on whether economic growth, a key policy target, could have contributed to the rampant rate of urbanisation which brought along a set of economic, social and environmental challenges. These potential problems though have not been studied in this chapter are addressed in the literature. Based on 2SLS estimates, this chapter has confirmed that economic growth caused urbanisation in China during 1985–2009 when the rapid pace of urbanisation threatened sustainable development (see Chen, 2002; Chang and Brada, 2006; Feng et al., 2009; Du et al., 2012). From the policy perspective, this means that managing a sustainable rate of urbanisation while maintaining high rates of economic growth could be difficult to balance, and perhaps the panacea for ameliorating the problems of urbanisation might involve recalibrating the GDP growth targets that are central to the economic plans of Chinese local governments.

[114] Henderson (2009) offers a comprehensive overview of urbanisation and its related policy issues in China.

Tab. 5.10: List of Variables

Δ*urban*	annual change in the urbanisation rate
growth	annual growth rate of real GDP per capita
coastal	dummy=1 if provinces are located in coastal regions
reform	dummy=1 if year is between 1992 and 1998
coastal×*reform*	coastal dummy multiplied by reform dummy
age	age of leaders, provincial secretary or governor
tenure	The kth year of one's current assignment as a provincial secretary or governor
education	dummy=1 if a leader holds university degree from choice universities
central connection	dummy=1 if a leader has past or current working experience in the central government
government expenditure share	local government expenditure ÷ local total GDP
government expenditure growth	annual growth rate of local government expenditure
population density	regional total population (unit: thousand)÷ regional area (km^2)
population growth	annual growth rate of regional total population
agricultural labour	size of agricultural labour force ÷ size of local labour force
state labour	size of labour force in state and collective firms ÷ size of local labour force
grain per capita	annual grain output per capita (ton)
wage growth	annual growth rate of real urban wage
rainfall	average annual precipitation (mm)
crisis	year dummy for negative macroeconomic shocks

Note: The coastal regions are Liaoning, Hebei, Shandong, Jiangsu, Zhejiang, Fujian and Guangdong. The choice universities are Peking University, Tsinghua University, Fudan University, Jiaotong University, and Renmin University. Real urban wage is defined as the average of annual real wage in urban public sector consisting of state-owned enterprises and collective enterprises.

6. WAGES AND ACCESS TO INTERNATIONAL MARKETS: EVIDENCE FROM URBAN CHINA

1. Introduction

In development economics literature, cross-country studies emphasise the contribution of transportation infrastructure to economic growth (e.g. Esfahani and Ramirez, 2003; Calderón and Chong, 2004; and Calderón and Servén, 2005), in which the positive link appears undebatable. However, China is a special case which makes the relationship between transportation infrastructure and economic growth more complicated. In China where economic growth was rapid and infrastructure investment was substantial during 1978 to 2008,[115] the increasing inter-regional disparity of transportation infrastructure drove heterogeneous income growth and economic development.[116] While the empirical studies on China (e.g. Démurger (2001); Chen and Yao (2011)) using highly aggregated data have arrived at a consensus that transportation infrastructure has a strong impact on economic growth, recent work by Banerjee et al. (2012), using Chinese county-level data, shows that proximity to transportation network does not necessarily cause GDP per capita growth. These contrasting findings raise a new question about how transportation infrastructure influences income (wages only) from a micro perspective. This is important, as highly aggregated data like provincial and national data may not explicitly capture individual

[115] For example, in 2008, the Chinese government announced a package that included committing 1) RMB 1.52 trillion for infrastructure projects that included road construction and to increase the total highway length by about 40 percent between 2010 and 2020, and 2) RMB 1.41 trillion in 2010 and 2011 for railroad construction and to raise the total operating length by about 33 percent between 2010 and 2015.

[116] See Démurger (2001) and Chen and Yao (2011) for the periods 1985–1998 and 1978–2006, respectively.

attributes that affect individual wages. Focusing on urban wage inequality, this chapter supplements Chapters 3 and 4, by providing some micro-level evidence for urban China.

In the growing literature which uses aggregated endowments to explain micro-level income differentials, researchers indicate that the differences in accessibility to transportation infrastructure, as a proxy for market access, may lead to income disparities (Banerjee et al., 2012; Hou and Emran, 2012). The market access reflects the trading activities between the origin location and its domestic and international trade partners. The seminal work in this area is Hering and Poncet (2010) which follows a New Economics Geography (NEG) framework. Using urban data from the China Household Income Project Survey (CHIPS, 1995), Hering and Poncet (2010) show that geographical heterogeneity of market access has significant impacts on the disparities of individual wages. Building on Hering and Poncet (2010), Kamal et al. (2012) employ a similar theoretical framework but extend the empirical analysis by including urban samples from both CHIPS (1995) and CHIPS (2002). They find that the impact of access to markets on individual wages is heterogeneous among different types of workers. Using CHIPS (2002) data, Hou and Emran (2012) show that the accessibility to market, as measured by the distance from the origin place to its local business centres and major seaports, significantly affects rural household consumption levels.

The major challenge of using cross-sectional income data is that omitted unobservables cannot be easily purged, as cross-sectional data do not contain time-series information thus fixed effects estimations like in Chapters 3 and 4 cannot be used to eliminate time-invariant unobservable factors.[117] Methodologically, one may eliminate city-level fixed effects by introducing city dummies in this case. However, it is not appropriate either, because the variable of interest is itself a part of fixed effects which will be removed by

[117] Recall that there are three types of endogeneity problems, i.e. omitted variables, measurement errors and reverse causality. In Chapters 3 and 4, the major resources of endogeneity are measurement errors and reverse causality, since time-invariant omitted variables which are problematic in empirical studies are eliminated in fixed-effects estimations. In this chapter, the serious issue of endogeneity is mainly due to omitted variables.

dummy variables. Therefore, following the studies that use instrumental variables to ameliorate omitted biases caused by endogenous problems (see Hering and Poncet, 2010; Hou and Emran, 2012; and Kamal et al., 2012, among others), this chapter proposes a new instrumental variable employing historical information to identify the exogenous variation in length of transport routes connecting the origin city and its nearest major seaport.

The instrumental variable relies on historical information, i.e. China's inter-prefecture population in 1820. It is worth noting that an instrument including historical population does not violate the exclusion restriction only if the population is predetermined prior to the construction of the first railroad. The instrument proposed in this chapter satisfies this condition, as the first Chinese railroad was completed in 1881, so it could not affect the distribution of population in 1820. In other words, the instrument is not correlated with unobservable error terms that may affect the endogenous variable (transport routes) and the dependent variable (individual wages).

Using urban samples of CHIPS (2002), this chapter finds that instruments that use information from the historical population are significantly correlated with the length of transport routes. The strong effect is not confounded by omitting city characteristics (e.g. geographical and topographical conditions, contemporary population and political ranking) that might contaminate the impact of historical population on the present transportation infrastructure, since additional covariates, such as elevation, slope, latitude, longitude, current population density, administrative level and autonomous status are carefully taken into account in the regressions. Following a Mincer (1974) wage equation, this study shows that while the OLS estimates provide statistically insignificant and quantitatively zero effects of accessibility to international markets, proxied by length of transport routes, on individual hourly wages in urban China, the 2SLS estimates indicate a clear causal relationship that an increase in length of transport routes from the origin city to the international market (i.e. the nearest seaport), *ceteris paribus*, has a negative impact on individual wages in that origin city. Furthermore, the causal result remains strongly resilient in a battery of sensitivity tests.

The rest of the chapter is organised as follows. Section 2 addresses the related literature and the Chinese economic history. Section 3 outlines the data and the methodology. Section 4 presents the main empirical findings and the results of robustness checks. Section 5 provides the concluding remarks.

2. Background

2.1 Related Literature

In this chapter, the market access refers to importing and exporting activities between locations which are affected by heterogeneous transport routes linking the origin city with the trade partners. This study benefits from the conceptual framework initiated by the seminal studies on the NEG (Krugman, 1991; Krugman and Venables, 1995; Fujita et al., 1999). In Fujita et al. (1999), the market access of a location is defined as the sum of the market capacity (total trade potential) of surrounding locations that open up their borders. It is worth nothing that the computation of market access requires a weighting scheme based on bilateral distance of the origin location and its trade partners. Given the definition of market access, the NEG theory models nominal wages in a location as a function of the market access, and predicts that wages are relatively high at business centres.[118] The prediction is important for this chapter for two reasons. First, it indicates a possible direction of the impact of accessibility to markets on wages from theoretical perspectives. Second, it implies the necessity of eliminating effects from accessibility to domestic markets, if one aims to identify the specific contribution of accessibility to international markets to wage levels.

Recent empirical studies also shed light on the world's largest developing economy, China, emphasising its rapid market liberalisation. During the second phase of economic reform (1992–1997),[119] Poncet (2005) finds that

[118] A business centre is the hub where trade quantity is the highest in the region. For example, a provincial capital can be the business centre within the province.
[119] The economic reform of China consists of three main phases, i.e. 1978–1991, 1992–1997 and 1998 onwards.

the domestic market fragmentation became severe,[120] indicating that the domestic market integration in a developing country like China may not be consistently improving. Poncet (2003) confirms that China's 'Open Door' policy succeeded in opening up its borders to international markets but failed to reduce inter-provincial trade barriers. Built on these preliminary explorations, Hering and Poncet (2010) estimate the wage equation embedded in an NEG framework, addressing the effect of access to both domestic and international markets on individual wages.[121] Using CHIPS (1995) data, they claim that the heterogeneous geography of market access has a significant impact on individual differences in economic returns to labour. In addition, they find greater wage sensitivity to market access for highly-skilled workers relative to low-skilled workers; and for workers in non-public firms compared with workers in public firms. Using both CHIPS (1995) and CHIPS (2002) data, Kamal et al. (2012) underscore that market access affects wages paid to both skilled and unskilled workers, and argue that this influence was stronger for workers in state-owned firms relative to workers in other types of firms (e.g. private firms) during 1995–2002.

Departing from Hering and Poncet (2010) and Kamal et al. (2012) who investigate urban wage earners, Hou and Emran (2012) look at rural households, and quantify the direct impact of being relatively far away from both domestic and international markets. Their findings, relying on CHIPS (1995), show that the better the access to markets, measured as the length of transport routes that connect households and domestic markets (local business centres) and international markets (the nearest seaports), the greater the positive impact on rural consumption, which supplements Hering and Poncet (2010) and Kamal et al. (2012). This chapter accepts the measure of market access from Hou and Emran (2012), but emphasises the effect of access to international markets rather than general access to markets (e.g. Hering and Poncet, 2010; Kamal et al., 2012) on urban wage earners.

[120] Local authorities govern most economic activities in one region across different economic sectors. Thus, the Chinese market structure is characterised as a 'cellular' structure, which is also known as market fragmentation in China.

[121] This is the first attempt to estimate the Mincer (1974) wage equation in an NEG framework using micro data from China.

