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The Impact of Economic Centres on City Level Growth in China
A panel data analysis of urban economic growth

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Abstract: China's space economy is highly fragmented with a few mega cities and a large periphery with less advantageous cities lagging behind. While this has been the explicit approach of China's policymakers to achieve rapid growth, less developed cities have been challenged as the suppliers in the process. The purpose of this paper is with the use of a production function examine the spatial spill overs from growth centres on cities in China. Controlling for known factors, the exogenous factor of economic centres promote the growth of cities, and this effect is conditional on development.

Key words: China, Economic Growth, Spatial Spill Overs.

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1 Introduction

China’s growth has followed an unbalanced path throughout recent decades. In contemporary China a number of mega-cities dominate the market with populations matching European countries, while other cities have lagged behind. These economic centres have been the cornerstones when economic reforms were initiated. But if government initiatives are the single most determinant for these centres to have grown to what they are today, the question rises what will happen to other ‘less important’ cities?

The rise of a few mega centres has been an explicit part of the larger agenda by China’s policymakers to achieve rapid development (Ying, 2000). As this process gathers momentum polarization of less advantageous cities are facing the backwash title as losers. Considered as suppliers of this unbalanced growth leads to the puzzle are they destined to remain in a ‘bad city trap’ or do they actually gain from the process? If economic centres are able to promote growth of other cities through dynamic externalities, cities may want to intensify this process to advance in backward sectors, also known as leapfrogging. This process describes well China’s rapid departure from an agrarian, backward economy in the late 1970s, to advance into world’s second largest economy in only three decades.

While it is evident that cities do not operate independently in a vacuum, evidence from surrounding regions spill overs, however, “remain a mystery” (Bai et al., 2012). This paper attempts to narrow this gap by examining how the exogenous force of economic centres affect nearby cities’ aggregate GDP growth. Using city level panel data over the period 1996-2013 contributes to the limited literature on spatial spill overs in China, and contextualizes the geographical distribution parameter and its attenuation.

1.1 Cities and Economic Growth in a Chinese Context

In 1978 reform and opening policy changed every aspect of Chinese society. The Communist Party adopted a more collective style of leadership, and rebuilding China's bureaucracy was one of the initial approaches to drive toward market-oriented policy (Li, 1998). The transition, a bold restructuring in socialist ideology, was aimed at transforming the country from a plan to a market economy. Three decades later China has taken a robust position in the global economy, dramatically decreased poverty, and risen to the world's second largest economy. The regional landscape follows characteristics unique to the sheer size of the country. Regions are divided according to an administrative hierarchy based on authorial distance to the central government. The three levels are provinces, autonomous regions and municipalities. Furthermore, five hierarchies of administrative divisions prevail under the levels: provincial, prefectural, county, township and village, which define the role of economic and political authority (Guo, 2013). As will be outlined throughout this chapter, these hierarchical attributes have impacted the growth of regions in a rather predictable way, whereas a few outliers have risen, rather unexpectedly.

Before reform, China had been shaped by a heavy industrial Big Push leading to unstable reallocation of resources and a distorted hierarchical system (Lin et al., 1996; Naughton, 2007: 55). In 1978 when reform began, the rural population totalled 838 million representing 87.5 per cent of the population. It was not until 2011 when the urban population surpassed the rural population, totalling just over 51 per cent. In 1980 the primary industry employed 68.7 per cent of the total workforce and contributed 30 per cent to the gross domestic product (GDP). In contrast, the secondary industry employed 18.2 per cent of the total workforce and contributed 48.2 per cent to the GDP[1]. But the effects from the Big Push had resulted to a divide between urban and rural regions beyond industrial attributes. A hukou system had been implemented that registered people according to rural and non-rural status. The hukou system had been established in the late 1950s and restricted free mobility, and thus, enforced the urban rural gap (Li and Gibson, 2012). As the majority of heavy industry was located in cities, the country was highly fragmented and unbalanced during the early reform period (Naughton, 2007: 56).

[1] China Statistical Yearbook 1981, 2014, China Data Online.

But as the urban regions mainly developed with support of government projects, the most striking evolution occurred in poor, rural China's Anhui and Zhejiang Provinces, where farmers started exploring cultivation with independent land slots. Before this, all land was distributed according to farming collectives, where several households were responsible for allocated land (Naughton, 2007: 114). The results from the independent farming were striking. By 1983 over 90 per cent of the farms across the country were utilizing the new model, and productivity soared (Lin et al., 1996). The emergence of independent farming thus sparked development in the micromanagement institution, where shifting regional emphases had led to unbalanced growth by two different approaches - top to bottom and bottom up, or simply, winners or losers from pre-reform policies (Andersson et al., 2013; Nee and Opper, 2012: 20). The recognition of independent farming, the Household Responsibility System, was the initial condition for bottom up private commerce to emerge.

Under Socialist Regime essentially all acts of private business had been nationalised. When Deng Xiaoping initiated market-oriented economic and opening up policies, other types of ownership forms were gradually allowed to emerge. While the state kept control in all sectors considered important, a hybrid form of ownership types came into existence (Nee and Opper, 2007). In rural regions, Township and Village Enterprises (TVE) emerged alongside traditional farming. Providing simple consumer goods and farm supporting equipment, the TVEs shifted the economy toward marketization through new ways of competition on market dominating SOEs (Naughton, 2007: 271). The new businesses were able to cut loose from the irrationalities under the Big Push, but focus on China's real economic endowments – abundant labour, limited land, and scarce capital (Naughton, 2007: 275).

The initial decoupling from traditional norms that occurred in the Yangtze Delta region started a domino like effect inducing diverse regional models. Zhejiang Province was particularly successful in the transition, introducing concepts as the Zhejiang Model, and more specifically the Wenzhou Model of development. Wenzhou, a city in Zhejiang's southern coastline, became particularly distinguished due to its achievements in marketization and private enterprise growth (Ye and Wei, 2005). It became the role model of grassroots-level growth during reform, and has since contributed to the region's development to become China's entrepreneurial hub. But it was not the Big Push policies that led to Zhejiang's rapid growth. On the contrary, the region suffered from less investments and state-industry during the Mao era, which, on contrary, deprived local economy (Ye and Wei, 2005). When liberalization policies were adapted local governments that rapidly supported private businesses were able to create a supportive environment for marketization to take hold. Consequently, Zhejiang Province has been particularly open toward small-scale private ventures, and has risen to become one of China's wealthiest provinces. In neighbouring Jiangsu Province, north of Zhejiang, key characteristics from the reform period were facilitated by its locational advantage, rather than the bottom-up approach experienced in Zhejiang Province. In Jiangsu Province, local TVEs grew through the influence of Shanghai's state-owned sector (Naughton, 2007: 282). Proximity to large urban enterprises provided an enhanced channel of linkages to evolve. Entrepreneurs built businesses around the urban industries that allowed them to learn from Shanghai's advancement. The Jiangsu model is, however, not as explicit, and regional differences within the province have remained broad. While the southern cities have benefited from Shanghai's proximity, cities in the north have remained relatively less developed (Ye and Wei, 2005). The cluster of cities adjacent to Shanghai features the dynamism of Yangtze River Delta. Through its international heritage of commerce, Shanghai, however, positions as an outlier in terms of development. The large and early development of an industrial base allowed Shanghai many privileges. Under-priced supplies turned to over-priced manufactures guaranteed artificially high returns (Zhang, 2003). Reforms and decentralization have since decreased Shanghai's dominance, as with the opening of the Pearl River Delta (Ying, 2000), however, modernising the state-sector and paving for services has ensured Shanghai's importance as the financial and economic centre in China.

When open door policies were adapted China's southern regions provided an ideal location for the explorative pilot, grasping Shanghai's lead. Economic activities in Guangdong Province's Pearl River Delta have long been influenced by Hong Kong's proximity. While the open door policies were most pronounced here, the region had also historically been open to migrants across the country (Liao and Wei, 2012). This openness and welcoming of the external labour force enabled manufacturing of labour intensive export goods (Naughton, 2007: 284). When China's first special economic zones (SEZ) were established the region developed quickly to become a concentration of international trade. Preferential policies in SEZs and the newly opened market accumulated large amounts of foreign direct investments. In 1996 Guangzhou's accumulated FDI was 35 per cent of Shanghai's equivalent. In 2000, the ratio had levelled to 95 per cent[2]. As domestic and foreign firms partnered through joint ventures the foreign influence induced new business innovations to be transmitted, and the open-door practices were soon extended to other cities. The witnessed export-led growth strategy has since resulted China to become one of the largest recipients of FDI, enabling technological upgrading, managerial knowhow, and innovations to spill from leader economies (Jarreau and Poncet, 2012).

The locational advantages seen in Guangdong demonstrate China's "growth miracle" (World Bank, 1993). This rapid growth, however, did not diffuse evenly. In China's north eastern provinces, rich natural resources have resulted to another type of industrial structure. Industries on the other end of the value chain dominate the market around extraction of resources, and have not enabled such dynamic growth to occur (Naughton, 2007: 25-26). Heavy industrial bases have resulted to a strong presence of SOEs. In 2010 the state-owned sector still employed 52.4 per cent of the total workforce in Liaoning Province while the equivalent ratio in Guangdong Province was 6.7 per cent[3]. State dominating industrial centres, which are particularly pronounced in north east China, results in more protected markets, contrary to what open door policies achieved in the Pearl River Delta (Ke, 2015).

A similar condition was experienced in western China's Sichuan Province and Chongqing. Chengdu, the provincial capital of Sichuan, and Chongqing that was separated from Sichuan Province and became an independent municipality in 1997, are located along the upper Yangtze River. This allows the two major cities a crucial advantage in the backward west. The region has been historically under the influence of war and defence industry leaving a strong state-owned heavy industrial heritage (Hong, 1999). The remoteness of Sichuan and Chongqing, however, resembles the industrial endowment seen in northern Liaoning and Heilongjiang Provinces. But although its remoteness and primitive industrial structure, Chongqing in particular has been performing well in restructuring its large state-owned industry. Contrary to the situation in Liaoning Province, the private sector has been overtaking several state-owned entities, and private firms now represent the major share in Chongqing. Albeit having progressed faster than other western China's areas, areas outside urban centres face vast challenges. Infrastructure in the region does not level to eastern standards and agriculture remains significant. In Sichuan Province and Chongqing, the

[2]Guangzhou City Statistical Yearbook 2008 and Shanghai Statistical Yearbook 2001 , China Data Online
[3] Liaoning Statistical Yearbook 2014 and Guangdong Statistical Yearbook 2014, China Data Online.

primary industries employed 43 and 33 per cent of the working population in 2010, contrasting to e.g. Zhejiang's 16 per cent, being one of the high performers. The shares employed in the state-owned sector were 59, 47 and 24 per cent respectively[4]. The government has nevertheless acknowledged the large gap between east and west. Trade linkages have been expanded and a wider opening up of the region has received national support. In 1999 a "Western Development Program" was established to recognize this diversity (Li and Wei, 2010).