This study also extends those explorations in economic history that emphasise the importance of transportation infrastructure in the early stages of market integration and economic development across countries, for instance, Keller and Shiue (2008), Michaels (2008), Donaldson (2010) and Banerjee et al. (2012). Importantly, these studies have raised the issue of endogeneity of the initial construction of transportation infrastructure. A typically endogeneity problem could be, for example, the construction of highways. The initial design of highway routes is likely to correlated with local attributes such as population and income level which may affect the economic outcomes that researchers are investigating. Looking at the US in the 1950s, Michaels (2008) uses the original plan of routes proposed in 1944 as an instrument for highway locations to deal with this endogeneity issue. Relying on Chinese county-level data, Banerjee et al. (2012) use the distance of a county from the transport networks that connect historical treaty ports and business centres to construct an exogenous proxy of accessibility to current transportation infrastructure.[122] Donaldson (2010) studies the effects of railroad construction in 19th century India, underlining the contribution of railroads to initial spatial agglomeration which reduced inter-regional trade costs. Keller and Shiue (2008) show that the effects of steam trains in 19th century Europe were substantially larger than customs liberalisation and currency agreements in terms of increasing market size. This chapter's venture into Chinese history aiming to find an appropriate instrument is informed by studies noted above.

Finally, the current studies that look at infrastructure development in China usually use aggregated data, for example, provincial data. Using

[122] The treaty ports are Chinese territories which were conquered by the westerners after the First Opium War (1840). These ports were forced to open up to foreign trade during the second half of the 19th century to the early 20th century by unequal treaties. The Chinese government considered these treaties as unequal "because they were not negotiated by nations treating each other as equals but were imposed on China after a war, and because they encroached upon China's sovereign rights ... which reduced her to semicolonial status"(Hsü, 1970). For example, the treaties were imposed the British (e.g. Treaty of Nanjing, Treaty of the Bogue, Convention of Peking and Boxer Protocol), the French (e.g. Treaty of Whampoa, Treaty of Tientsin, Convention of Peking and Boxer Protocol), the American (e.g. Treaty of Wanghia, Treaty of Tientsin and Boxer Protocol), and the German (Treaty of Tientsin and Boxer Protocol), among others.

provincial panel data (1985–1998), Démurger (2001) investigates how heterogeneous provision of transportation infrastructure could drive provincial income disparities in China. Relying on Chinese provincial panel data over the period 1978–2006, Chen and Yao (2011) find that the increasing proportion of the government budget allocated to investments in transportation reduced household consumption. Using Chinese provincial panel datasets, Chapters 3 and 4 of this thesis confirm the contributions of the improvement of transportation infrastructure to short-run and long-run economic growth. Although the existing literature has found aggregated effects of transportation infrastructure on income and consumption, it is still possible to improve the understanding of the role of transportation infrastructure by introducing microeconometric analysis. In general, increased provision of transportation infrastructure may raise regional income growth, but it is not clear-cut whether this may have heterogeneous effects on the wage distribution. Thus, the empirical section of the chapter intends to quantify the causal impact of the provision of transportation infrastructure, as measured by length of current transport routes that connect the origin city and its nearest seaport, on income inequality in urban China. This chapter contributes to the literature by offering micro-level evidence built on individual income data from urban China in 2002.

2.2 Historical Factor Endowments

The central concern of this chapter is to find exogenous variations in transport routes connecting a location and its nearest seaport in 2002 in China. Thus, this section discusses historical population at prefecture level in 1820 which serves as the instrument variable. Moreover, the effects on individual wages imposed by other potential historical endowments are documented as well.

Cao (2000) provides a rich dataset including prefecture-level population density in the Qing Dynasty (1776, 1820, 1851, 1880 and 1910). This study gathers the information from the 1820 'census' to construct the instruments.[123] Three main reasons for choosing this dataset are presented. First, the earliest railroad in China had been completed in 1881, implying that data from 1880 and 1910 'censuses' are not usable, as they could be affected by the determinants of initial railroads and thus this would invalidate exclusion restrictions in a 2SLS approach. Second, this study does not employ data in 1851 not only because the timing is close to the First Opium War (1840) but also because it is influenced by the Taiping Rebellion (1850–1864) both of which caused a severe decline of population across Chinese prefectures. Last, this study prefers the 1820 'census' to the 1776 'census', as the former is relatively more accurate.

The intuitions of using prefecture-level historical population density as instruments for current transport routes are presented as follows. First, the example in the 19th century US reveals a positive link between population and expanding demand for railroads (Fogel, 1962), which in part explains why current routes which are built on initial railway networks are designed according to the pattern of population distribution. Recall that prefecture population in 1820 was not affected by the existence of the modern railway system, which does not violate exclusion restrictions.[124] Second, the history of Chinese railroads which is reviewed by Ma (1983) offers some evidence that rail routes are associated with surrounding population. For example, the Beijing-Shenyang railroad (construction: 1881–1930) connects Beijing, Tianjin, Hebei province and Liaoning province which were all areas of high population density in the late 1800s. Figures 6.1 and 6.2, which illustrate the railway density by the end of the Qing Dynasty (1911)[125] and the average

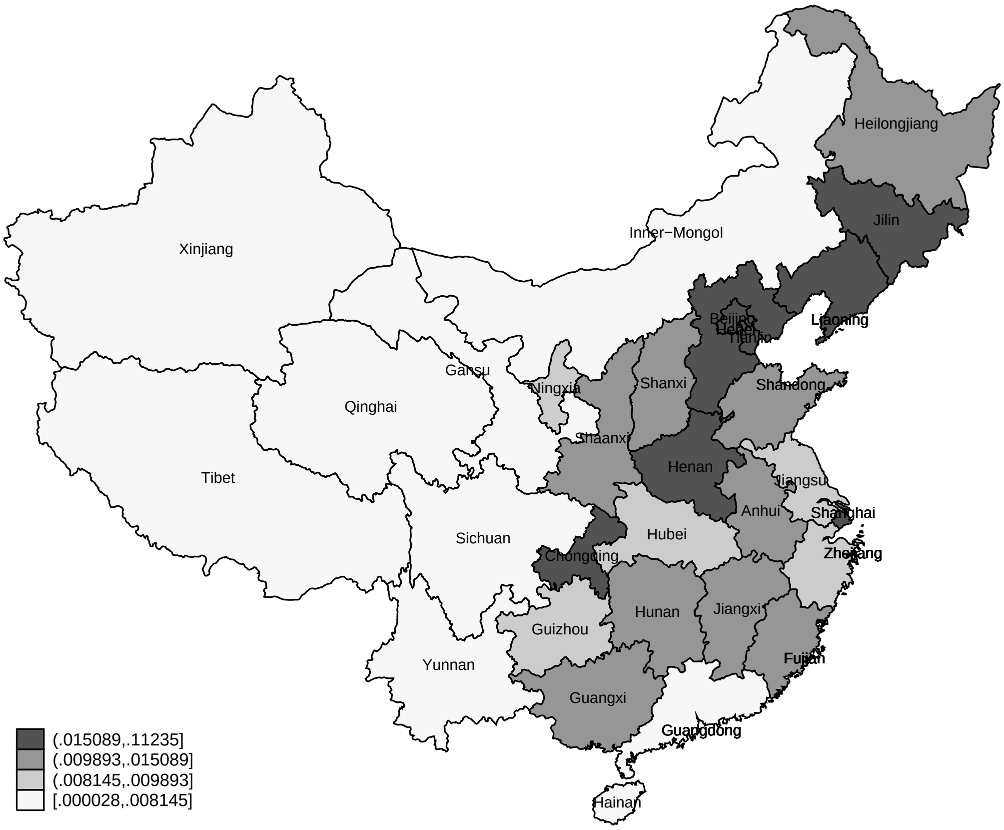
[123] In the Qing dynasty (1644–1911), there were no formal population censuses according to the modern-time statistical and demographical criterion. However, the Qing government had relatively complete records of registered prefecture-level population in some years, e.g. 1776, 1820, 1851, 1880 and 1910.

[124] The inclusion of other factors such as geographical and topographical conditions in the analysis will ensure that the estimation does not omit key determinants of current transport routes.

[125] Since provincial boundaries do not remain constant from 1911 onwards, this study uses the current Chinese map for provincial boundaries and the length of railways in 1911 to compute the railway density in Figures 6.1 and 6.2. Based on information such as railway track lengths, the years when construction started, the years when tracks opened, and the locations of origin and terminal stations of both main and spur lines provided by

railway density during 1978–2008, look similar. This suggests that the initial level of provision of railroads completed a century ago is positively related to the level of provision of infrastructure in the contemporary Chinese railway system.

Fig. 6.1: Average Railway Density (1978–2008)

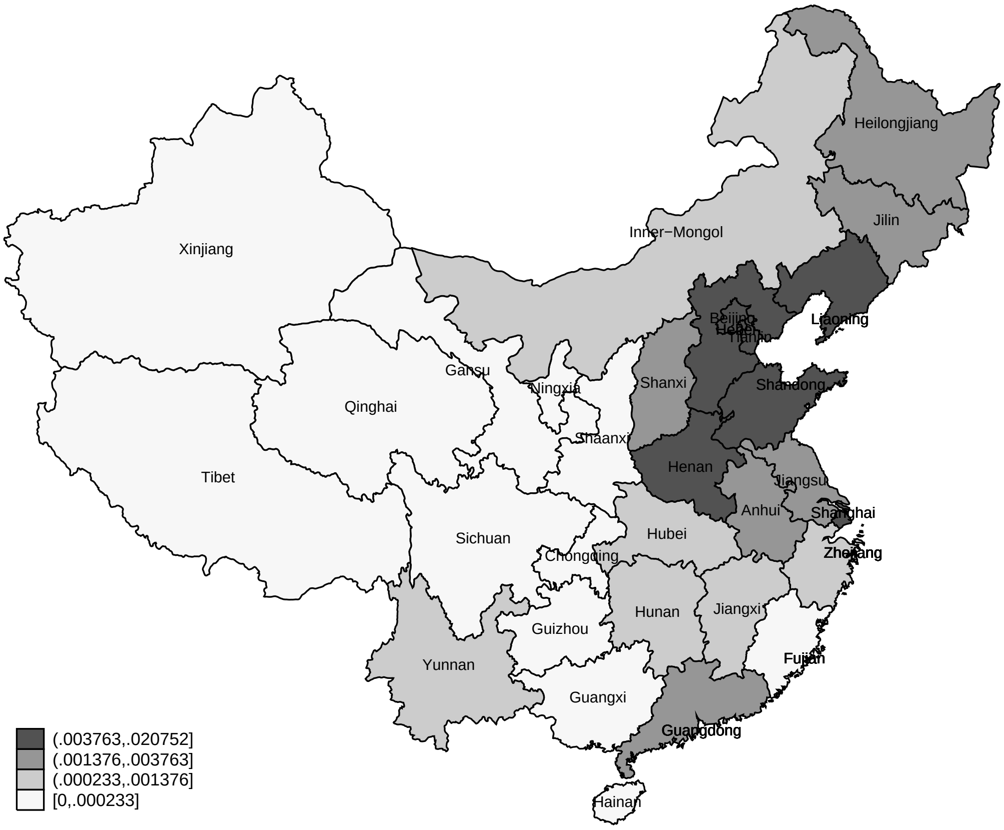


Source: National Bureau of Statistics of China (NBSC).

It is not easy to gather information for various historical endowments. Fortunately, the identities of treaty ports can provide rich information describing the differing levels of historical endowments cities contain. Generally,

Ma (1983), it is possible to obtain the total lengths of railroads that existed in 1911, which this study then assigns to each province according to contemporary provincial boundaries provided by *Google Maps* for the calculation of the historical railway density variable. In the calculation, this study eliminates the spur lines that were reported as dismantled, where the various reasons for the dismantling are discussed in Ma (1983).

Fig. 6.2: Railway Density (1911)



Source: Ma (1983).

treaty ports were Chinese territories that were forced to open up to foreign trade during the late Qing Dynasty (1842–1911) by unequal treaties imposed by the westerners, for example, the British, the French, the American and the German. The majority of treaty ports were seaports and became famous metropolitan centres in the 20th century such as Hong Kong, Shanghai and Guangzhou.

In the literature, e.g. Jia (2012), researchers use an indicator, i.e. treaty port, to proxy for an aggregated historical endowment of a particular prefecture. This is because, first, accurate Chinese historical data at prefecture or county level are never easy to collect; second, it is reasonable to believe that a treaty-port membership implies multi-dimensional attributes which determine a region's modern-time economic development, and ultimately the average individual income level.

Using the difference-in-difference approach, Jia (2012) points out that population as a key measure of economic development grew around 30 percent faster in treaty ports which were opened up to international markets after the First Opium War (1840) than the rest of regions that were not opened up during the second half of the 19th century. Furthermore, the effect from historical endowments, though often unobservable, plays a pivotal role in long-run economic growth. Findings from Jia (2012) show that treaty ports were among the first to integrate with international markets and took advantage of globalisation opportunities post to China's 'Open Door' policy implemented from 1978. On average, the growth rate of GDP per capita in treaty ports was 35 percent higher than in surrounding regions that were not forced to opened up to foreign trade after the First Opium War (1840), over the period 1988–2007 (Jia, 2012).

This chapter emphasises the importance of the inclusion of historical endowments in the estimation of wage differentials between treaty ports and other cities. This is because they not only contribute information to contemporary size of population and GDP per capita growth by prefecture (city), but also because they have implications for the quality of institutions among Chinese cities, which in turn could drive economic divergence (Fang and Zhao, 2009). Fang and Zhao (2009) find that treaty ports are normally better in the sense of both economic growth and institutions. These institutions, i.e. social rules that protect property rights, can be interpreted as municipal authorities, police, and judiciaries established by westerners during the 1850s to the 1910s in treaty ports. Although one may argue about how tight the links between the 'western' institutions and today's Chinese socialism are, empirical findings from Fang and Zhao (2009) reveal that the large influence of the western institutions on China's transition from antiquity (prior to 1911) to modernity (1911 onwards) well explains contemporary institutional differentials among Chinese cities. This study therefore carefully controls for these historical endowments, proxied by an indicator for treaty ports, in the sensitivity tests to partial out unobservable confounding effects.

3. Data and Methodology

3.1 Data

This chapter utilises individual information from the urban samples in the China Household Income Project Survey (CHIPS, 2002), covering 20,632 individuals and 6,835 households from 77 cities in 12 provinces.[126] Excluding those areas that do not have complete city-level information, the empirical analysis focuses on 63 cities and 7,979 urban wage earners aged from 18 to 60 whose personal characteristics of interest are not missing.[127] In order to visualise the geographical distribution of locations analysed in this chapter, Figure 6.3 plots all sampled areas.

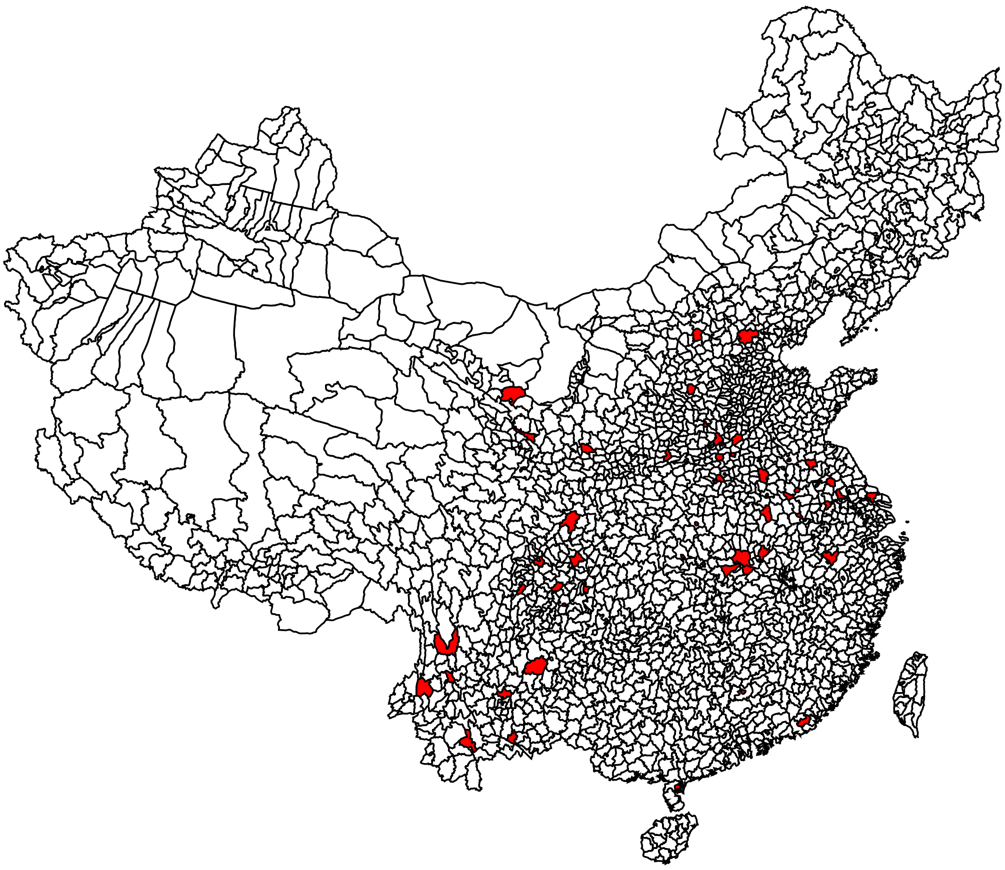
The dependent variable is the logarithm of individual hourly wage (lnW). In CHIPS (2002), individuals report their nominal annual income which consists of regular salaries, bonuses and subsidies (including housing, medical, child care and various regional subsidies). Following Hering and Poncet (2010), this study defines the hourly wage as total income per working hour. The actual working hours are obtained based on the number of claimed work days per month along with the number of working hours per day by individuals.[128] The causal variable of interest is the accessibility to international markets proxied by the logarithm of length of transport routes from a sampled location to its nearest major seaport (lnD). The three major seaports are Tianjin, Shanghai and Guangzhou located in the north-east, east and south-east, respectively. This study measures the transport routes as the shortest length of transport routes including railroads and highways which

[126] These provinces (includes municipalities) are: Beijing, Shanxi, Liaoning, Jiangsu, Anhui, Henan, Hubei, Hunan, Guangdong, Chongqing, Sichuan, Yunnan and Gansu. Note that this chapter employs a broader definition of *city* which includes counties from the urban samples in CHIPS (2002) following Hering and Poncet (2010) and Kamal et al. (2012).

[127] This chapter only looks at urban samples. For the sake of simplicity, the remaining sections refer to individual wages of urban wage earners as ‘individual wages’.

[128] Note that this study has excluded the number of days that workers are unemployed.

Fig. 6.3: Map of Sampled Areas



Source: China Household Income Project Survey (CHIPS, 2002) and National Bureau of Statistics of China (NBSC).

are provided by *Google Maps*.[129] The summary statistics and definitions of full variables are provided in Table 6.1 and Table 6.8.

[129] For remote counties and small cities that are located far from local business centres (provincial capitals), this study measures their accessibility to international markets as follows. First, the shortest highway route connecting the origin city and its provincial capital is recorded. Second, the shortest railway route connecting its provincial capital and one of the three major seaports is recorded. Last, the summation of the above two records is used as the distance to international markets for a remote location.

Tab. 6.1: Summary Statistics

Variables	Obs	Mean	SD	Min.	Max.
	Individual Characteristics				
log of hourly wage	7,979	1.49	0.71	-2.52	4.92
age	7,979	40.39	8.9	18	60
age^2	7,979	1,710.96	709.99	324	3,600
experience	7,979	20.07	9.54	0	41
male	7,979	0.56	0.50	0	1
schooling	7,979	11.46	3.01	0	23
communist party member	7,979	0.29	0.45	0	1
ethnic minority	7,979	0.04	0.20	0	1
	City Characteristics				
access to international markets	63	6.58	1.04	4.60	7.90
elevation	63	408.48	653.12	4	2395
slope	63	0.03	0.03	0.0003	0.12
latitude	63	32.23	5.17	21.2	41.12
longitude	63	110.92	11.90	29.58	121.14
population density (2001)	63	1.00	0.83	0.05	4.13
administrative level	63	0.24	0.43	0	1
autonomous regions	63	0.05	0.22	0	1
skill intensity	63	0.84	0.37	0	1
treaty ports	63	0.13	0.34	0	1
log of population (1953)	63	12.77	1.15	9.71	14.83
population growth (1953–1964)	63	0.04	0.04	-0.02	0.19
	Instrumental Variables				
population density along routes (sd)	63	104.45	76.78	13.93	293.47
population density along routes (max.)	63	409.95	263.44	102.3	874.1
population density along routes (min.)	63	102.51	104.06	10.4	531.7
population density along routes (max./min.)	63	6.40	4.53	1.15	20.34

Note: The definitions of variables are provided in Table 6.8.

3.2 Methodology

The empirical model investigates the causal impact of access to international markets on the hourly wage for individual i from city j in province k as follows,

$$lnW_{ijk} = c + \phi lnD_{ijk} + \gamma' x_{ijk} + \beta' z_{jk} + u_{ijk} \quad (6.1)$$

The parameter c denotes the common intercept term across all individuals. lnW_{ijk} and lnD_{ijk} are the dependent and independent variables respectively. u_{ijk} is the disturbance. The causal effect of lnD_{ijk} on lnW_{ijk}, i.e. ϕ, explains to what extent the accessibility to international markets, as measured by length of current transport routes from the origin city to its nearest major seaport, could affect individual wages. Considering omitted variables that are correlated with individual wages, this study thus controls for two sets of covariates.

The first set of covariates (x_{ijk}) aims to pin down the unobserved individual heterogeneity. Following the Mincer (1974) wage equation, this study includes the information of individual age (including its square), working experience, gender and years of schooling in the empirical model. Additionally, as Li et al. (2007) among others point out, the identity of the Communist Party member could have an impact on income,[130] and this chapter considers a binary indicator which is equal to unity if an individual is a member of the Chinese Communist Party. Given the fact that cultural and linguistic background could potentially affect income (see Gustafsson and Li, 2003; Gustafsson and Ding, 2009; Li and Ding, 2009), it is worth identifying whether an individual belongs to a minor ethnic group according to the official classification.[131] Following the literature (Zhao, 2002; Chen et al., 2005; Hering and Poncet, 2010), this chapter employs various indicators to partial out multi-dimensional fixed effects, for instance, sectoral categories, firms' ownerships, individual occupations and provincial unobservables.[132]

[130] The positive selection effect of the Party membership exists at least for the older generation. Thus, the membership of the Communist Party is employed in the covariates as a safeguard.

[131] The latest population census (2010) reports that the proportion of *Han*, the only major ethnic group, is 91.51 percent (National Bureau of Statistics China, 2011). The remaining 55 groups are officially defined as minor ethnic groups in China.

[132] All fixed effects are captured by dummy variables. See Table 8.6 and Table 8.7 in Appendix D for detailed classifications.