The influence from Beijing has scattered down across China in an unbalanced manner. One fundamental reason why China has experienced vast regional inequality is due to high concentration of economic centres in the east. The Beijing Shanghai pole is the core of China's economy, and major cities are highly interrelated. Beijing and Tianjin, for example, are only separated by a distance of approximately 130 km and together have a population of 32.6 million, as of 2010. Shanghai Jiangsu and Zhejiang have a total 156 million people and accounted for 21 per cent of total GDP[5].

To sum, post-reform growth took various forms in regions depending on endogenous and exogenous factors, and often a mix of both. Conditions that nurtured growth during reform include geographical advantages, trade linkages, and a supportive local government willing to encourage private entrepreneurship. As in the particular examples of Jiangsu Province and the Pearl River Delta, their geographical locations were able to absorb and benefit from urban proximity. Resource endowment, central planning, and local authorities have had a significant impact on regional development, resulting to major differences in growth and key determinants. A gradual approach has allowed China to avoid a Soviet-like "big bang", but instead transform and adopt new policies as the economy has matured (Naughton, 2007: 88). Trial and error guided early innovators to develop sophisticated linkages, and while interventionist regional policy initiatives favoured selected locations during Maoist era, this was not a necessity, nor a requisite for post-reform growth.

[4] Zhejiang Statistical Yearbook 2011, Sichuan Statistical Yearbook 2011, Chongqing Statistical Yearbook 2011, China Data Online

[5] Beijing Statistical Yearbook 2011, Tianjin Statistical Yearbook 2011, Shanghai Statistical Yearbook 2011, Jiangsu Statistical Yearbook 2011, Zhejiang Statistical Yearbook 2011, China Data Online

1.2 Aim and Objectives

The aim of this paper is to study the impact of growth centres. Do centre cities promote growth, or is there a crowding-out effect for other cities? The research question asks how this exogenous factor affects Chinese cities and their growth dynamics. More specifically:

How proximity to growth centres affects economic growth of cities at different levels of development?

If the effect is found to be positive the higher developed, and negative the less developed city, these finding can shed light on how economic policy should be guided for cities at different levels of development.

The limitation of this study signals challenges from the sample size. When the proximity to an economic centre is examined a larger sample of cities would allow for larger variation. Furthermore, although the data set was explored rather extensively, future studies should attempt different categorization of cities, as to broaden the scope of analyses.

The remainder of this paper is organized as follows. In section 2 the theoretical framework is presented together with literature review and the hypothesis. Section 3 outlines the methods and describes the data. Section 4 presents the results and additional model extensions and section 5 concludes.

2 Theory and Literature Review

This chapter links China's growth experience to the theoretical framework. First, the dynamics of economic growth will be presented on the grounds of a production function. Secondly, the focus goes further to consider economic centres with aims to understand city space. Then, previous and related literature will be reviewed and lastly, the hypothesis that forms the core of the empirical part is formulated.

2.1 Economic Growth

The agglomerations of people and firms that interact under close knit networks of complex social systems have the tendency to grow as a result of cumulative causation (Myrdal, 1957: 23). Cities therefore have the ability to promote growth through discrete patterns of synergies. With the use of a growth model, the objective of this chapter is to propose a framework which helps to navigate the process how externalities diffuse across tiers of space. In the first part, the dynamics of growth will be outlined with a neoclassical production function, providing the background for spill over diffusion in growth centres in section 2.2.

Modern growth models became popular in 1950s and 1960s by the infamous works of Solow (1956) and Swan (1956). The aggregate production function aims at understanding the dynamics of economic growth and its determinants (Weil, 2005: 56-57). While the Solow model has gained wide acceptance, the role of technological progress has remained the central source of debate between different growth theories across time. Two major fields can be branched into neoclassical, as modelled by Solow, and endogenous growth theory, e.g. Romer (1986). The neoclassical model determines technological progress as an exogenous source, outside the model, whereas endogenous growth theory assigns an endogenous source of technology. In the latter, progresses in technology result from within the model. Productivity growth then is caused by growth in capital, through mechanisms of learning by doing and technology spill overs (Durlauf and Blume, 2010: 40). This alternative view, states that endogenous technological change is driven by accumulation of knowledge which, in turns, ‘grow without bound’ (Romer, 1986: 1003). The endogenous growth theory thus incorporates various forms of capital and implies that combined investments in these factors allow for growth in the long run. The spill overs from these investments then create the desired outcome of avoiding diminishing returns to capital, underlying the neoclassical assumptions (Barro, 1997). The choice between the two theories has important implications; higher productivity growth may be targeted through different allocations, and depending on the theory, have varying roles. In this section, the neoclassical model will be studied, conjoined with the most important factors determining economic growth.

Cities are the agglomeration of firms and people that are under the jurisdiction of a government authority. As such, it can be seen as a production unit, with people and firms as inputs that produce all possible goods and services. The local government authority regulates and generates the institutional environment under which its firms and residents belong. In a simple setting, the Solow model describes how a closed economy uses two factors to produce output. Equation 1 describes the relationship between output, capital and labour:

$$Y = F(K, L), \qquad (1)$$

where Y is output, K is capital and L is labour. The Solow model assumes two criteria: constant returns to scale and diminishing marginal product. In the first condition, if the quantities of inputs are increased by a factor z then the quantity of output will also increase by z. Second, if a specific input is continuously increased, keeping all else constant, the output produced by this increase will diminish in relation to the previous unit of increase. Given these conditions, by varying the amounts of capital and labour, eventually an equilibrium position will be achieved, where adding more inputs will no longer create additional output, i.e. growth will cease (Barro, 1997). This condition, the steady state, can occur due to scarcity in factors of production or depreciation. The Solow model shows that as long as there are decreasing returns to factors of production (a and b <1, a + b=1), productivity growth, an exogenous process, can be the only source of long-term growth (Sørensen and Whitta-Jacobsen, 2005: 127). Moreover, at a given position, a production unit (e.g. an economy) will grow faster the further below its steady state, or have slower or negative growth the further above its steady state level.

Capital and labour can be viewed as the pillars for an economy. When economic reform began in China the productivity of capital soared (Dollar, 2013: Figure 9). The increase in productivity of capital attributed to the opening-up policies occurred at a time when capital was scarce but labour abundant. With the introduction of markets and opportunity for individuals to earn income a nationwide structural decomposition occurred. Aggregate income became redistributed in a more decentralized way, away from the central-planned system. As a result, government income decreased drastically, and household income increased, eventually leading to tax-reform in 1994 (Naughton, 2007: 102). Moreover, while the central government maintained a high investment rate during the Big Push, it has continually increased the rate of investments even after reform. The structure of capital within an economy may take several distinct forms with, consequently, different effects on growth. Within a closed economy, nationwide income minus expenses equals the savings rate made by various actors. For the government, the savings rate is made by tax collection minus purchases, which consequently equals investments. China's investments have always been high. Thus, domestic saving rates are also high. Higher saving rate raises the steady state level of output, but China's savings, and thus, investments, have been exceptionally high when comparing to its neighbours, but also most other countries. Figure 1 show that not only is China's capital formation very high, but also that household consumption is exceptionally low. These two components illustrate China's unique structural position and underline that the government is responsible for a large part of domestic demand.

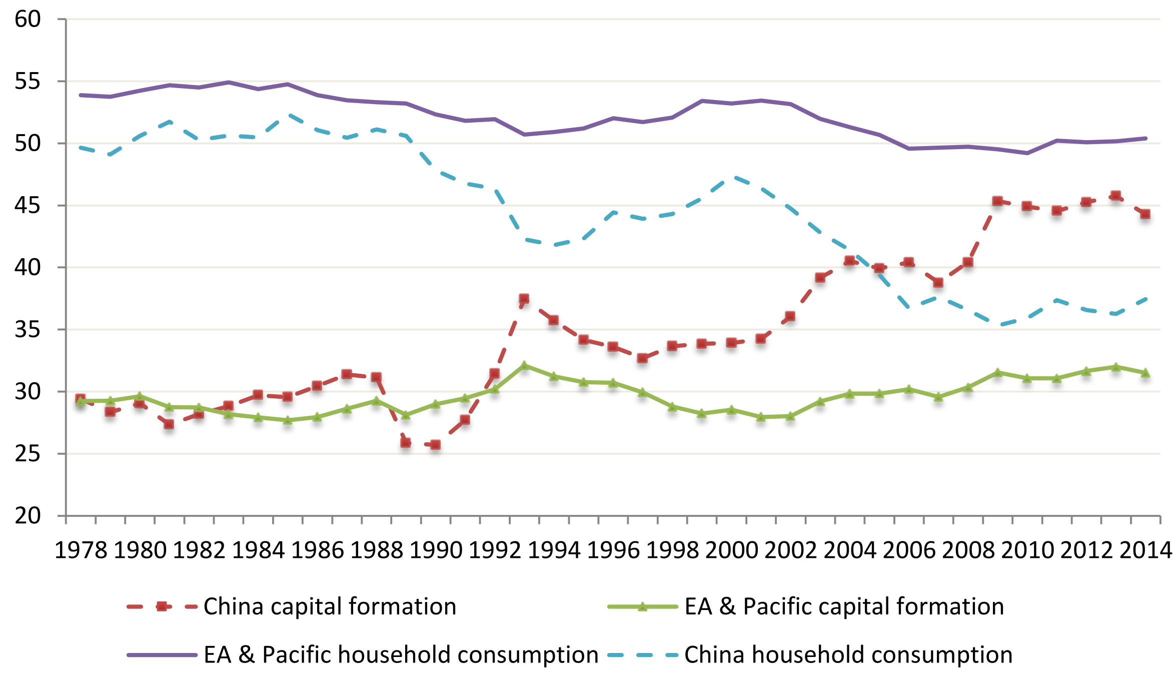

Figure 1. *Household consumption & gross fixed capital formation % of GDP. Source: World Bank Indicators, 2016.*

Figure 1 show China's capital formation and household consumption in relation to East-Asian & Pacific economies[6]. In 1978 capital formation was roughly 30 per cent of GDP for all above countries. Between 1978 and 1990 China faced a tumultuous period compared to the other economies. During this time China faced inflationary pressures which eventually lead to a halt in government investment in the late 1980s (Ying, 2003). Starting from the early 1990s China has steadily increased its investments, totalling up to above 40 per cent starting from 2004, whereas the rate for the other economies have been more stable staying at around 30 per cent. China's household consumption rate has moved been between 5 and 15 per cent below the other countries, staying between 35 and 40 per cent the last years, compared to 50 per cent of the others. This structure show China's emphasis on the export led growth and high savings rate in relation to the other countries, having proportionally stronger local private demand, as represented by household consumption rates totalling between 55 and 50 per cent of GDP throughout the entire period, but also lower investment rates.