The second set of covariates is denoted by the vector z_{jk}, which consists of cities' attributes. The heterogeneous geographical and topographical conditions of locations are possibly associated with household income and consumption (Hering and Poncet, 2010; Hou and Emran, 2012), therefore, this chapter controls for these confounding factors such as elevation, slope, latitude and longitude of each sampled city.[133] Moreover, the vector z_{jk} includes other characteristics of cities, for instance, current population density, administrative level and autonomous status, as they may be correlated with both individual wages and instrumental variables.[134] Omitting current population density is dangerous, because it is closely linked with historical population that is used to construct the instrumental variables used in the analysis. In other words, the failure to partial out this confounding effect invalidates the exclusion restriction that requires instruments to be uncorrelated with omitted variables. In addition, administrative level is important. It in part denotes the political ranking of a city within a province, which may determine the priority of development in the Chinese political hierarchy hence local income level. Meanwhile, it to some extent implies the historical development of a location, which may be influenced by the population density in the 1820s. Last, autonomous status[135] is included as it captures fundamental features of ethnically minor counties that are culturally and linguistically distinct from major Chinese *Han* regions.

Furthermore, the inclusion of cities' characteristics purges the potential impact of access to domestic markets on individual wages.[136] In practice, it is not easy to measure the influences from domestic markets. Some studies like Hering and Poncet (2010) and Kamal et al. (2012) have defined access to domestic markets. They first compute market capacity for a province

[133] These data are collected from `http://www.heavens-above.com`. See Table 6.8 for detailed definitions.

[134] This study also takes current labour market structure, historical endowments, and initial population into account in the robustness checks.

[135] Counties where minor ethnic groups are major residents may be officially designated as autonomous counties.

[136] For instance, this study controls for a city's population density in 2001 which is correlated with its consumption potential. Moreover, this study includes a city's latitude and longitude to pin down its relative location. The consumption potential and location information can help to reduce the potential spill-over effects from domestic markets.

according to inter-province input-output tables, and then allocate it to each city within the province by the GDP share of each constituent city. Alternatively, Hou and Emran (2012) define access to domestic markets as the distance from each rural household to the nearest local business centre which most likely is a provincial capital. In this chapter, the potential confounding effect of surrounding domestic markets has been pinned down by the inclusion of cities' attributes, for instance, geographical location, i.e. latitude and longitude. Even if the geographical location *per se* fails to capture a large share of spill-over effects from domestic markets nearby, the additional control variables, like local population density, ranking of political hierarchy and administrative status, can serve as a multi-dimensional indicator to mimic a city's accessibility to domestic markets.

3.3 Instrumental Variables

Even if the issue of omitted variables is carefully taken care of by ruling out city-level and province-level time-invariant heterogeneity, OLS estimates could still be inconsistent due to the endogeneity problems. This is because, first of all, individuals (or households) choose the place to live based on their own abilities which affect their earning potential. This is usually unobserved but may affect individual income. Second, China's transportation infrastructure developed unevenly across regions during 1978–2006 (Chen and Yao, 2011). Intuitively, the distribution of highways and railroads is rarely random, and it is likely to be positively associated with abundant natural endowments, higher income levels and future development potential. To mitigate the potential bias in OLS estimates which cannot purge out all city-level unobservables, this chapter proposes a new identification strategy, which uses the historical population density along the route that connects each origin city and its nearest large seaport as instruments.

The historical population should not violate the exclusion restriction, otherwise it becomes a problematic instrument for at least two reasons. First, the literature has shown that the population level and distribution are affected by the presence of railroads in the past (Atack et al., 2009; Donaldson, 2010). Second, for the case of China, Kung and Li (2011) find that railways facilitated migration from the North China Plain (north) to Manchuria (north-east) in the early 1900s, which confirms that the historical distribution of population could have been influenced by the development of initial railway system. In this regard, using historical population as an instrument in the context of China is possible in principle but formidably challenging in practice, as this requires the information from the early 1800s, a period for which accurate prefecture-level population data are extremely rare. After a venture into history, the author chooses to use data from Cao (2000) which offers detailed population information for each prefecture in 1820. The novel dataset allows the construction of a set of instrumental variables consisting of four components — the standard deviation, maximum, minimum, and ratio of the maximum over the minimum of prefecture-level population density along the transport routes that link the origin cities with their nearest major seaports.[137]

There may remain a concern about the exogeneity of the instruments, and one may question why this study does not use historical county-level population information which seems to be more accurate in this case. The responses to the above two concerns are as follows. First, it is better to let the data speak. The first-stage results reported in section 4.3 show that the instruments are sharp and robust. Second, countless changes of administrative boundaries during the last two centuries make it almost impossible to use historical county-level population information as instruments. In contrast, most boundaries of prefectures remain constant in their administrative areas (Cao, 2000), facilitating the attempt to construct historical instruments in this study.

To sum up, having carefully considered other possible channels relating historical population to contemporary economic activities, this chapter seeks to use the heterogeneity of inter-prefecture population to generate the exogenous variation in accessibility to international markets which is proxied by length of transport routes connecting a city to its nearest major seaport.

[137] Summary statistics are available in Table 6.1.

4. Empirical Results

4.1 OLS Estimates

Table 6.2 summarises the compressed results from the OLS regressions. At first glance, the OLS estimates reveal that being far from international markets could significantly lower individual wages as column (1) shows. However, ignoring individual characteristics and city-level fixed effects, the OLS estimate tends to overemphasise the effect of *access to international markets* on individual wages. This effect attenuates to less than half when province fixed effects are included in column (2), suggesting that regional heterogeneity is crucial in explaining China's inter-regional wage differentials. Alternatively, one may interpret the importance of the inclusion of province fixed effects by looking at the R^2 in column (2) that solely explains around 6 percent of variations in urban wages.[138] In column (3), the estimation examines how individual heterogeneity affects wages. Surprisingly, the effect of accessibility to international markets on wages tapers off to almost zero and becomes statistically insignificant, which confirms that neglecting individual attributes may cause serious omitted variable bias. Moreover, the R^2 reported in column (3) shows that individual characteristics explain two more percentage points of total variations in wages than province dummies do.[139] Last, column (4) shows zero and insignificant impacts of *access to international markets* on individual wages when city characteristics and province dummies are considered only.

As the effect of access to international markets on urban wages becomes statistically insignificant and quantitatively small in the baseline OLS estimation (column (4) of Table 6.2), further investigation intends to control for more covariates to eliminate biases due to omitted variables. Table 6.3 looks at the suitability of the OLS estimations with the inclusion of both

[138] It is derived from the exclusion of the 5 percent of variation which is explained by *access to international markets* in column (1).

[139] The explained fraction of wages variation by individual attributes is 13 percent. This is derived from $0.29 - 0.11 - 0.05 = 0.13$.

Tab. 6.2: OLS Regressions 1

	(1)	(2)	(3)	(4)
	Dependent Variable: *log of hourly wage*			
access to international markets	-0.158***	-0.062**	-0.029	0.009
	(0.008)	(0.030)	(0.027)	(0.034)
Individual characteristics included?	No	No	Yes	No
City characteristics included?	No	No	No	Yes
Province dummies included?	No	Yes	Yes	Yes
Observations	7,979	7,979	7,979	7,979
R-squared	0.05	0.11	0.29	0.13

Note: The numbers in parentheses are robust standard errors. The definitions of variables are provided in Table 6.8.

individual characteristics and regional heterogeneity. As shown in columns (1) to (5), all coefficients of individual attributes show reasonable signs. For instance, the impact of age on wages is concave. Male urban wage earners tend to have an advantage compared to female urban wage earners in the Chinese labour market. Schooling, not surprisingly, plays an important role in determining individual wages. The results in Table 6.3 are consistent with the finding in Li et al. (2007) that being a Chinese Communist Party member is positively correlated with higher wages. But no significant evidence is found to support the argument that ethnic minorities suffer from lower wages. However, for the variable of interest, *access to international markets*, the OLS regressions show unexpected signs and insignificant coefficients, even after multi-dimensional fixed effects are soaked up by ownership, occupation and sector dummies in column (5). In other words, the inclusion of more covariates cannot easily ameliorate the omitted variables bias. Therefore, given the confidence that OLS estimates are troublesome, this study employs 2SLS regressions in the following discussions.

Tab. 6.3: OLS Regressions 2

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: *log of hourly wage*				
access to international markets	0.023	0.015	0.011	0.018	0.008
	(0.031)	(0.029)	(0.029)	(0.029)	(0.028)
	Individual Characteristics				
age	0.048***	0.053***	0.050***	0.052***	0.056***
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
age^2	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
experience	0.016***	0.013***	0.011***	0.013***	0.010***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
male	0.113***	0.119***	0.090***	0.103***	0.085***
	(0.014)	(0.013)	(0.014)	(0.013)	(0.013)
schooling	0.072***	0.055***	0.045***	0.050***	0.034***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)
communist party member	0.162***	0.114***	0.094***	0.125***	0.079***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
ethnic minority	-0.056*	-0.050	-0.035	-0.051	-0.044
	(0.033)	(0.034)	(0.032)	(0.032)	(0.032)
	City Characteristics				
elevation	0.000***	0.000**	0.000***	0.000***	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
slope	0.202	0.709	-0.091	0.594	0.759
	(0.964)	(0.932)	(0.925)	(0.907)	(0.887)
latitude	-0.047***	-0.035***	-0.044***	-0.050***	-0.041***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
longitude	-0.001	-0.000	-0.002*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
population density (2001)	0.026**	0.027**	0.018*	0.036***	0.026**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
administrative level	-0.146***	-0.113***	-0.162***	-0.177***	-0.149***
	(0.026)	(0.025)	(0.025)	(0.024)	(0.024)
autonomous regions	0.237***	0.264***	0.233***	0.236***	0.236***
	(0.049)	(0.048)	(0.047)	(0.047)	(0.046)
Province dummies included?	Yes	Yes	Yes	Yes	Yes
Ownership dummies included?	No	Yes	No	No	Yes
Occupation dummies included?	No	No	Yes	No	Yes
Sector dummies included?	No	No	No	Yes	Yes
Observations	7,979	7,979	7,979	7,979	7,979
R-squared	0.30	0.36	0.35	0.36	0.41

Note: The numbers in parentheses are robust standard errors. The definitions of variables are provided in Table 6.8.

4.2 2SLS Estimates

Using the same covariates from Table 6.3, Table 6.4 reports the 2SLS estimates employing historical population information as instruments. Unlike the OLS estimates which are statistically insignificant and quantitatively close to zero, the 2SLS estimates paint a different picture, indicating a significantly negative causal impact of access to international markets on individual wages.

Generally, the causal effects become stronger with the increase in the number of multi-dimensional fixed effects considered in columns (1) to (5), implying the presence of heterogeneity among urban wage earners in China. This result is consistent with the findings in Hering and Poncet (2010) who underline the within-province heterogeneous effects on individual wages. Interestingly, Table 6.4 reports similar coefficients of all regressors but the independent variable compared with that which have been found in Table 6.3, suggesting the endogeneity of *access to international markets*.

Using the estimate in column (5) as a benchmark, one can interpret that every 1 percent increase in distance from the origin city to the international market (i.e. the nearest seaport), *ceteris paribus*, has a negative impact on individual wages of 0.086 percent. The effect is smaller than that found by Hering and Poncet (2010) who report 0.136 as the elasticity of market access derived from a similar wage equation controlling for the same fixed effects.[140] This may be because this study uses transport routes as a proxy only for access to international markets,[141] while Hering and Poncet (2010) derive the indicator for both access to domestic and international markets from an NEG model.[142] Although the findings in this chapter and in Hering

[140] See column (5) in Table 1 in Hering and Poncet (2010).

[141] The effects of domestic markets are probably ruled out by controlling for detailed city attributes including population density and administrative level, among others.

[142] Since this study does not estimate the same causal effect as Hering and Poncet (2010), it is hard to say that this study underestimates the impact of accessibility to international markets on individual wages in urban China. Moreover, even though this chapter estimates a broader concept of market access, the estimates could still be smaller than those in Hering and Poncet for two reasons. First, this chapter has carefully controlled for cities' characteristics in the wage equation but Hering and Poncet have not. Comparing R^2s in Table 6.4 with those in Table 1 in Hering and Poncet (2010), one can see that the variation in individual wages explained in this chapter on average is twice as much as that which has been explained in Hering and Poncet. Second, as Hering and Poncet have used CHIPS (1995) data, the smaller estimates this chapter reports could perhaps be the consequence of a convergence of economic returns to market access, which indicates that a catch-up effect occurred in inland China during 1995–2002.

and Poncet (2010) are not directly comparable, their results considered as a benchmark imply that at first pass the results of this study do not fall within an unreasonable range.

As a model-based assessment of instrument validity, this study employs the overidentifying restrictions test.[143] The Hansen J tests in Table 6.4 all well exceed 0.1 thus one cannot reject the null hypothesis, indicating that there is no evidence that the quantitatively significant estimates this study finds above are an unintended consequence of model misspecification and questionable instruments validity. Besides, this chapter also reports the Kleibergen and Paap (KP) (2006) Wald statistic for evidence on instrument weakness.[144] As clearly shown in Table 6.4, all KP Wald statistics are sufficiently large so that it is not necessary to worry about the issue of weak instruments. To provide further evidence, Table 6.5 offers the first stage results where the overall F-statistics are also large enough to avoid standard weak instruments.

4.3 Robustness Checks

Using historical instruments in empirical studies is challenging, as they are likely to be correlated with omitted determinants of individual wages. For the sake of robustness, this section offers two sets of sensitivity tests, responding to those concerns that first, instrumental variables may be associated with macro-level unobservables and second, the causal effect found in section 4.2 may be driven by extreme values.

Table 6.6 reports the first set of robustness checks aiming to partial out other channels through which historical population density could potentially affect individual wages. Following Hering and Poncet (2010), the first robust-

[143] Rejecting the test implies that one or more instruments are invalid, or the model is misspecified, or both. But it does not distinguish which condition or if both conditions are violated.

[144] The KP statistic is evaluated against a critical value, adopted from Stock and Yogo (2005), that 10 percent is the maximum rejection rate the researcher is willing to tolerate if the true rejection rate is 5 percent. This follows from the suggestion of Stock et al. (2002).

Tab. 6.4: 2SLS Regressions (Second Stage)

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: *log of hourly wage*				
access to international markets	-0.066*	-0.065*	-0.078**	-0.081**	-0.086***
	(0.035)	(0.033)	(0.034)	(0.034)	(0.033)
	Individual Characteristics				
age	0.049***	0.054***	0.050***	0.053***	0.057***
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
age^2	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
experience	0.016***	0.013***	0.011***	0.013***	0.010***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
male	0.113***	0.119***	0.090***	0.103***	0.085***
	(0.014)	(0.013)	(0.014)	(0.013)	(0.013)
schooling	0.072***	0.055***	0.045***	0.050***	0.034***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)
communist party member	0.164***	0.115***	0.095***	0.126***	0.079***
	(0.015)	(0.015)	(0.015)	(0.014)	(0.014)
ethnic minority	-0.056*	-0.050	-0.034	-0.051	-0.044
	(0.033)	(0.034)	(0.032)	(0.032)	(0.032)
	City Characteristics				
elevation	0.000***	0.000**	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
slope	-0.649	-0.062	-0.934	-0.335	-0.133
	(0.977)	(0.943)	(0.935)	(0.917)	(0.896)
latitude	-0.038***	-0.027***	-0.034***	-0.040***	-0.031***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
longitude	-0.002	-0.000	-0.002**	-0.002*	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
population density (2001)	0.027**	0.028**	0.019*	0.037***	0.027**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
administrative level	-0.137***	-0.106***	-0.153***	-0.167***	-0.140***
	(0.026)	(0.025)	(0.025)	(0.025)	(0.024)
autonomous regions	0.231***	0.259***	0.226***	0.229***	0.229***
	(0.049)	(0.048)	(0.047)	(0.047)	(0.046)
Province dummies included?	Yes	Yes	Yes	Yes	Yes
Ownership dummy included?	No	Yes	No	No	Yes
Occupation dummy included?	No	No	Yes	No	Yes
Sector dummy included?	No	No	No	Yes	Yes
Weak IV	641.99	634.60	643.88	643.86	630.16
Hansen J	0.58	0.46	0.75	0.75	0.85
Observations	7,979	7,979	7,979	7,979	7,979
R-squared	0.30	0.35	0.35	0.37	0.40

Note: The numbers in parentheses are robust standard errors. *Weak IV* reports the Kleibergen-Paap Wald statistic. *Hansen J* reports the p-value for the overidentifying restriction test. The definitions of variables are provided in Table 6.8.

Tab. 6.5: 2SLS Regressions (First Stage)

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: *access to international markets*				
population density along routes (sd)	-0.020***	-0.020***	-0.020***	-0.020***	-0.020***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (min.)	-0.007***	-0.007***	-0.007***	-0.007***	-0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (max.)	0.008***	0.008***	0.008***	0.008***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (max./min.)	0.014***	0.014***	0.014***	0.014***	0.014***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Individual characteristics included?	Yes	Yes	Yes	Yes	Yes
City characteristics included?	Yes	Yes	Yes	Yes	Yes
Province dummies included?	Yes	Yes	Yes	Yes	Yes
Ownership dummies included?	No	Yes	No	No	Yes
Occupation dummies included?	No	No	Yes	No	Yes
Sector dummies included?	No	No	No	Yes	Yes
First-stage F-statistic	3.6×10^5	2.1×10^5	2.4×10^5	1.9×10^5	1.1×10^5
Observations	7,979	7,979	7,979	7,979	7,979

Note: The numbers in parentheses are robust standard errors. *F-statistic* reports the F-statistic for the overall significance of the first stage regressors. The definitions of variables are provided in Table 6.8.

ness check includes city-level skill intensity which implies the accumulation of local human capital. The indicator, *skill intensity*, is defined as the proportion of the adult total labour force in the CHIPS (2002) that had completed at least nine years of schooling.[145] Accounting for skill intensity, this chapter finds that the coefficient of *access to international markets* remains statistically significant but quantitatively smaller than in column (5) of Table 6.4. The shrink in the magnitude of the effect is possibly due to external returns to schooling[146] in Chinese cities as indicated in Liu (2007).[147]

The second robustness check looks at the inclusion of historical endowments proxied by a binary indicator which is equal to unity if a city was assigned to be a treaty port during the late 1800s.[148] Treaty ports generally developed better, because the westerners established municipal authorities, police, judiciaries, manufacturing, and infrastructure in these cities (Banerjee et al., 2012; Jia, 2012). Along with the 'better' institutions and earlier industrialisation, the accessibility to railroads may facilitate the economic prosperity in the majority of treaty ports, which could confound the effect of *access to international markets* on wages.[149] However, column (2) shows that being a treaty port does not significantly raise individual wages given that all other factors are carefully controlled for.[150] More importantly, the effect of *access to international markets* on wages is the same as column (5) of Table 6.4, suggesting that the 2SLS estimates are tight and robust.

The final two robustness checks focus on the impact of the size of city-level

[145] Nine years of schooling is equivalent to the completion of junior high school in China.

[146] External returns to schooling are the economic gains from the sharing of knowledge among workers. The key assumption is that a worker will gain a wage premium with the increase in the average level of schooling of his group (e.g. firm level, sectoral level and city level, among others).

[147] Using CHIPS (1988 and 1995), Liu (2007) finds a one-year increase in city average education could increase individual earnings by between 11 and 13 percent, which indicates the presence of external returns to schooling among Chinese cities.

[148] Relevant information is obtained from Jia (2012).

[149] Note that even though prefecture population in 1820 used in this chapter is not determined by the status of treaty port after the First Opium War (1840), historical population still could be correlated with unobservables that raise the likelihood of being a treaty port.

[150] Jia (2012) analyses 57 treaty ports and finds a positive relationship between being a treaty port and contemporary income over the period 1987–2007. In this study, only eight sampled cities were treaty ports in the late 1800s.

population in 1953 and the early average rate of population growth during 1953–1964.[151] It is possible that historical population is correlated with initial population and its growth, although the population density in 2001 has been considered in equation (6.1). Therefore, one may argue that the instrumental variables violate the exclusion restriction in a 2SLS estimation. But, as columns (3) and (4) of Table 6.6 have shown, the coefficients of *access to international markets* neither attenuate to zero nor become statistically insignificant, which indicates that the historical instruments are not invalid. The coefficients herein are similar to the baseline result in column (5) of Table 6.4, implying that the inclusion of early status and growth of population does not confound the explanatory power of the instruments.[152] Furthermore, only the initial size of population in 1953 raises wages in 2002 but not the early growth rate of population.

Although the omitted variables problem has been carefully examined in Table 6.6, one may still be worried about the possibility that extreme values can bias estimates. To this end, Table 6.7 provides a further test to evaluate the sensitivity of the baseline 2SLS estimates to the exclusion of extreme values in both dependent and independent variables. Columns (1) and (2) show that the coefficients of *access to international markets* remain unchanged compared with the result reported in column (5) of Table 6.4, excluding the top and bottom 10 percent urban wage earners in the baseline model. This finding is crucial as it indicates that the causal effect revealed in the 2SLS estimation is neither driven by the highest income nor the lowest income group. Furthermore, Table 6.7 examines how the exclusion of the nearest and farthest urban wage earners in terms of routes distance from one's location to the nearest major seaport affects the 2SLS estimates, which is motivated by Banerjee et al. (2012). As one can see in columns (3) and (4), the coefficients of interest are still significant, although their magnitude departs from the baseline result in column (5) of Table

[151] This is because 1953 and 1964 are the two population censuses after 1949 when the People's Republic of China was founded. County-level population information is provided by National Bureau of Statistics China (1988) in which the first and second population census (1953 and 1964 respectively) data are available.

[152] This is further confirmed by the first stage results listed in columns (3) and (4).

Tab. 6.6: Robustness Checks

	(1)	(2)	(3)	(4)
	Dependent Variable: *log of hourly wage*			
access to international markets	-0.059*	-0.086***	-0.073**	-0.079**
	(0.032)	(0.033)	(0.032)	(0.033)
skill intensity	0.180***			
	(0.063)			
treaty ports		-0.016		
		(0.024)		
log of population (1953)			0.064***	
			(0.010)	
population growth (1953–1964)				-0.331
				(0.294)
	Dependent Variable: *access to international markets*			
population density along routes (sd)	-0.020***	-0.019***	-0.020***	-0.019***
	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (min.)	-0.007***	-0.007***	-0.007***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (max.)	0.008***	0.008***	0.008***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (max./min.)	0.014***	0.011***	0.017***	0.023***
	(0.000)	(0.002)	(0.002)	(0.002)
skill intensity	0.442***			
	(0.028)			
treaty ports		0.091***		
		(0.008)		
log of population (1953)			0.051***	
			(0.003)	
population growth (1953–1964)				1.018***
				(0.084)
First-stage F-statistic	60,221.69	1.1×10^5	1.5×10^5	94,462.59
Weak IV	1,271.99	662.41	635.24	668.18
Hansen J	0.52	0.84	0.68	0.93
Observations	7,979	7,979	7,979	7,979
R-squared	0.41	0.40	0.41	0.40

Note: All estimations include individual and city-level characteristics, province dummies, ownership dummies, occupation dummies and sector dummies. The numbers in parentheses are robust standard errors. *First-stage F-statistic* reports the F-statistic for the overall significance of the first stage regressors. *Weak IV* reports the Kleibergen-Paap Wald statistic. *Hansen J* reports the p-value for the overidentifying restriction test. The definitions of variables are provided in Table 6.8.