[6] East-Asian & Pacific economies: American Samoa, Australia, Brunei, Cambodia, Fiji, French Polynesia, Guam, Hong Kong, Indonesia, Japan, Kiribati, Korea, Dem. People's Rep., Korea. Rep., Lao PDR., Macao, Malaysia, Marshall Islands, Micronesia, FED. STS., Mongolia, Myanmanr, Nauru, New Caledionia, New Zealand, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Singapore, Salomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, Vanatu, Vietnam, World Bank Indicators.

The other component, labour, is inevitable dependent on demographics, and Chinas population growth has been slowing steadily since the late 1970s. In Figure 2 the population and GDP annual growth rates show that an increasing amount of income is available in per capita terms. The rapid growth in GDP accompanied with a slowing population growth thus strengthens the growth in terms of GDP per capita. However, as discussed in chapter 1.1 the labour force has not been freely mobile, contributing to an uneven distribution of wealth. Therefore, it may be viewed that China has not yet fully utilized its huge labour pool to its fullest, given the still relatively large rural population. However, this condition has certainly supported China's robust growth. A slowing population growth has the ability to increases the steady state level, whereas higher population growth lowers the steady state, as more (less) resources are needed to sustain growth (Barro and Sala-i-Martin, 2004: 20).

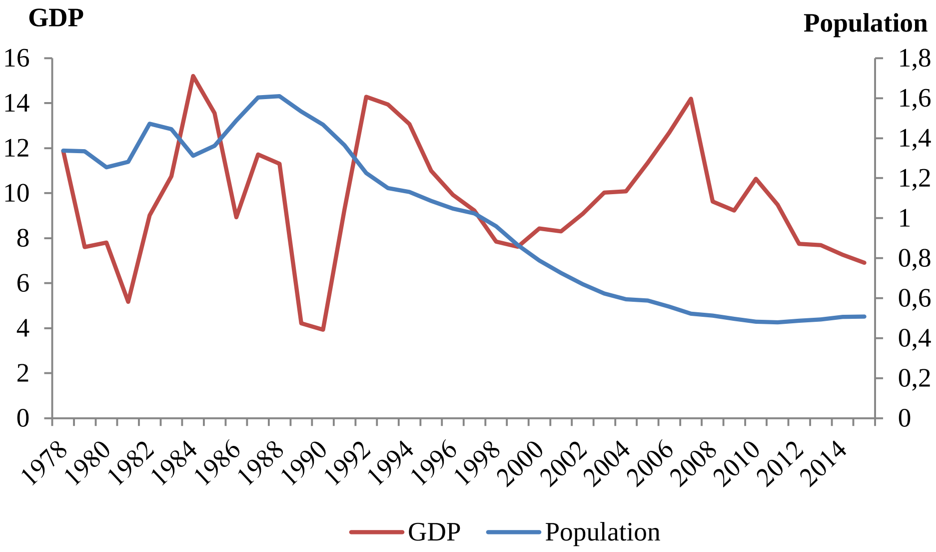

Figure 2. *Population and GDP annual growth rates. Source: World Bank Indicators, 2016.*

Figure 2 shows China's steadily slowing population growth, levelling somewhat during the past years. The sharp drop in GDP occurred when the government reduced its investment rate due to inflation and documents the process outlined in Figure 1. The combinations of these two forces of an increasing GDP growth along with a slowing population growth have intensified China's steady state level higher. Indeed, Figures 1 and 2 therefore present how in the case of China, the theoretical assumptions of capital moves the steady state level, and the underlying forces.

In the Solow model the underlying neoclassical theory implies that long-run growth can be achieved by technological progress, which, however, is exogenous and stems from outside the model (Barro, 1997). In that sense, the technological progress can be calculated by multiplying each factor, capital and labour by their respective weights and let the 'residual' be attributed to technology, or productivity, in that matter. Using a production function of Cobb-Douglas, Equation 2, the factor of productivity is included. A production function is Cobb-Douglas when satisfying the neoclassical framework (Barro and Sala-i-Martin, 2004: 30).

$$Y = F(K, L) = AK^{\alpha}L^{1-\alpha}, \tag{2}$$

where K is capital, L is labour, and A is a measure of productivity. The constant α between 0 and 1 determines how the factors combine to produce output (Weil, 2005: 53). In a Cobb-Douglas production function the assumptions of constants returns to scale and diminishing marginal product are kept the same. In the neoclassical perspective knowledge is exogenous and non-rival, or a public good, and may therefore spill across space (Barro and Sala-i-Martin, 2004: 18). Similarly, by extending the Cobb-Douglas production function in Equation 2 to account for human capital, thus:

$$Y = AK^{\alpha}(hL)^{1-\alpha} \tag{3}$$

where, h represent the amount of labour input, which can vary across space, unlike in Equation (1), where L was represented by one unit of labour. In Equation (3), hL represents total labour input. Now, the relationship of output is studied between physical capital (*K*), human capital and labour (*hL)*, and productivity (*A*). Generally, a standard value given for α is 1/3 (Weil, 2005: 56; Durlauf and Blume, 2010: 40). At any point, both sides of the equation can be divided by L to get per worker terms. For comparing two economies, the respective production functions can be divided with each other to obtain the ratio of output (*Y),* which tells how their output levels differ. Then, by dividing the output ratio with the factor accumulation (*K* and hL) ratio, the difference in respective country's productivity (*A)* can be obtained, see Weil, 2005: 186-188 for details.

As the capital-output ratio in China initially declined induced by open door policies, it has steadily increased (Dollar, 2013), and as seen in Figure 1, China has continuously invested heavily. Then, it must be assumed, in line with the theory, that productivity has been higher than diminishing returns, given China's increasing economic growth during the past decades. By continuously having increased investments China has been able to steadily move its steady state level, and it is thus evident that fixed capital investment has had a significant impact on the continuous growth. Technological advancements can intuitively be associated with efficiency. China's relative backwardness has allowed it to quickly adapt technologies and innovative practices from leader economies when the market was opened. As outlined in chapter 1.1, Guangdong Province was able to rapidly accumulate large amounts of FDI in the light of open-door policies. When countries engage in trade and become integrated internationally the flows of various resources expand. The accumulation of foreign assets allowed China to upgrade in backward sectors and consequently productivity of capital increased. The increase in FDI flows and the export led emphasis led to rapid growth, attracting entrepreneurs to tap on opportunities from new markets. But although the level of FDI has increased in all China since the late 1970s, the concentration pattern of inward FDI has largely remained same. The advancements of the early 'forerunners' have not been able to pour down in a balanced manner. In this process, polarization of less developed regions has furthered the gap between the coast and periphery (Liao and Wei, 2012).

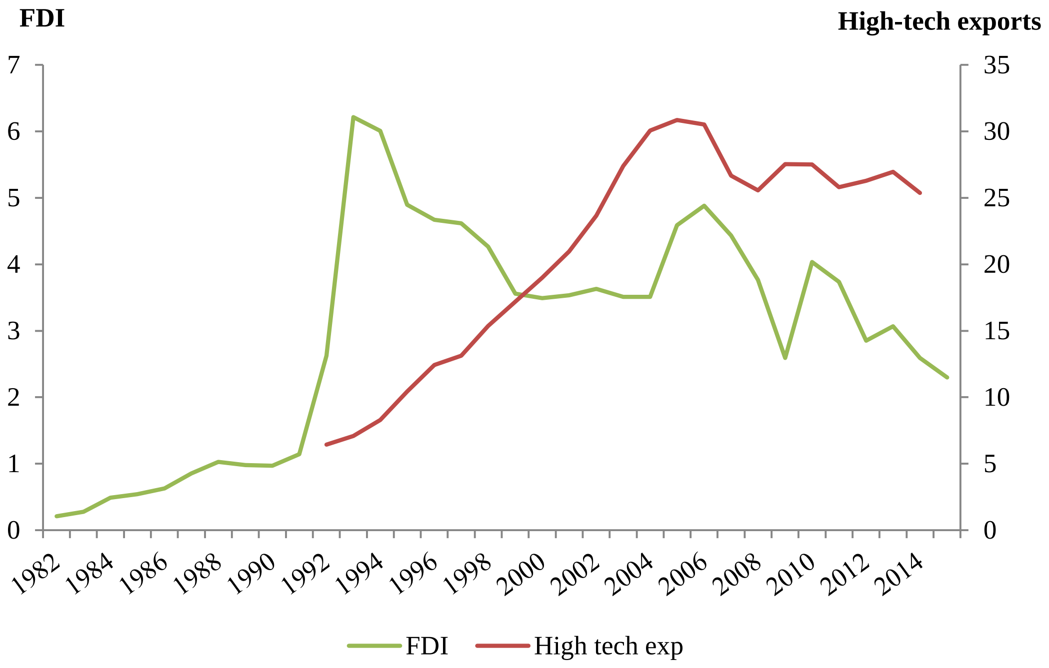

Figure 3. *FDI % of GDP and high-tech export share of total exports. Source: World Bank Indicators, 2016.*

Figure 3 shows the shares of high-technology exports and FDI in China. Starting from an agrarian economy China's knowledge base was low at the early 1980s (Lin et al., 2009). With the opening up policies the abundant, inexpensive labour pool attracted increasing amounts of FDI into the previously closed economy. Figure 3 shows that starting from around the early 1990s an increasing share of total exports has been devoted to high-technology commodities. A steep rise in the share of FDI occurred when further liberalization was implemented, and were yet extended by China's accession to TWO in 2001 (Whalley and Xin, 2010). In 2011 foreign enterprises accounted for nearly half of total exports (Wen, 2013). Thus it can be seen that while an increasing amount of foreign capital has been flowing into China, the main purpose of these investments have been processing and further exporting to other countries.