Tab. 6.7: Sample Sensitivity Tests

	(1)	(2)	(3)	(4)
	Wage		Distance	
Omitted samples	Highest	Lowest	Farthest	Nearest
	Dependent Variable: *log of hourly wage*			
access to international markets	-0.081***	-0.074***	-0.067*	-0.167***
	(0.031)	(0.0289)	(0.039)	(0.041)
	Dependent Variable: *access to international markets*			
population density along routes (sd)	-0.020***	-0.021***	-0.019***	-0.015***
	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (min.)	-0.006***	-0.007***	-0.006***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (max.)	0.008***	0.008***	0.007***	0.006***
	(0.000)	(0.000)	(0.000)	(0.000)
population density along routes (max./min.)	0.014***	0.014***	0.031***	0.001
	(0.000)	(0.002)	(0.002)	(0.001)
First-stage F-statistic	681,696.17	1.0×10^5	1.8×10^5	44138.81
Weak IV	550.46	574.06	824.62	623.66
Hansen J	0.20	0.72	0.75	0.08
Observations	7,182	7,181	7,292	6,951
R-squared	0.39	0.35	0.41	0.37

Note: Columns (1) and (2) exclude the top 10 percent and bottom 10 percent wage earners respectively. Columns (3) and (4) exclude the farthest 10 percent and nearest 10 percent inhabitants respectively. All estimations include individual and city-level characteristics, province dummies, ownership dummies, occupation dummies and sector dummies. The numbers in parentheses are robust standard errors. *First-stage* reports the F-statistic for the overall significance of the first stage regressors. *Weak IV* reports the Kleibergen-Paap Wald statistic. *Hansen J* reports the p-value for the overidentifying restriction test. The definitions of variables are provided in Table 6.8.

6.4. The interpretation is two-fold. Firstly, the significant results again suggest the 2SLS estimates are robust and reliable. Secondly, on the one hand, not accounting for the farthest urban wage earners tends to weaken the effect of access to international markets on wages, on the other hand, excluding the nearest urban wage earners strengthens this effect. Overall, the differential magnitude of these impacts complements the basic average estimates in Table 6.4, which contributes to a comprehensive understanding of the heterogeneous effect of being located far from international markets. In sum, the results presented in Table 6.7 confirm the robustness of the baseline 2SLS estimates.

5. Conclusion

Focusing on urban China, this chapter proposes a new identification strategy that uses heterogeneity of inter-prefecture population density in 1820 to identify the effect of accessibility to international markets on individual wages in urban China. It finds that the length of contemporary transport routes connecting the origin city and its nearest major seaport is strongly influenced by differentials in historical population density, which suggests that the set of instruments this study constructs successfully captures independent variation in access to international markets. Using these instruments, this chapter finds that every 1 percent increase in length of current transport routes from the origin city to international markets (i.e. the nearest seaport), *ceteris paribus*, has a negative impact on individual wages of 0.086 percent. An alternative interpretation could be that every 1 percent reduction of length of transport routes from the origin city to its nearest seaport can raise individual wages by 0.086 percent. This causal effect is robust to the inclusion of a large number of additional control variables such as current labour market structure, historical factor endowments, and initial population development, to running separate regressions that exclude the 10 percent highest-income and lowest-income urban wage earners respectively, and to running separate regressions that get rid of the 10 percent nearest and farthest urban wage earners in terms of routes distance from one's location to the nearest major seaport respectively.

This chapter makes two contributions. First, it explores the research area of using historical information as instrumental variables to mitigate endogeneity problems of contemporary variables. The effort of providing new historical instruments is related to the work in Banerjee et al. (2012) and Chapter 4. Although this is not the first attempt to employ historical information as instrumental variables, it is one of the pioneering studies that use this approach to identify causal effects in the area of China's economic development.

Second, the main finding confirms that the accessibility to international markets has significant and heterogeneous effects on individual wages among Chinese cities. Relating to Chapters 3 and 4 that confirm the contributions of the improvement of transportation infrastructure to short-run and long-run economic growth using provincial data, this chapter provides some micro-level evidence that the heterogeneity of transportation infrastructure, i.e. the varying length of transport routes connecting the origin city and its nearest major seaport, may result in income disparities in urban areas.

This chapter also has important policy implications. While Chapters 3 and 4 have pointed out the 'positive' effect of improving transportation infrastructure which can raise regional economic growth, this chapter reveals the 'negative' effect that it may widen the wage gap between urban wage earners. The presence of the negative effect indicates the drawback of a policy that focuses on raising investment in transportation infrastructure. Therefore, policy-makers should realise that reducing wage inequality in urban China while maintaining high rates of regional economic growth could be difficult to manage. A possible solution may require complementary policies that can efficiently deal with the increasing wage inequality among urban wage earners.

Tab. 6.8: List of Variables

Variable	Definition
	Individual Characteristics
log of hourly wage	the logarithm of individual hourly wage
age	age (18-60)
age^2	age squared
experience	the total length of working experience (years)
male	equal to 1 if male
communist party member	equal to 1 if a member of the Chinese Communist Party
ethnic minority	equal to 1 if belongs to a minor ethnic group
	City Characteristics
access to international markets	the logarithm of length of transport routes from a city to its nearest major seaport[1]
elevation	the elevation of a city where an individual is located (metre)
slope	the difference of elevation between a city and its nearest large seaport ÷ the linear distance between the two places
latitude	the latitude of a city where an individual is located
longitude	the longitude of a city where an individual is located
population density (2001)	the total population ÷ total area (1,000 people/km^2)
administrative level	equal to 1 if officially defined as a county, zero if city
autonomous regions	equal to 1 if an autonomous region due to ethnic minority
skill intensity	highly-skilled labour[2]÷total labour
treaty ports	equal to 1 if a historical treaty port post 1840
log of population (1953)	the logarithm of total population in 1953
population growth (1953–1964)	(total population in 1964÷total population in 1953)-1
	Instrumental Variables
population density[3] along routes (sd)	the standard deviation of population density along the route that connects a city to its nearest large seaport
population density along routes (max.)	the maximum value of population density along the route that connects a city to its nearest large seaport
population density along routes (min.)	the minimum value of population density along the route that connects a city to its nearest large seaport
population density along routes (max./min.)	the ratio of the maximum and minimum value of population density along the route that connects a city to its nearest large seaport

Note: [1] 'Major seaports' are defined as Tianjin, Shanghai and Guangzhou. [2] A 'highly-skilled' worker is one who completes nine or more years of education. [3] The population density is defined as total population ÷ total area (people/km^2).

7. CONCLUSION

This research has investigated three causal relationships in China's economic development during 1978–2008, i.e. transportation infrastructure to economic growth, economic growth to urbanisation, and transportation infrastructure to income inequality. This chapter summarises empirical findings from Chapters 3 to 6, outlines key contributions of this thesis, and addresses potential further research.

1. Concluding Remarks

The first question of interest is: "What is the short-run effect of changes in the density of transportation infrastructure on economic growth in China?" Based on provincial panel data over the period 1985 to 2008, Chapter 3 uses the timing of the National Congress of the Communist Party of China to construct 2SLS estimates of within-province effect of changes in the density of transportation infrastructure on GDP growth per capita. Chapter 3 finds that while the OLS estimate is nearly zero, the 2SLS estimate shows that a one standard deviation increase in the density of transportation infrastructure, *ceteris paribus*, has an effect of raising GDP growth per capita by more than 6 percentage points on average. This short-run effect is robust to the inclusion of a large number of additional control variables, to running separate regressions for the coastal and non-coastal regions, and to the use of instruments that still draw information from the National Congress but are constructed in four different ways.

The second question this thesis has looked at is: "What is the long-run impact of changes in the density of transportation infrastructure on economic growth in China?" The quantification of this long-run impact contributes to a better understanding of the role of transportation infrastructure in China's economic growth, which extends the analysis in Chapter 3. In order to mitigate endogenous issues in the analysis, Chapter 4 employs the density of ownership of Chinese guilds, as measured by the number of guilds in the Qing dynasty per 10,000 people, to identify exogenous variation in the initial level of provision of the transportation infrastructure. Using Chinese provincial panel data over the period 1978 to 2008, Chapter 4 shows that the OLS estimates of the effect of changes in the density of transportation infrastructure on economic growth in the long run, i.e.over a 15-year period, are very close to zero. However, the instrumental variable estimates suggest that transportation infrastructure is an important determinant of long-run economic growth, where a one standard deviation increase in the density of the initial level of transport infrastructure is associated with a 1.54 to 2.44 percentage point increase in the long-run economic growth on average. This result is not directly comparable with the magnitude of the short-run effect estimated in Chapter 3, because it captures an average effect of the improvement of initial level of transportation infrastructure on a 15-year average of economic growth rather than an effect of annual changes in transportation infrastructure on yearly economic growth. Furthermore, this strong long-run causal effect of transportation infrastructure is highly robust in a battery of sensitivity tests where four potentially relevant determinants of growth – urbanisation, openness, share of agricultural labour, and share of public sectoral labour – are added into the regression.

The third question that has been addressed in the thesis is: "Does economic growth affect urbanisation?" Using a panel dataset for Chinese provinces during 1985–2008, Chapter 5 proposes a new identification strategy to construct instrumental variable estimates of the within-province effect that GDP growth per capita has on the urbanisation rate. This strategy uses the timing of the National Congress of the Communist Party. Chapter 5 finds that GDP growth per capita is strongly associated with the timing of the National Congress. Using instrumental variables that convey this timing information, 2SLS estimates suggest that economic growth has a statistically significant effect on raising the urbanisation rate. This result is robust not only to the inclusion of a battery of additional controls, i.e. attributes of provincial leaders, government expenditure, labour force composition, agricultural output, urban wage growth, population density and rainfall, but also to the employment of alternative forms of time trend, i.e. national time trend, its quadratic form and quadratic region-specific time trend.

The fourth question that has been investigated in the thesis is: "How does access to international markets affect individual wages?" Chapter 6 proposes a new identification strategy that uses heterogeneity of inter-prefecture population density in 1820 to identify the effect of accessibility to international markets, as proxied by length of transport routes connecting the origin city to its nearest major seaport, on individual wages in urban China. Using China Household Income Project Survey (2002) data, Chapter 6 finds that the length of contemporary transport routes is strongly influenced by differentials in historical population density. Based on 2SLS estimates, Chapter 6 also shows every 1 percent increase in length of transport routes from the origin city to international markets (i.e. accessibility to international markets), *ceteris paribus*, has a negative impact on individual wages of 0.086 percent. An alternative interpretation could be that every 1 percent reduction of length of transport routes from the origin city to its nearest seaport can raise individual wages by 0.086 percent. This indicates the importance of the provision of transportation infrastructure based on micro-level evidence. The causal effect is robust to the inclusion of a host of additional control variables such as current labour market structure, historical factor endowments, and initial population development. The causal effect remains unchanged, when the estimation excludes the 10 percent highest-income and lowest-income urban wage earners respectively, or gets rid of the 10 percent nearest and farthest urban wage earners in terms of distance from one's location to the nearest major seaport respectively.

2. Key Contributions

2.1 Identification Strategies

Methodologically, this thesis contributes to the empirical literature by proposing new identification strategies, using China as a case study. A common problem that occurs in the empirical analysis is endogeneity caused by omitted variables, measurement errors, and reverse causality. The instrumental variables approach, based on China's political cycle and historical information, helps to ameliorate endogeneity biases and achieve identifications in the analysis.

In Chapter 3 and Chapter 5, two major casual relationships, i.e. transportation infrastructure-economic growth and economic growth-urbanisation, which suffer from the reserve causality problem, are analysed. The endogeneity issues become more severe, as this thesis uses data obtained from the National Bureau of Statistics of China (NBSC) which may contain measurement errors (Rawski, 2001; Rawski and Xiao, 2001; Chow, 2006; Ravallion and Chen, 2007). Chapters 3 and 5 employ standard fixed-effect estimation in a panel data framework to purge provincial time-invariant unobservables. For the time-variant unobservables, they use instrumental variables, i.e. the timing of the National Congress of the Communist Party of China (CPC), to mitigate the biases result from omitted variables. This is the first study embedded in a economic growth framework that uses China's political cycle to construct instrumental variables. Technically, it helps to generate exogenous variations in endogenous variables in order to ameliorate biases caused by reverse causality and measurement errors. Intuitively, the first-stage results in Chapters 3 and 5 paint a picture, illustrating that China's improvement of transportation infrastructure and GDP per capita growth are statistically positively associated with the time of National Congress of the CPC. Realising such a unique pattern of China's economic growth, development economists may follow the instrumental variables proposed in this thesis to study other causal relationships of interest.

In addition, this thesis is one of the pioneering studies that uses China's historical information to construct instrumental variables.[153] Chapters 4 and 6 employ information about ownership of Chinese guilds in the Qing dynasty and prefecture-level population density in 1820 to instrument for the initial level of transportation infrastructure and accessibility to transportation infrastructure, respectively. The strong and robust first-stage results shown in Chapters 4 and 6 indicate that historical events, even if this happened more than 100 years ago, can still be important determinants of contemporary macro variables. The close links between historical instrumental variables and modern-time endogenous variables of interest are consistent with what has been demonstrated in those influential studies in the literature exploring the area of using historical instruments, e.g. Acemoglu et al. (2001), West and Woessmann (2010), and Pascali (2012), among others.

In sum, this thesis provides powerful weapons to deal with complicated endogeneity issues in the context of China. Importantly, those instrumental variables involved in this research work well in both panel data framework and cross-sectional data framework, which may benefit other empirical studies that suffer from endogeneity problems.

2.2 Policy Implications

Combining macro and micro evidence, this research provides the first policy implication that although the improvement of transportation infrastructure can raise GDP per capita growth as presented in Chapter 3, policy-makers should pay attention to the current uneven distribution of transportation infrastructure across regions. Firstly, contemporary disparity of the provision of transportation infrastructure may substantially affect regional economic growth in the long run as shown in Chapter 4. Secondly, the divergence of accessibility of transportation infrastructure may result in increasing income inequality in urban areas as analysed in Chapter 6. This research provides a reminder that although the overall quantity of transportation

[153] To date, there is just a handful of working papers, e.g. Banerjee et al. (2012) and Fang and Zhao (2009) among others, have used historical information to look at China's economic development.

infrastructure is crucial for China's economic growth, the even distribution of transportation infrastructure should not be neglected in the long run. Furthermore, as Chinese policy-makers often emphasise the construction of transportation infrastructure without a clear understanding of how to distribute it, researchers should provide more evidence-based policy advice, for instance, quantifying the actual influence of (un)even distribution of transportation infrastructure on regional economic development relying on both macro and micro data.

The second policy implication is related to the balancing of economic growth and urbanisation. As shown in Chapter 5, China's economic growth causally raises its urbanisation rate. At first glance, policy-makers might choose to focus on the positive contribution of economic growth to urbanisation, if they intend to encourage rural-to-urban migration when the overall urbanisation rate is relatively low during a certain stage of development. However, the rapid pace at which urbanisation is occurring in China raises critical issues that are not examined in this thesis but in existing studies, such as rising CO_2 emissions (Feng et al., 2009; Du et al., 2012) and the proliferation of substandard living habitats known as urban villages.[154] From the sustainable development perspective, policy-makers have to keep the balance between increasing urbanisation and rates of economic growth. However, this requires recalibrating the GDP growth targets, which is detrimental to economic growth. This research advises that Chinese policy-makers should consider lowering economic growth targets at least for those highly-urbanised regions.

[154] Song and Zenou (2012) describe urban villages as habitats where "buildings are overcrowded; public stairways and pathways inside buildings are extremely narrow; public facilities are inadequate and poorly maintained; public roadways cannot meet the basic requirements of transportation and fire control standards; distances between buildings are well below standard and cannot meet fire control standards; and garbage is scattered and unhygienic".

3. Further Research

This research has at least two directions of extension. The first one is closely related to the topics that have been addressed in this thesis, while the second one is a concern about technical issues.

Two causal relationships studied in this thesis are transportation infrastructure to economic growth and economic growth to urbanisation, but this thesis has not yet investigated whether the improvement of transportation infrastructure causally raises urbanisation in China. If this causal link exists, researchers may be interested in quantifying the contribution of the provision of transportation infrastructure to urbanisation. Several recent studies, for instance, Baum-Snow and Turner (2012) and Baum-Snow et al. (2012),[155] use historical infrastructure networks (railroads) to capture exogenous variations in contemporary transportation, and identify the causal effects of the improvement of transportation infrastructure on China's urbanisation process. As they do not find statistically significant evidence that the expansion of transportation infrastructure results in higher urbanisation rates, more empirical studies in this area are desired to check the robustness of their findings.

The second direction could be a further exploration in the area of using historical information as instrumental variables. For example, guilds density employed in Chapter 4 could instrument for current trade or FDI. Alternatively, there are many potential candidates of historical instruments, and they can be used in the areas other than the focus of this thesis. For instance, Shiue (2002) provides a novel dataset of rice prices over the period 1743–1795 which can be used as instruments for the long-run condition of agricultural production or stability of agricultural markets. Another example could be to use temperature and rainfall information from *Terrestrial Air Temperature and Precipitation: Monthly and Annual Time Series (1900 - 2008)* during 1900–1957 to construct a set of instrumental variables for agricultural outputs during the Great Chinese Famine (1958–1961).

All ideas listed above may result in a host of studies that contribute to

[155] These are all unpublished manuscripts.

a more comprehensive understanding of China's economic development and Chinese economic history.

8. APPENDIX

Appendix A: Supplementary Results for Chapter 3

Tab. 8.1: Supplementary Results for Table 3.5

	(1)	(2)	(3)
	Dependent Variable: *growth* (2nd Stage)		
transport	0.233***	0.222***	0.240***
	(0.062)	(0.061)	(0.063)
	provincial CPC secretaries		
age	-0.006		-0.004
	(0.007)		(0.007)
age squared	0.000		0.000
	(0.000)		(0.000)
tenure	0.002***		0.003***
	(0.001)		(0.001)
university	0.000		0.002
	(0.007)		(0.007)
central connection	-0.015***		-0.015***
	(0.005)		(0.005)
	provincial governors		
age		0.005	0.003
		(0.007)	(0.007)
age squared		-0.000	-0.000
		(0.000)	(0.000)

tenure		0.000	0.000
		(0.001)	(0.001)
university		-0.011*	-0.009
		(0.006)	(0.006)
central connection		-0.000	-0.001
		(0.006)	(0.006)
	Dependent Variable: *transport* (1st Stage)		
Congress	0.056***	0.057***	0.056***
	(0.012)	(0.012)	(0.012)
Congress (-1)	0.046***	0.047***	0.045***
	(0.010)	(0.011)	(0.010)
Congress (-2)	0.018*	0.019*	0.019*
	(0.010)	(0.010)	(0.010)
First-Stage (F-stat)	46.60	46.78	40.811
Hansen J (p-value)	0.51	0.66	0.56
Weak IV (F-stat)	12.51	12.52	12.28
Weak IV critical value	4.36	4.36	4.36
N	501	501	501
x vector included?	Yes	Yes	Yes
z vector included?	Yes	Yes	Yes

Note: The numbers in parentheses are robust standard errors and the asterisk represents significance levels according to *** p<0.01, ** p<0.05, * p<0.1. Columns (1)-(3) are estimated by fixed effects 2SLS regression. The vectors x and z are outlined in section 4.1. The instrument set consists of *Congress*, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. The additional control variables included in the regressions are x^{SEC}, x^{GOV} and z. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test. *Weak IV* reports the Kleibergen-Paap Wald statistic and *Weak IV critical value* is the Stock-Yogo critical value to evaluate that 15 percent is the maximal rejection rate if the true rejection rate is 5 percent. Region-specific time trends are included in Columns (1)-(4). Variable definitions are provided in Table 3.8.

Appendix B: Background of Chinese Guilds (Chapter 4)

Origins and Characteristics

The Chinese guilds were forms of corporate collective action that first came about during the Ming dynasty (1368–1644) and flourished towards the end of the Qing dynasty (1644–1911). In Chinese, the most appropriate translation of 'guild' is *Hanghui* which means "trade-line associations" (Quan, 1934). The Chinese guilds provided a wide range of economic and social services, for examples, the matching of skilled workers with employers, providing a meeting place for merchants and their buyers, and offering hospitality services in the form of hotels, restaurants and entertainment centres.

Generally, guilds were established by merchants who aimed to protect themselves from being exploited and discriminated against by the Chinese bureaucrats (Peng, 1995), since merchants were treated as the last-tier citizens according to a transitional ranking of social strata before 1911. The ranking was scholars (*shi*), peasants (*nong*), artisans (*gong*) and merchants (*shang*). In this regard, merchants had to struggle for their own rights by setting up associations like guilds.

There were many types of guilds such as *Gongsuo*, *Huiguan* and *Tang*, among others. The majority of guilds (e.g. *Gongsuo*, *Huiguan*, *Tang*, *Dian*, *Bang*, *Hui*, *Gonghui*, *Ge*, *Zhuang*, *Gongguan*, *Hang* and *Hanghui*) were related to merchant and trade activities. A few of the guilds were named as religious (or sacrificial) shrines and traditional Confucian academies (i.e. *Miao*, *She*, *Shuyuan*, *Ci* and *Si*) but still served as merchant and trade associations (Moll-Murata, 2008; Peng, 1995).

In general, all forms of "Chinese craft, merchant and trade associations" could be regarded as guilds (Moll-Murata, 2008), although they might have different functions. Table 8.2 shows the most common types of Chinese guilds (1655-1911), of which *Gongsuo* and *Huiguan* were by far the largest groups.

Gongsuo and *Huiguan* mean 'public hall' and '(common-origin) assembly house', respectively. However, along with other forms of guilds, they were also well known as "mutual help associations" among numerous sectors (Moll-Murata, 2008), for instance, private banks (*qianzhuang*) in the Yangtze Delta

Tab. 8.2: Designations for Qing Dynasty Guilds (1655–1911)

Source: Moll-Murata (2008).

(finance),[156] the Wuzhou[157] opium guild and the Ningbo[158] fishermen's guild (fishery) (Peng, 1995).

Guilds had various functions, for example, *Gongsuo* and *Huiguan* played different roles in commercial activities. The major members of *Gongsuo*, which could be recognised as pre-modern (prior to 1911) Chinese unions,

[156] The Yangtze Delta consists of southern Jiangsu province, northern Zhejiang province and Shanghai municipality.