The factors outlined throughout this chapter represent the basic macroeconomic structure in China. Varying the factor shares can affect growth through different mechanisms. One overlooked role, however, is played by the regional institutions which in turns impacts how the economy is organized and how factors are used. Productivity differences among economies reflect differences in these institutions and incentives and thus 'rules of the game' vary (Weil, 2005: 335). The wide gap between east and west, and, while less obvious, outside economic centres, highlight distortions in China's regional institutions. Backward areas therefore face lower productivity levels even if same factors would be available. The next section examines the diffusion of productivity externalities and how these factors results in their absorption or deterioration.

2.2 Economic Centres

The previous chapter showed how various factors of production affects economic growth. Technology plays an important role and can affect an economy through various ways. In the neoclassical setup, technology is exogenous, and may affect growth from e.g. leader economies, through spill overs. In this chapter city space is examined more carefully by focusing on economic centres. For simplicity an economic centre is defined as being more developed in terms of higher long-term GDP contribution and higher ratio of non-agricultural

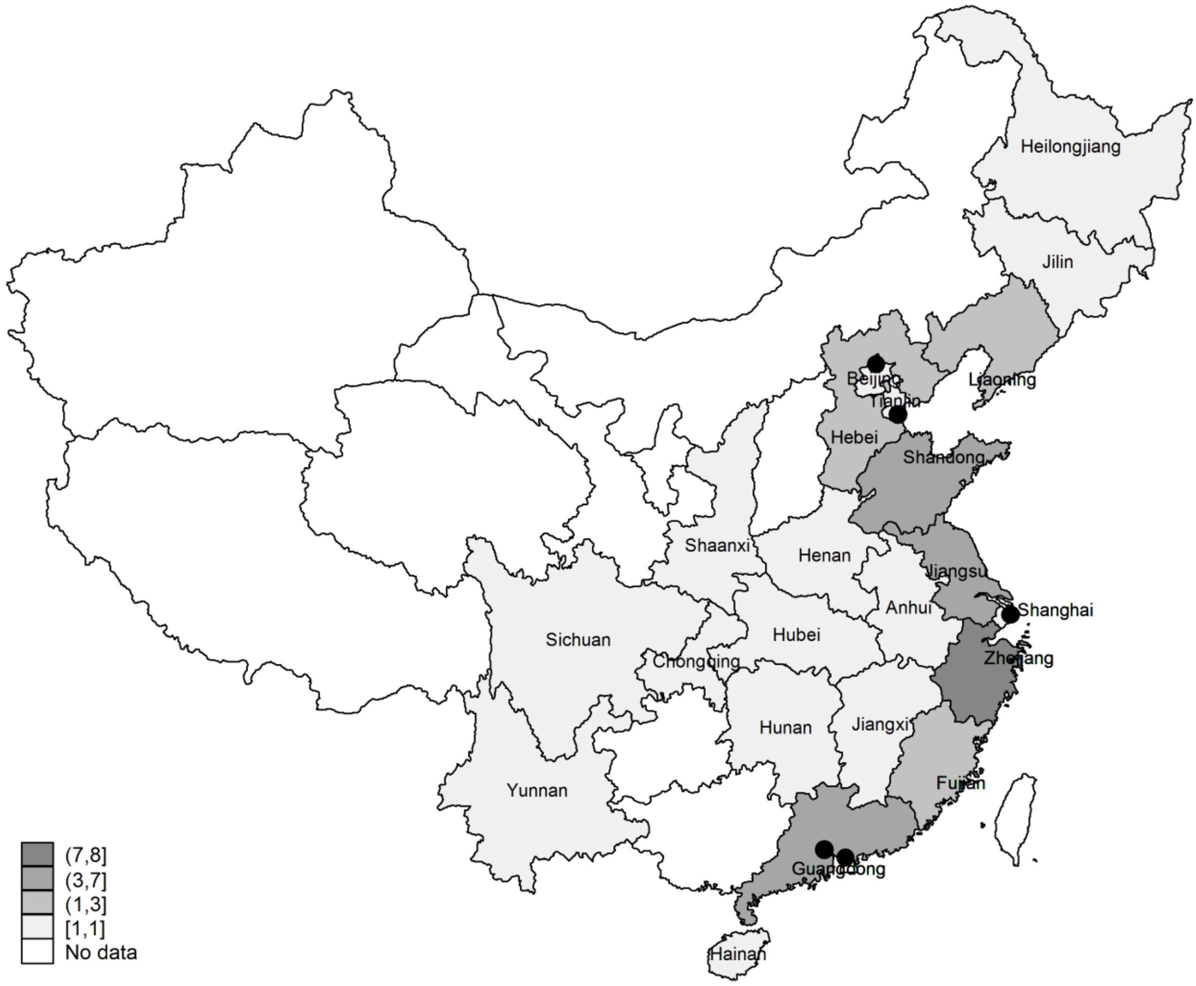

Figure 4. *Map of sample cities.*

output. In this setting it is appropriate to graphically introduce the sample cities in the study. Figure 4 shows the provinces in which the 47 sample cities are located. The density of the colour represents more cities within the province. Zhejiang Province south of Shanghai, has the largest representation with eight cities, the second largest is Guangdong Province with seven cities and third Jiangsu Province with six cities. Shandong Province has four, Fujian Province three, and the rest have either two or one city within their province. The black dots represent the economic centres. Two of the economic centres, Guangzhou and Shenzhen, the southernmost dots, are not classified as independent municipalities, whereas Shanghai and Tianjin are independent municipalities and Beijing is the capital of China. From China's total 31 provinces 18 provinces and municipalities are included in this study.

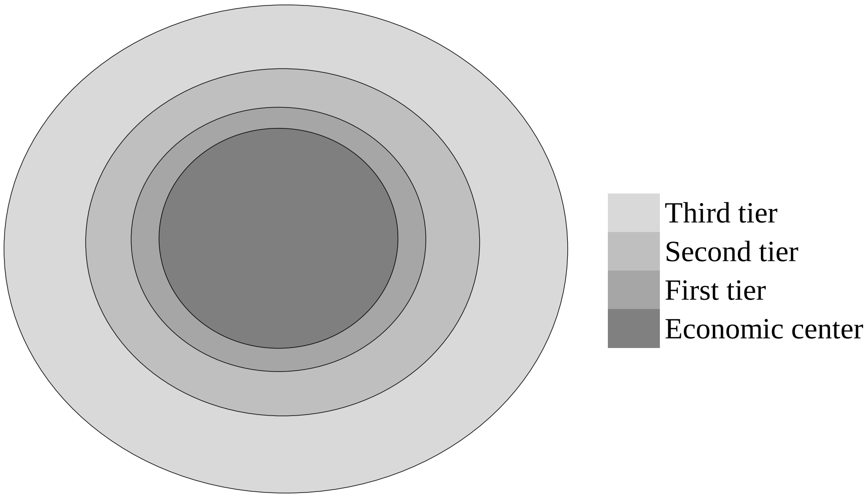

Figure 5. *Economic centre and tiers by level.*

Economic centres can be viewed as the core business districts in a city space, with layers extending away from the centre gradually to inner circles and outer suburbs. In this manner, Figure 4 can be imagined as a circle, with the economic centres at its core. Figure 5 graphs this simple setting. The influence of the centre fades the further away, by the distance to the following tier.

Urban economics and new economic geography provide useful tools to understand this setting. Cities are the agglomeration of firms and people, the inner core in Figure 5. With reference to the centre, the relative effect fades the further away, by a factor weighted by its location within the circle. The consequences that emerge through cities where people and firms come together are the benefits of being close to each other. Alfred Marshall pioneered the subject in his novel book Principles of Economics (1890) that shed light on localized industry spill overs, describing:

"*When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another*"

Inside the economic centre in Figure 5 proximity to customers and suppliers benefit firms, who can save in transport costs of input factors and final goods. If firm B would be located furthest away, in tier 3, then it would be less productive than firm A, who is located within the circle. The concentration of economic activity within the economic centre thus has a centripetal force, where the market is superior to tiers 1 to 3 (Krugman, 1998). Higher productivity levels inside the economic centre results to higher wages. The cost of high wages buys more productivity for firm A, whereas high wages are offset by high living costs for workers in firm A. Spatial equilibrium state that if something is particularly good in one location, then, something bad should be offsetting the particular gain (Glaeser, 2007a). Perhaps one of the strongest outcomes from being a citizen, or a firm etc. within the economic centre can be attributed to spill over effects (Krugman, 2011). Spill overs take place through the exchange of ideas that are facilitated by physical proximity (Glaeser, Kallal and Scheinkman, 1991). Cities are places of complex interaction networks between socioeconomic and ecological systems (Glaeser, 2007a; Jiang and Shen, 2013). When the density of people and firms are expected to be highest in the economic centre and fade the further away, then, externalities are also expected to be highest and fade the further away (Glaeser et al., 1992).

To resume focus on technology, which was found to be the most significant factor for long-run growth across spaces, cities provide an enhanced condition for technology, or productivity diffusion. A higher concentration of firms in the economic centre allows a platform for advanced interaction and knowledge exchange. However, as formulated in the previous chapter, knowledge is non rival, and thus, is expected to spill rapidly across all tiers. But if firm B is also expected to have a relative technology gap to firm A, by some factor weighted by its technological distance, then firm B might not be fully able to take advantage of firm A's advancements, due to its backwardness (Döring and Schnellenbach, 2006). Knowledge therefore may take various forms which affect how it can be absorbed and used. Such differences are explicit and tacit knowledge that relates to their ability to be communicated, developed by Michael Polanyi in late 1950s and 1960s (Grant, 2007). In the example above, the spill over effect is not bound by physical, but rather technological distance. This departures from the general assumption that knowledge diffuses without bound. Then, how do tiers 1 to 3 differ in their ability to absorb the positive spill overs from the economic centre?

Various factors affect a region's ability to absorb positive externalities. One notable condition relates to the issues on regional differences in both willingness and ability to innovate and the local institutional heritage thus affects if and how positive externalities can promote regional growth (Feldman and Florida, 1994; Döring and Schnellenbach, 2006). The heavy-industrial heritage seen in northern China's provinces, for example, exhibits how local structural differences affect the ability to innovate, leaving less room for small-scale entrepreneurial activity. Agglomeration of young and diverse, small-scale firms, promote such externalities, whereas large-scale industrial agglomerates deter the capacity to innovate (Glaeser, 1994). When the aim is to understand the external spill overs from economic centres, it is the capacities to innovate and to assimilate innovation that lies at the core in understanding the tier specific differences (Rodriguez-Pose and Crescenzi, 2008). Interaction between tiers can facilitate spill overs, but tacit knowledge fades with distance in the absence of interaction, both geographically and technologically. The economic centre can utilize the workforce in tier 1, and further sell its products throughout tiers 1 to 3, generating a dynamic interaction network for knowledge diffusion. This population (Glaeser, 1998) and market (Bai, Ma and Pan, 2012) potential is defined as the potential market of workers, customers, suppliers etc. within reach. Similarly, if a worker in firm A quits and takes a new job in firm B, he or she may transfer the skills learned to the new firm. Labour mobility furthermore displays a catalyst for tacit knowledge to spill, as the new employee can decipher what was previously inaccessible for firm A (Cowan, David and Foray, 2000). Therefore, employee mobility has the ability to take the role of 'new technology' diffusion, which increases with agglomeration (Glaeser and Gottlieb, 2009).