[157] Wuzhou is a city which is close to the border between Guangxi and Guangdong provinces.

[158] Ningbo is a coastal city and important seaport in Zhejiang province.

were retailers and artisans. *Gongsuo* distinguished itself from other guilds, because they engaged in wage bargaining between employees and employers, whereas other guilds did not (Peng, 1995).

Huiguan did not serve as unions. Instead, they played a crucial role in commercial activities that channel merchants, workers and artisans from the same original communities. Most *Huiguan* functioned as hotels, restaurants, entertainment centres and even job markets, since their members usually came from the same provinces or prefectures. A good example would be Sichuan *Huiguan*,[159] i.e. those *Huiguan* located in Sichuan province and financed by early immigrants. They were famous for their great contribution to hosting new immigrants by providing accommodation and job information. The new immigrants were peasants from neighbouring provinces who moved to Sichuan province for jobs and better earnings. The presence of *Huiguan* lowered their living and job-search costs. By contrast, those *Huiguan* located in Peking[160] mainly served as liaison offices, where the representatives of the guilds would meet with the representatives of the central government to discuss business and regulation issues (Moll-Murata, 2008). From an economic perspective, the density of ownership of guilds in one province could indicate the nature of local business networks, financial development and commercial prosperity.

With regard to the question of whether Chinese guilds were legal entities, Peng (1995) indicates that most guilds did not register their activities in government departments. This was an issue because governments did not recognise guilds as legal business entities. Meanwhile, guilds themselves did not intend to be regulated by governments. They preferred to manage business activities within sectors themselves. While there were no formal arrangements, guilds were sometimes allowed informally by the governments to regulate their markets given the condition that their members would pay commodity taxes imposed by governments.

Having significant market power, guilds promised to protect their mem-

[159] Sichuan is a south-western Chinese province.

[160] Also known as Beijing, the capital city of the Ming dynasty, the Qing dynasty and the People's Republic of China.

bers against various uncertainties. For example, when diplomatic conflicts between local merchants and foreigners occurred, the representatives of guilds might negotiate with government officials to resolve issues on behalf of guild members. The protection could also be achieved for some internal affairs without the involvement of the governments, since the highest commissions of guilds had jurisdictions which ensured that they could deal with internal issues according to their 'laws' (Moll-Murata, 2008; Peng, 1995). But this did not mean that the Chinese governments never attempted to regulate guilds. In 1867, the government of Guangdong province banned a secretly-founded tobacco guild which intended to monopolise the local market (Moll-Murata, 2008). This case implied that although sophisticated laws that could regulate guilds were few, guilds still faced the risk from local government interventions. In short, the answer to the question about whether Chinese guilds were legal would be Hosea Morse's[161] famous dictum: "The guilds were never within the law: they grew up outside the law; and as associations they neither recognised the law nor claimed its protection." (Morse, 1909)

To sum up, Chinese guilds essentially were not purely commercial communities like European guilds (Moll-Murata, 2008; Peng, 1995). They were not 'normal' associations either, in the sense that they were able to perform as a form of independent socio-economically integrated entity which implemented private rules, standards and even jurisdictions, and central government rarely intervened if local governments acknowledged the activities of particular guilds.

Economic Functions

The first economic function of guilds in the Qing dynasty was serving in part as modern-time labour unions and pricing committees. As introduced in Peng (1995), guild members including both employers (e.g. craftsmen and merchants) and employees (e.g. apprentices) had to obey the regulations in their guilds. These regulations mainly constituted of minimum wages for apprenticeships and regulated prices of commodities or services. For example,

[161] Hosea Morse (1855-1934) was the Statistical Secretary of the Inspectorate General of Customs in China.

the management boards, the highest committees of all types of guilds whose directors were recruited from registered members, imposed minimum wages to protect the second-tier members, i.e. apprentices (*xuetu*), from being exploited by the first-tier members — masters (*shifu*). The protection of apprentices led to a relatively stable number of potential masters in the future, because most masters (e.g. craftsmen or merchants) were previously apprentices who had completed three-year formal apprenticeship contracts and could afford registration fees of guilds (Moll-Murata, 2008; Peng, 1995). Although some of the rules like the regulation of pricing might lead to monopolies in a particular market, the other policies like the minimum wages during the late Qing dynasty (1840–1911) ensured that people on low incomes could afford food, clothes and accommodation.[162] Overall, those regulations imposed by Chinese guilds resulted in a stable provision of skilled labour and contributed to the reduction of income inequality among members.

The second economic function of guilds was imposing some controls on trade. For instance, a saggar maker in Jingdezhen[163] could only purchase raw materials from one supplier and sell their saggars to the nominated buyers (Moll-Murata, 2008). Another example was the textile industry in Suzhou.[164] Merchants (*duanzhuang jihu*) provided materials (e.g. cottons and silks) to skilled workers (*jigong*). These workers were weavers who were involved in the household production with their own spinning machines, and paid by piece-rate wages (Peng, 1995). Although this might potentially restrict free capital flows from a modern economics point of view, the control had been a great revolution of resource allocation in an agrarian economy like the Qing dynasty before 1840. Thus, an increase in the number of guilds was seen as a positive signal of China's commercialisation, industrialisation and modernisation.

Last but not least, guilds donated to education and municipal services

[162] From a modern perspective, guilds distorted wages and market prices. However, in pre-modern China (prior to 1911), guilds served as a successful stabiliser for the society.

[163] A saggar is a ceramic, boxlike container used in the firing of pottery to enclose or protect ware in kilns. Jingdezhen is a town in Jiangxi province which is famous for the production of high-quality china.

[164] Suzhou is a city in Jiangsu province.

(Moll-Murata, 2008). They provided elementary schools to members, as well as firefighting, policing and maintenance of streets and bridges for local residents (Rowe, 1992).

Appendix C: Additional Results for Chapter 5

Tab. 8.3: Supplementary Results for Table 5.3

	(1)	(2)	(3)
	Panel A. Dependent Variable:		
	$\Delta urban$	$\Delta urban$ $(t+1)$	$\Delta urban$ $(t+2)$
growth	0.452**	-0.235	0.286
	(0.191)	(0.290)	(0.182)
year 1989	0.052**	-0.060	0.035
	(0.023)	(0.039)	(0.024)
year 1990	-0.028*	-0.008	0.021
	(0.017)	(0.006)	(0.016)
year 1997	-0.003	-0.004	0.006
	(0.005)	(0.003)	(0.004)
year 1998	0.003	-0.010	0.014
	(0.006)	(0.008)	(0.026)
year 2000	0.013	-0.042**	0.009
	(0.027)	(0.020)	(0.006)
year 2007	0.000	-0.001	
	(0.005)	(0.006)	
	Panel B. Dependent Variable: *growth*		
Congress	0.025***	0.021***	0.023***
	(0.008)	(0.008)	(0.008)
Congress (-1)	0.002	-0.004	-0.004
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.019***	0.015**	0.015**
	(0.007)	(0.007)	(0.007)

year 1989	-0.108***	-0.110***	-0.110***
	(0.023)	(0.009)	(0.009)
year 1990	-0.012	-0.010	-0.010
	(0.013)	(0.013)	(0.013)
year 1997	-0.022**	-0.025**	-0.027***
	(0.011)	(0.010)	(0.010)
year 1998	-0.013**	-0.017**	-0.017**
	(0.006)	(0.006)	(0.007)
year 2000	-0.027***	-0.026***	-0.026***
	(0.008)	(0.008)	(0.008)
year 2007	0.017**	-0.017**	
	(0.009)	(0.009)	
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Region-specific time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	50.77	44.37	40.15
Hansen J (p-value)	0.26	0.86	0.57
N	593	571	549

Note: The numbers in parentheses are robust standard errors. Column (1) estimates the baseline estimating equation of (6.1). Columns (2)-(3) re-estimate the model by regressing $\Delta urban$ at period $t+1$ and $t+2$ on the period t control variables of (6.1). The variable μ_i represents province fixed effect, and γ captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2 of Chapter 5. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of $Congress$, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

Tab. 8.4: Supplementary Results for Table 5.8 (Rainfall)

	(1)	(2)	(3)
	Panel A. Dependent Variable: $\Delta urban$		
growth	0.425**	0.405**	0.411**
	(0.189)	(0.186)	(0.185)
rainfall	0.0002		-0.00004
	(0.001)		(0.0002)
rainfall squared	-0.001		
	(0.003)		
rainfall first lag		-0.0003	-0.0003
		(0.0002)	(0.0002)
	Panel B. Dependent Variable: *growth*		
Congress	0.026***	0.025***	0.032***
	(0.007)	(0.007)	(0.005)
Congress (-1)	0.002	0.0001	0.004
	(0.005)	(0.005)	(0.005)
Congress (-2)	0.018***	0.019***	0.026***
	(0.007)	(0.007)	(0.005)
rainfall	0.001***		0.00003
	(0.001)		(0.0002)
rainfall squared	-0.006***		
	(0.002)		
rainfall first lag		-0.0001	-0.00007
		(0.0002)	(0.0002)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Region-specific time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	44.75	47.17	44.16
Hansen J (p-value)	0.21	0.21	0.20
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2 of Chapter 5. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of $Congress$, a dummy variable indicating the year when the National Congress of the Communist Party of China is held, and $Congress(-k)$, a dummy variable indicating the kth year before the National Congress. Definitions of the variables are provided in Table 5.10. *First Stage* reports the F-statistic for the overall significance of the first stage regressors. *Hansen J* reports the p-value for the overidentifying restriction test.

Tab. 8.5: Rainfall as Instruments of GDP Growth Per Capita

	(1)	(2)	(3)
	Panel A. Dependent Variable: $\Delta urban$		
growth	0.227	1.263	1.197
	(1.417)	(1.599)	(1.132)
	Panel B. Dependent Variable: *growth*		
rainfall	0.0002	0.0001	0.0002
	(0.0001)	(0.0002)	(0.0002)
rainfall, first lag		0.0002	0.0002
		(0.0002)	(0.0002)
rainfall, second lag			0.0001
			(0.0002)
$\mathbf{z}_{it}$ included?	Yes	Yes	Yes
μ_i and γ_t included?	Yes	Yes	Yes
Region-specific time trend included?	Yes	Yes	Yes
First-Stage (F-stat)	44.75	47.17	44.16
Hansen J (p-value)	0.21	0.21	0.20
N	593	593	593

Note: The numbers in parentheses are robust standard errors. The variable μ_i represents province fixed effect, and γ captures possible systemic shocks to the urbanisation rate that come from four key events discussed in section 2 of Chapter 5. The vector $\mathbf{z}_{it}$ consists of the indicator variable *reform* and interaction between *reform* and *coastal*. The instrument set consists of *rainfall* and its first and second lags. Definitions of the variables are provided in Table 5.10. This table reports our findings using rainfall variation as an instrument for GDP growth per capita. It shows that rainfall is not a statistically significant determinant of GDP growth per capita. The rainfall data are obtained from the *Terrestrial Air Temperature and Precipitation: Monthly and Annual Time Series (1900 - 2008)* (http://climate.geog.udel.edu/~climate/html_pages/download.html)

Appendix D: Additional Information for Chapter 6

Tab. 8.6: Category of Occupations

Source: CHIPS (2002).

Tab. 8.7: Category of Sectors and Ownerships

Sector	Ownership

NOTE:
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Source: CHIPS (2002).

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