China's special economic zones provide an interesting case study. It is not unusual that a specific SEZ is focused on a particular industry, say Nano-technology, which provide concentration of similar firms, creating a specialized cluster of tacit knowledge. When explicit knowledge is assumed to have the ability to diffuse over larger distances, tacit knowledge in turns, requires close-knit interaction, which results to concentration of innovation (Ernst and Kim, 2002). If SEZ A´ is located in tier 1 it is expected to have a relatively higher skilled labour force, by some factor weighted by its 'technological distance' to SEZ B´ in tier 3. The labour pool in tier 3 is less productive than in tier 1 and therefore has weaker effect on the economy, which is illustrated by the core's distance to the outer circle. Figure 6 illustrates this relationship. According to neoclassical theory, it is also assumed that the steady state levels between the tiers are different. Then, tier 3 would be expected to face fastest growth toward a new steady state level, induced by technological advances from the upper tiers. The catch-up speed, however, depends on the 'technological distance' between the tiers, institutions and other socio-economic factors (Rodriguez-Pose and Crescenzi, 2008). An innovation created in SEZ A´ does not automatically materialize in SEZ B´ due to these contrasts. The dynamics of this process lays the essence in this paper. The exogenous rate of technology formulated in the previous section, where technology spills induced by leader economies, provides a useful tool to model this process. The remaining chapters attempt to empirically test this process with Chinese cities.

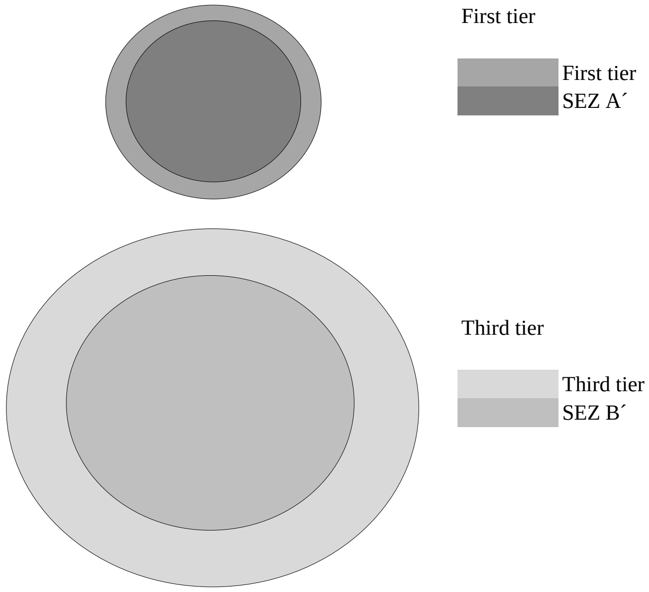

Figure 6. *Graphical example of technology diffusion.*

2.3 Previous Literature

China’s unique structural inheritance offers an interesting complement to the context of geographical patterns of path dependence. The sheer size of the country, but also the complex and regionally fragmented institutional framework separates China in various ways from the experiences of western economies. Thus, not surprisingly, scholars have acknowledged that many theories developed in the west have limits in explaining China’s regional differences (Li and Wei, 2010; Sun, Hong and Li, 2010). A general classification of China’s spatial economy can be divided to east, central and west, which all have distinct characteristics. The eastern regions are characterized by advantageous open door policies, the central as a populous origin of China’s culture, and west as sparsely populated land with rich natural resources (Li and Wei, 2010). The inequality perspectives have received the attention of several scholars to study the differing abilities to absorb externalities from leader provinces (Ying, 2003; Brun, Combes and Renard, 2002). Not surprisingly the eastern regions exhibit fastest development in most measures (Chen and Fleisher, 1996). But studies also suggest evidence of convergence across regions whereas inequality between regions has, conversely, increased (Yao and Zhang, 2001; Andersson et al., 2013). Induced by China's export led growth model, and by major part of export processing being concentrated in the coastal regions, studies on foreign direct investments have received broad attention. The promotion of inward FDI has long been a means of national policy in China (Wen, 2013) and the reason why foreign investments have been so well received by developing countries in general are in the beliefs in their positive spill overs (Jarreau and Poncet, 2012; Fu and Gong, 2011; Sun, 2011). Besides accounting for technological upgrading and introducing foreign practices and managerial knowhow, the larger presence of FDI in a region often reflect other institutional advantages as better protection of property rights and law (Du et al., 2008). However, while such spill overs can be said to have gained a broadly accepted consensus Döring and Schnellenback (2006) note that the study of externality diffusion has not. In China city level studies have been overshadowed by provincial level studies which undoubtedly relates to availability of data. Even so, studies on spatial spill overs are limited (Bai et al., 2012; Sun, Hong and Li, 2010).

With beliefs that provincial growth is also subject to factors from surrounding provinces Bai et al. (2012) investigates provincial growth with the use of market potential. They find positive inter-provincial spill overs that strengthen over time, and that increasing the market potential by 10 per cent increases provincial GDP per capita by 3.2 to 5.1 percentage points. They conclude suggesting further facilitating market freedom and removing local economic protection, as to promote balanced growth across different regions. Sun, Hong and Li (2010) use a spatial dynamic model to test for technology diffusion, factor mobility and structural change across China's provinces between 1980 and 2005. Their labour-augmenting Cobb-Douglas production function, where the technology parameter A, (presented in Equation 2) takes that province i's depends also on its neighboursA_{it}. This effect spills with an elasticity of $\rho \cdot w_{ij}$ measured by their distance. Their study reveals the significance of technology diffusion as support for spatially correlated income between provinces. The latter becomes available due to technological spill overs and factor mobility.

Ying (2000) takes another approach, using exploratory spatial data analysis to explore spill overs across China's provinces. The spatial dependence analysis is made on Chinese provincial output growth rates for 1978 to 1994. By examining patterns of spatial interaction, and defining Guangdong as the reference, spatial patterns could be analysed. This method identifies provinces that are either positively or negatively related to growth of Guangdong Province, suggesting a “trickle down” or “backwash” pattern. A general pattern of interior provinces’ polarization could be identified, preventing them from adopting Guangdong’s market institutions. Additionally, evidence of this condition is also identifiable for Shanghai, Tianjin, and Shandong, where Guangdong’s effect is rather crowding-out, as in the particular examples for Shanghai and Tianjin, having lost significance with the opening up of the Pearl River Delta. Brun et al. (2002) examine regional growth spill overs in China’s provinces between 1981 and 1998. The spread from coastal success to inner regions is acknowledged through three externalities: demand, trade and supply. The estimated growth model tests the existence of spill overs between coastal and non-coastal provinces, between coastal provinces, and differences between them. The effect from coastal provinces is insignificant for western provinces, whereas the effects for central provinces and between coastal provinces are positive and significant. These estimates were obtained using separate variables for respective geographical areas (central, western and coastal) to capture the spill over effects.

The studies above use various methods for the analyses. Moran’s index was used by Bai et al. (2012), and Ying (2000), which detects spatial autocorrelation across regions. Brun et al. (2002), Sun et al. (2010) and Bat et al. (2012) used growth models in line with Barro (1991). All studies suggested that the level of economic development and interregional interaction promotes growth and increases the ability to absorb externalities. These linkages do not, however, automatically promote growth as evidenced from Guangdong Province’s effect on Shanghai and Tianjin (Ying, 2000). Therefore, spatial dependence in China is expected to vary broadly between cities due to various conditions presented throughout this chapter. Next the hypothesis will be presented that will be used to test this mechanism on a sample of cities at different levels of development. Sun, Hong and Li (2010) revealed structural change, reallocation from agriculture to non-agricultural sector, to have been a major contributor to post-reform growth, and a source of future opportunities for productivity gains. This paper will use this methodology to construct a city-tier categorization.

2.4 Hypothesis

With the aim to establish an understanding in how cities at different development stages in China respond to the proximity to economic centres, this paper employs the following hypothesis:

All else being equal – proximity to economic centres has higher explanatory power on GDP growth in first-tier cities than in second and third-tier cities.

Given the background in this chapter, the effect from an economic centre is expected to fade the further away in terms of development. The economic centre is defined as the top five overall GDP contributors, and development is measured according to industrial structure. All else being equal, the effect from proximity to a centre is expected to fade the larger development gap. This approach allows distinguishing how the explanatory power of factors varies based on three tiers with different industrial structure.

The above hypothesis bases on the argument that a higher developed city, thus relatively similar to the economic centre, is able to better absorb positive spill overs from economic centres. Development, which is defined by industrial structure, relates to the quality of institutions and economic environment, which are assumed to advance together with industrial structure. The underlying concept is, in accordance with the literature, that mature institutions, highly skilled labour pool, and an advanced economic environment, are able to absorb more sophisticated spill overs, and thus, facilitating a positive and larger explanatory power on GDP growth.

3 Methodology and Data

The empirical part of this study is organized as follows. In this chapter the research approach that forms the econometric testing process is outlined. Next the data and variables are presented, and finally, the empirical model specifications are formulated.

3.1 Research Approach

This study uses city-level data on a sample of 47 Chinese cities over the period 1996 to 2013. With the use of GDP growth as the dependent variable, this study examines the effect of economic centres on cities at different development levels. The cities are grouped into three categories based on non-agricultural output to GDP ratio. Thus, tier 1 has the highest ratio of non-agricultural output to GDP, tier 2 the second highest, and tier 3 the least. The effect from proximity to an economic centre will be studied according to this grouping, to find out how the effect varies based on level of development. This approach eliminates the regional specific (coast, inland, and west) cluster but focuses on the city specific industry setting. Although the method is much in line with such growth 'clubs', it allows for a number of outliers to move to a more appropriate category. Economic centre is defined as the top five performers of overall GDP contribution. When the average GDP rate over 1996 to 2013 is calculated the top five performers are Beijing, Shanghai, Shenzhen, Guangzhou and Tianjin.

In the empirical testing, the dependent variable is regressed by gradually adding variables to establish a benchmark model for hypothesis testing. The benchmark model is then separately regressed to find tier specific results. To test for the robustness of the model various tests are made. First, additional models, in line with previous literature, are applied to test for model fit. Then, the time dimension will be reorganized into two periods. Finally, a cross-sectional regression for the year 2010 is made to eliminate the time dimension. Here, the economic centre is gradually relaxed in distance whereas controlling for tier effects.

The empirical part employs a panel data study on city-level data. While the bulk of previous studies apply province-level data, city-level data allow focusing on China's vast city-specific differences, which are difficult to extract from provincial-level data. As formulated in chapter 1.1 cities within provinces have had tremendously varied growth paths stemming from various reasons, which argues for the latter choice. The data is structured as strongly balanced panel data and has been analysed using the software program STATA 14.

3.2 Data

The data set was constructed from 1997 to 2014 China City Statistical Yearbooks and compiled from Michigan University's All China Data Centre[7]. The time period 1996 to 2013 was chosen because it was the longest comprehensive period with accessible data. The data are in current yuan and FDI is reported in dollars. All are scaled to equivalent units. The sample cities were chosen from the 47 most competitive cities in the China City Competitiveness Report (Ni, 2009), and are listed in Appendix A. The dataset has a total 846 observations, but some variables experience missing values. These are reported at the end of this section. Another issue relates to the quality of data from China's National Bureau of Statistics (NBS). One of the main arguments is that official data are politically sensitive, and different accounting standards at times and between bureaus have resulted to inconsistent figures (Ying, 2000). Official data is, however, extensively used in all studies discussed in this paper, and therefore, should result in reliable outcomes.

3.2.1 Variables

The dependent variable uses *GDP* growth as a measure of economic growth. This variable was chosen over GDP per capita as to increase consistency. The accounting standard for population has been varying during the sample period, and at times jumping at staggering standards, leading to overestimation (Ying, 2000). Also, this method satisfies well the underlying analysis as focus is on growth performance. The independent variable economic *centre* is constructed as a binary variable and represents proximity to an economic centre. A city that has an economic centre within 100 km proximity has the value 1, and otherwise 0 and all economic centres have the value 0. The benchmark reference will be held at 100 km,

[7] http://chinadataonline.org/

but also relaxed in other estimations to 200 km and 300 km to identify possibility of attenuation. A positive sign suggest that *centre* benefit the receiving city whereas a negative sign suggest the opposite. Moreover, 0 and statistically insignificant estimates suggest that there is no effect of externalities.

The control variables represent factors that are found to have significance on economic growth, theoretical foundation, and according to previous research. In the neoclassical framework physical capital accumulation raises a steady state level, and the marginal product of capital diminishes towards the new equilibrium. But in the case of China, overinvestment have been found of issue, particularly in state owned heavy industries, consequently leading to distortions in local markets (Ke, 2015; Montinola, Qian and Weingast, 2015). Close political connections with central government have kept large, and often unprofitable, companies running despite acknowledging the issue of inefficiency. Physical capital accumulation thus affects a broad variety of conditions which help to control for differences between cities. In accordance with the theoretical background this variable is expected to have a positive impact on local growth. Capital accumulation is captured through *fixinv* reporting total fixed capital investments in a city.

One of China's comparative advantages has been its large, inexpensive, labour pool. Due to the hukou policy adapted in late 1950s, however, a large amount of the aggregate labour force is still employed in the primary sector and, while having decreased substantially during the last decades, in subsistence farming (Naughton, 2007: 3; Deininger et al., 2013). But demographics in China also yield another challenge. As seen in Figure 2, China's population growth has been slowing, but what this graph fails to report is that the working population is also shrinking (Cai and Lu, 2013). This combination may at worst lead to bottlenecks, especially where polarized regions lose their skilled labourers to growth centres (Ying, 2000). The labour pool accessible within an economy may be viewed as the pillar input to produce output. Glaeser (2007b) identifies an appropriate workforce as the most powerful predictor of new firm growth, and thus is expected to have a positive impact on regional economic growth. This variable is constructed as *labour* and reports the amount of staff and employees.

There is a unified consensus on human capital's impact on growth, skilled workers produce more product varieties and furthers the technological frontier (Glaeser, Ponzetto, Tobio, 2014). Simon and Nardinelli (2002) finds that human capital adjusts slowly to the steady state i.e. it persists for long periods of time. And as empirically evidenced by Rosenthan and Strange (2008) human capital exhibit positive externalities moving off the farm (Deininger et al., 2013) and migration experienced in China has consequently had cumulative causation (Myrdal, 1957) for China as a whole, much in line with structural transformation of developed economies in the late 19th and early 20th century. Having explored that a city's human capital level has a positive relationship with growth, this variable is included in the analysis, which is proxied by *teachers* representing the amount of teachers in secondary schooling, lacking consistent data on education attainment.

To control how different cities organize and uses the above factors a productivity variable is added. As outlined in chapter 2.1 productivity tells how well a production unit utilizes various factors to produce output, which are embodied in the skills of workers, technology used, and the institutional environment. To capture different productivity levels across Chinese cities, average *wages* are used. This variable is constructed from average wages of staff and workers. Higher wages are expected to reflect a high productivity level, and other locational advantages and better institutions (Glaeser, 2007). This variable then also expects to control efficiencies from transportation, natural resources and input gains. The effect from this variable is expected to have a positive impact on a city's economic development.

Starting from the late 1970s China became increasingly integrated internationally induced by the open door policies. The influence of foreign firms introduced new technology and business practises that were rapidly absorbed by local entrepreneurs. Coastal regions developed quickly abilities to mimic, supply, and build networks with foreign firms. This locational advantage was intensified at the expense of other disadvantageous regions (Ying, 2000). International trade, openness, and contractual work with foreign enterprises have taught cities to absorb spill overs (Sun, 2011). To control for this advantage, the variable *fdi* is included, and is constructed from amount of foreign capital actually used. The effect from FDI is expected to have a positive impact on ability to innovate, and thus on economic growth. Moreover, Du et al. (2008) found in their study of U.S. multinationals, that FDI location choice was highly related to better property rights protection, and thus, this effect is assumed to be captured through higher levels of FDI in a city.

Table 1 reports summary statistics of all variables described in this section. Under regional categories, the first column describes the number of cities in respective tiers. The following columns report the number of cities being within a given proximity from the economic centre.

Table 1. *Descriptive statistics of key variables*

Variable	Obs	Mean	Std. Dev.	Min	Max
dependent variable					
log.GDP	846	25.78495	1.022919	22.83445	28.41118
independent variables					
log.fixinv	778	24.66391	1.314927	21.20754	27.67362
log.labour	845	13.77814	.865479	11.52781	16.64276
log.teachers	844	9.863743	.6883906	7.600903	11.64308
log.wages	846	9.914307	.673238	8.446182	11.45102
log.fdi	800	20.54486	1.335113	15.69954	23.54637
regional categories	***Cities***	***centre100***	***centre200***	***centre300***	
Tier1	16	3	5	6	
Tier2	16	2	5	6	
Tier3	15	1	3	5	

3.3 Empirical Model Specification

The empirical model specification in this paper estimates an aggregate production function of Cobb-Douglas to model economic growth. In line with previous literature outlined in section 2.3 the following model is used to fit the purpose in this study:

$$\Delta GDP_{it} = \alpha + \varphi_1 Centre_i + \beta_2 X'_i + \sum_{n=1}^{c} tier_i + \varepsilon_{it}$$

where, α is the constant, *centre* the *i*:th economic centre, *X´* a vector of control variables, *tier* refer to tiers 1 to 3, and ε_{it} is the error term. The *centre* variable measures the growth centre *i*'s effect on city *i* weighted by their distance. Following e.g. Sun, Hong and Li (2010) the empirical testing will use Pooled OLS and Fixed Effects to analyse the effects of the given variables on GDP growth. Furthermore, Random Effects and Generalised Methods of Moments (GMM) models will be used to compare the estimation results. The stationary of the series is tested with LLC, IPS, ADF and PP tests. Unit root is found in levels but not in first differences, thus the following models uses variables in logged first differences. All variables passed the VIF test for multicollinearity and autocorrelation was rejected using Wooldridge test for autocorrelation in panel data. Test results are reported in Appendix B.

Three benchmark models are formulated by gradually adding variables:

$$log\ Y_{it} = \alpha + \beta_1 d.lncapital_{it} + \beta_2 d.lnlabor_{it} + \varepsilon \quad (1)$$

$$log\ Y_{it} = \alpha + \beta_1 d.lncapital_{it} + \beta_2 d.lnlabor_{it} + \beta_3 d.lnhumancap_{it} + \beta_4 d.lnwage_{it} + \varepsilon \quad (2)$$

$$log\ Y_{it} = \alpha + \beta_1 d.lncapital_{it} + \beta_2 d.lnlabor_{it} + \beta_3 d.lnhumancap_{it} + \beta_4 d.lnwage_{it} + \beta_5 d.lnfdi_{it} + \varepsilon \quad (3)$$

For the hypotheses testing the inclusion of economic centre dummy is necessary. For the model to allow for the binary-specific effect Pooled OLS estimations are used in an initial analysis. Time-invariant variables are omitted from FE models and therefore do not provide a feasible solution. The model below is applied to the three tiers respectively.

$$log\ Y_{it} = \alpha + \beta_1 d.lncapital_{it} + \beta_2 d.lnlabor_{it} + \beta_3 d.lnhumancap_{it} + \beta_4 d.lnwage_{it} + \beta_5 d.lnfdi_{it} + \delta\ centre_{\ i} + \varepsilon \quad (4)$$

where y_{it} is GDP in city *i* at time *t*, $\beta_{n\ it}$ factor variables δ the binary variable capturing proximity to the economic centre, and ε is the error term.

4 Results

This chapter presents the results from the models presented in the previous chapter. The benchmark model in section 4.1 is gradually extended for models 1-3. In section 4.2 the model 4 is applied for the three tiers respectively to test for the hypothesis. Finally, the robustness of the models is tested in section 4.3.

4.1 Benchmark Results

Table 1 reports the results from models (1), (2) and (3). In column (1) GDP is regressed on fixed capital investment and number of workers. Fixed investment has a positive sign and is significant at a 1 per cent level. The log-log relationship indicates a 2 per cent increase in GDP for a unit increase in fixed investments. Number of workers has a positive sign and is also significant at a 1 per cent level. In model (2) number of secondary school teachers and average wages are added. Wages enter the regression with a coefficient of 0.103 indicating an increase of 10 per cent in GDP for every unit increase in labour. Number of teachers is insignificant but has a positive sign. In model 3 FDI is included and increases the R-square value from 10 to 12 per cent. FDI has a marginal positive sign but is insignificant. The Hausman test results rejected the null hypothesis that random effects are appropriate and thus fixed effects provide good estimations. Model (3) has the highest R-squared value, and satisfies for further analysis. The weak statistical significance observed for variables in models two and three are expected to be attributed to spatial misspecification. In the following models the inclusion of *tier* controls are expected to eliminate the issue of weak significance.

Table 2. *Benchmark model*

	(1)	(2)	(3)
Dep. Var.	d.lngdp	d.lngdp	d.lngdp
d.lnfixinv	0.0209***	0.0208***	0.0184***
	(0.00613)	*(0.00658)*	*(0.00677)*
d.lnemp	0.0355***	0.0379***	0.0384***
	(0.00398)	*(0.00413)*	*(0.00420)*
d.lnteachers	-	0.0440	0.0419
		(0.0444)	*(0.0461)*
d.lnwage	-	0.103*	0.0838
		(0.0598)	*(0.0639)*
d.lnfdi	-	-	0.00535
			(0.00890)
Constant	0.137***	0.124***	0.128***
	(0.00135)	*(0.00692)*	*(0.00725)*
R-squared	0.093	0.108	0.124
No. cities	47	47	47
Hausman test	-	-	21.65***
Observations	716	712	621

*Cross section fixed effects, Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

4.2 Extension of Model

This section extends the benchmark model (3) to extract tier- specific effects, resulting to model (4). The model is applied separately for the three tiers and allow for hypotheses testing as presented in section 2.4. First, the binary variable representing economic centres only have a significant effect on the first tier. This finding tentatively support the hypothesis formulated in the paper. A city in tier 1 is able to benefit externalities from the economic centre, corresponding to a 3.6 per cent increase in output. The effect is statistically significant at a 5 per cent level. Secondly, this result supports the hypothesis that the explanatory power fades in the lower tiers 2 and 3. Compared to the lower tiers, the externalities absorbed by tier 1 are over 50 and 76 per cent higher than in tiers 2 and 3 respectively. However, neither tier 1 or 2 have a coefficient that is statistically different from zero.

Table 3. *Model extension*

	Tier 1	Tier 2	Tier 3
Dep. Var.	d.lngdp	d.lngdp	d.lngdp
D.lnfixinv	0.0334***	0.0231**	-0.000788
	(0.00977)	*(0.00952)*	*(0.0129)*
D.lnemp	0.0405***	0.0350***	0.0391***
	(0.00868)	*(0.00627)*	*(0.00799)*
D.lnteachers	0.134***	-0.0193	-0.0371
	(0.0506)	*(0.0381)*	*(0.0761)*
D.lnwage	0.211**	-0.00779	0.101
	(0.102)	*(0.0842)*	*(0.0886)*
D.lnfdi	-0.0192	0.00724	0.0272***
	(0.0197)	*(0.0111)*	*(0.0102)*
centre100	0.0359**	0.0175	0.00860
	(0.0153)	*(0.0112)*	*(0.0118)*
Constant	0.112***	0.136***	0.118***
	(0.0128)	(0.0110)	(0.0116)
R-squared	0.213	0.150	0.154
Observations	217	204	200

*Pooled OLS, Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

When controlling for tiers, all coefficients report statistical significance for at least one of the tiers, as expected. Fixed investment has the largest explanatory power in the first tier, with a coefficient of 0.33. Interestingly, FDI has most explanatory power on GDP growth in tier 3, whereas the effect in tier 2 is positive but insignificant. In tier 1, FDI has a negative sign. Wages only have significant effect on tier 1. A unit increase in wages increases the GDP by 21 per cent. Then, it may be viewed that low-cost labour is a driving force in the lower tiers compared to tier 1. Labour obtains significant results for all tiers. Tier 1 has the highest coefficient and decreases in power through tier 3 to 2. This finding implies that the variable is not sensitive to the level of development. The variable capturing human capital has a positive and significant sign only in tier 1, and tiers 2 and 3 have negative signs. In the above estimates the R-square value has increased from a previous 12.4 per cent to 15-21.3 per cent, tier 1 reporting highest model fit. This indicates that controlling for development is significant for growth. In the following models, the robustness of these results will be tested using different models and altering the time dimension.

Table 3 used Pooled OLS to estimate the results for the respective tiers. This implies that the sample has one common, 'pooled' intercept and neglects the cross-section and time series effects. Although this approach would in a normal setting be inconsistent and likely cause biased estimates, grouping the cities in tiers reduces this effect and can therefore provide useful results. While the FE model was found appropriate using the Hausman test, including a binary variable with FE is not possible due to its time-invariant nature. Thus, the estimated results will be treated with caution and examined further to check for the robustness.

4.3 Robustness Tests

First, the models in Table 3 will be tested using an RE model, allowing for the inclusion of the *centre* variable and comparing results from the previous estimates. Two analyses were conducted, with and without time fixed effects. Both confirmed the nature of the *centre* dummy. With time fixed effects, the coefficient for centre in tier 1 was 0.0319 whereas the estimate without the time effects was 0.0363 and both were statistically significant at a 5 per cent level. For tiers 2 and 3, all tests obtained positive but insignificant results for *centre*. Time fixed effects resulted in slightly lower power for *centre* in all tiers. For tier 1, all variables remained similar and kept the same sign when comparing the results from the Pooled OLS. In tier 2, the results without time fixed effects resulted in similar results, whereas when included, the coefficients for teachers and wages changed to positive, but remained insignificant. For tier 3, using time fixed effects turned employment into negative and lost its statistical significance. Teachers turned to positive but remained insignificant. The estimates for FDI remained robust in all versions for tier 3. When including other versions of the *centre* variable to control for cities within 200 and 300 km, none of the effects were significant. Results are reported in Appendix C.

Following the methodology of e.g. Sun et al. (2010) and Madariaga and Poncet (2007), a lagged dependent variable is included. For this, Generalized Methods of Moments (GMM) provide an attractive solution to correct for serial and spatial endogeneity between variables. In this analysis model (3) is used on GMM to compare the results from previous findings. In a series of initial tests tier 3 did not respond significantly to spill over effects from the economic centres, in line with previous findings. For tiers 1 and 2, however, the spatial distributions of externalities from the growth centres are positive and significant throughout a span from 100, 200 and 300 km from the source. This departs from prior findings. The significant contribution of the analyses when applying GMM is that the effect from *centre* persists longer, and spills further to tier 2. All obtained coefficients for the binary have a positive sign and are significant at 1, 5 or 10 per cent levels. Within the proximity of 100 km, Tier 1 cities exhibit on average 32 per cent higher growth due to the economic centre than tier 2 cities. When the parameter is relaxed another 100 km tier 1 cities advantage on average 45 per cent more, and 58 per cent more when comparing all cities from both tiers within 300 km from the centres. Table 8 in Appendix D reports the estimates for tiers 1 and 2 for three *centre* dummies representing 100 km, 200 km and 300 km distance from an economic centre.

Next the time dimension will be reorganized into two periods from 1994 to 2004 and 2005 to 2013 respectively. Using the model in Figure 3 this reorganization has the possibility to identify changes within the time dimension which can be of significance for the variable estimates, Table 5 below reports the results. Fixed investments increases in power for both tiers 1 and 2 throughout the time periods, and while showing a similar trend, the coefficients are insignificant for tier 3. Labour has most significance during the initial period, and all tiers obtain significant and positive coefficients, but are only significant for tier 1 in the latter period from 2005 to 2013. Wages obtains a negative and significant coefficient for tier 2 in the initial period whereas tiers 1 and 2 have positive signs but insignificant estimates. In the second period tiers 1 and 2 obtain statistically significant coefficients and positive signs, and tier 3 has a negative but insignificant sign. The higher power for the latter period could imply that as the economies mature the significance of higher paying jobs increases, whereas the initial period is driven with lower-paying jobs. This is especially evident for tier 2 which exhibits a negative and statistically significant coefficient for wages during 1996 to 2004, but a positive and significant result in the latter period. The effect from foreign investment is only significant in the latter period and exclusively for tier 1, whereas an increase in FDI corresponds to an increase in GDP growth by 4.2 per cent. The spill over effect from economic centres reports wider spread during 1996 to 2004 as tier 2 also obtains a positive and significant coefficient. Cities in tier 1 and 2 located within 100 km from the growth centres experience on average a 2.2 and 2 per cent increase in output from this effect respectively. In the latter period, tier 1 cities are the only cities benefiting significantly from these externalities, whereas tier 2 and 3 experience a negative effect, although insignificant.

Table 4. *1994-2004 and 2005-2013*

	1996-2004			*2005-2013*		
	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3
Dep. Var.	D.lngdp	D.lngdp	D.lngdp	D.lngdp	D.lngdp	D.lngdp
D.lnfixinv	0.0337***	0.0308***	0.00853	0.111***	0.109***	0.0305
	(0.0101)	*(0.00756)*	*(0.0116)*	*(0.0402)*	*(0.0388)*	*(0.0360)*
D.lnemp	0.0236***	0.0178***	0.0219***	0.0396**	0.0693	0.0172
	(0.00878)	*(0.00566)*	*(0.00733)*	*(0.0163)*	*(0.0461)*	*(0.0425)*
D.lnteachers	0.101	-0.0242	-0.136***	0.129**	-0.177	0.254***
	(0.0634)	*(0.0350)*	*(0.0464)*	*(0.0514)*	*(0.177)*	*(0.0901)*
D.lnwage	0.167	-0.151**	0.0844	0.298***	0.262***	-0.0677
	(0.123)	*(0.0683)*	*(0.115)*	*(0.109)*	*(0.0944)*	*(0.159)*
D.lnfdi	0.00179	0.00951	0.0138	0.0420***	-0.0112	0.0264
	(0.00965)	*(0.00953)*	*(0.00874)*	*(0.0135)*	*(0.0138)*	*(0.0160)*
centre100	0.0226*	0.0203*	0.00989	0.0197***	-0.00367	-0.00850
	(0.0132)	*(0.0110)*	*(0.0129)*	*(0.00696)*	*(0.00799)*	*(0.0140)*
Constant	0.105***	0.135***	0.104***	0.0890***	0.119***	0.159***
	(0.0151)	*(0.00962)*	*(0.0137)*	*(0.0160)*	*(0.0140)*	*(0.0190)*
R-squared	0.253	0.279	0.177	0.327	0.274	0.231
Observations	126	124	119	75	64	66

*Pooled OLS, Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Finally, a cross sectional analysis is done separately for the single year 2010. Here three economic centre dummies are included where the proximity to economic centre is relaxed gradually according to the previous method, to test the robustness of the variable for the sample as a whole, without defining city development. The final estimation builds on model (1) where GDP is regressed for fixed capital investments and labour. Additionally, two binary variables are included to control for Tiers 2 and 3, whereas Tier 1 is the reference variable. The choice of using model (1) was made due to high significance in model fit and coefficient power.

This explorative regression was employed to test the consistency for the dummies employed throughout these analyses, and is merely used to test if the coefficient signs hold. At a first review the results suggest the attenuation effect formulated for Figure 5. The effect from the economic centre fades the further away. The effect from within 100 km has a 36.9 per cent explanatory power on growth, whereas another 100 km fades the effect by one third, and a final 100 km one tenth. All effects are statistically significant at 1 or 5 per cent level. Fixed investments have the opposite direction than experienced in earlier models. When controlling for cities within 300 km from the growth centre, fixed investments obtain the highest power, with a coefficient 0.65, and weakens in power when controlling for stricter distances. This finding contradicts with prior findings. Employment remains relatively unchanged, consistent with earlier findings. The cross-sectional analysis for year 2010 reports higher power for all variables, and demonstrate in a simple setting the power of tier specific effects. Tiers 2 and 3 have on average 27.7 and 31 per cent lower effect on overall growth than tier 1 cities, when controlling for cities within 100 km from growth centres. This effect increases but in a weaker significance when controlling for growth cities within 200 km and 300 km distances from growth centres. Table 9 in Appendix E reports the results.

4.4 Discussion

The growth centres were found to diffuse positive externalities throughout the empirical analyses in this chapter. Findings support the theoretical presumptions outlined in chapter 2.2. In a variety of estimations, tier 1 was the strongest receiver of externalities. Depending on the model, the findings also provided support for positive spill overs to tier 2 at times. However, tier 3 was in none of the tests able to absorb significant effects. The externalities had strongest power on growth of receiving cities when the proximity was strictest. When the distance was relaxed, cities in tier 1 increased their ability of absorbing these effects in relation to the other tiers.

Using a rather homogenous sample of cities allowed for a closer examination of externality diffusion in China’s space economy. Yangtze and Pearl River Deltas were found to host advantageous conditions for positive externalities to take place. While Beijing has a strong economy, its region do not provide as dynamic environment as the former regions. The former regions are characterized by a relatively large amount of cities within close connections that have evolved interdependently accelerated by the open door policies. The agglomeration of cities within these areas support that the externalities are triggered by intensified interaction (Glaeser et al., 1998). The interesting findings of nearby cities at lower levels of development that do not acquire positive externalities from the growth centres corresponds to wider challenges in China.

This study used a tier classification that was constructed using a non-agricultural output to GDP ratio. The total range varied from a 99 per cent high for Shenzhen in Guangdong

Province to 80 per cent low for Zhoushan in Zhejiang Province. Analyses were unable to detect any positive spill overs to cities with 91 per cent or lower development ratio. This finding suggests that development is highly related to the ability to absorb positive spill overs from leader cities, consistent with Döring and Schnellenbach (2006). In Table 4 the time dimension was divided into two equal length periods. This allowed for a closer examination of the dynamics within the growth process. An interesting contribution from this analysis was that tiers 1 and 2 were able to absorb similar amounts of positive spill overs during the initial period, whereas only tier 1 reported positive results for the latter. If this is the case, tier 1 cities exhibit not only a robust performance in absorbing positive externalities from the growth centres, but also that this effect was intensified during the period in relation to the lower tier. During this time, Suzhou, a tier 1 city was able to climb to the high performers of overall GDP contribution while Jiaxing, a tier 2 city, has remained at the lower end. The results indicate that developed cities within proximity to growth centres have achieved above average growth when examined through per capita terms.

Tier 3 was the only reporting a positive and significant coefficient for increases in foreign direct investments. Intuitively this appears against the presumption established earlier. When FDI location choice generally corresponds to higher productivity areas, better institutions and locational advantages tier 1 would be expected to exhibit a positive and significant estimate. But given higher wages in these cities and the investment decision of expected returns, two possible scenarios are possible (Du et al., 2008). When the majority of FDI goes into export processing these decisions could be attracted by lower wage cities, and secondly, given the lower steady state levels, tier 3 cities are expected to achieve higher gains (Wen, 2014; Barro, 1997). This finding cannot, nevertheless, be interpreted conclusively as tier 1 cities were the only reporting positive and significant coefficients in the latter period. The relative gap between the investor and receiver defines the extent at which assimilation occur (Rodriguez-Pose and Crescenzi, 2008). Given the results and theoretical support, it seems that tier 3 cities do obtain capacities for spill overs diffused by foreign direct investments, but these may be in the lower ends of manufacturing. For developed cities it may infer that as higher productivity jobs are increasing the spill overs also intensifies, and thus, results to higher growth when the economies mature.

The dynamic business environment of the Pearl River Delta and Yangtze has been recognized in an increasing fashion since the open door policies were initiated. In Pearl River Delta, however, while initially having a favourable environment for low-cost labour through flows of inward migration, rising costs during the last decade have transformed the environment. New government initiatives have been undertaken to relocate labour intensive manufactures into periphery areas outside major cities (Liao and Chan, 2011). As the developed areas mature this is a great demonstration how advancements descend to lower tiers. Given such relocation, areas outside growth centres have the ability to become more independent. As Shenzhen and Guangzhou advance into more advanced activities, intensified through the relocation of lower-end production, their technological distance also appear. Polarization through factor mobility between growth centres and the periphery has contributed to the increasing development gap of cities (Liao and Wei, 2012). As the upper tier cities advance ahead of the lower tiers they intuitively diffuse matured activities to lower tiers in exchange of higher productivity. Tier 1 was the only obtaining significant and positive results for increases in wages, proxied for productivity. During the latter half of the time-series in Table 4, however, tier 2 obtained a near equivalent estimate with tier 1, exemplifying this process on the expense of tier 3 cities.

5 Concluding Remarks

This paper aimed to narrow the gap between agglomeration and spatial distribution of externalities. China offers an outstanding case study as the literature is limited and city level studies even more so. More importantly, as the extreme case of a few mega-cities and a large rural economy this approach contributes to the understanding what is needed for positive externalities to diffuse. Using a growth production function and classifying cities into three categories of developmental stages allowed a new entrance into understanding spatial differences in China. The evidence in this paper supports the existence of conditional spill overs from growth centres into the periphery. This finding is consistent with previous literature that externalities impact the growth of other cities. When these externalities take place, the leaders diffuse their technological institutions and practices to the receiving cities. Therefore, cities within proximity of growth centres do not absorb such externalities simply due to their vicinity, but require the institutional willingness and ability to assimilate the spill overs.

The proximity to dynamic economic activities is the driving force in prospering cities. Agglomerations of events are intensified by close interaction to diverse skills. Through these mechanisms tacit knowledge spreads between actors. The results in this paper shed light on this effect between similar and interconnected cities. Similarly, the effect fades the further the gap. For cities to benefit from leaders this paper provides a few key findings. Linkages strengthen the impact in externality diffusion between leader and receiving cities. For these to take place, however, the institutions between the parties need to level. This implies that less developed cities should intensify linkages between similar cities to benefit from agglomeration, rather than relying on linkages with too large of a gap, to avoid the effect of polarization.

References

Andersson, F. N., Edgerton, D. L., & Opper, S. (2013). A matter of time: revisiting growth convergence in China. *World Development*, *45*, 239-251.

Bai, C. E., Ma, H., & Pan, W. (2012). Spatial spillover and regional economic growth in China. *China Economic Review*, *23*(4), 982-990.

Barro, R. J. (1991). A cross-country study of growth, saving, and government. In *National saving and economic performance* (pp. 271-304). University of Chicago Press.

Barro, R. J. (1997). *Determinants of economic growth : a cross-country empirical study*. Cambridge, Mass. : MIT, 1997.

Brun, J. F., Combes, J. L., & Renard, M. F. (2002). Are there spillover effects between coastal and noncoastal regions in China?. *China Economic Review*, *13*(2), 161-169.

Barro, R. J., & Sala-i-Martin, X. (2004). Economic Growth: MIT Press. *Cambridge, Massachusettes*.

Cai, F., & Lu, Y. (2013). Population change and resulting slowdown in potential GDP growth in China. *China & World Economy*, *21*(2), 1-14.

Chen, J., & Fleisher, B. M. (1996). Regional income inequality and economic growth in China. *Journal of comparative economics*, *22*(2), 141-164.

Cowan, R., David, P. A., & Foray, D. (2000). The explicit economics of knowledge codification and tacitness. *Industrial and corporate change*, *9*(2), 211-253.

Dollar, D. (2013) China's Rebalancing: Lessons from East Asian Economic History.

Deininger, K., Jin, S., Xia, F., & Huang, J. (2014). Moving off the farm: Land institutions to facilitate structural transformation and agricultural productivity growth in China. *World Development*, *59*, 505-520.

Durlauf, S. N., & Blume, L. (2010). *Economic growth*. Basingstoke [England] ; New York: Palgrave Macmillan

Du, J., Lu, Y., & Tao, Z. (2008). Economic institutions and FDI location choice: Evidence from US multinationals in China. *Journal of comparative Economics*, *36*(3), 412-429.

Döring, T., & Schnellenbach, J. (2006). What do we know about geographical knowledge spillovers and regional growth?: a survey of the literature. *Regional Studies*, *40*(03), 375-395.

Ernst, D., & Kim, L. (2002). Global production networks, knowledge diffusion, and local capability formation. *Research policy*, *31*(8), 1417-1429.

Feldman, M. P., & Florida, R. (1994). The geographic sources of innovation: technological infrastructure and product innovation in the United States. *Annals of the Association of American Geographers*, *84*(2), 210-229.

Fu, X., & Gong, Y. (2011). Indigenous and foreign innovation efforts and drivers of technological upgrading: evidence from China. *World development*, *39*(7), 1213-1225.

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A., & Shleifer, A. (1991). *Growth in cities* (No. w3787). National Bureau of Economic Research.

Glaeser, E. L. (1994). Cities, information, and economic growth. *Cityscape*, *1*(1), 9-47.

Glaeser, E. L. (1998). Are cities dying?. *The Journal of Economic Perspectives*, *12*(2), 139-160.

Glaeser, E. L. (2007a). *The economics approach to cities* (No. w13696). National Bureau of Economic Research.

Glaeser, E. L. (2007b). *Entrepreneurship and the City* (No. w13551). National Bureau of Economic Research.

Glaeser, E. L., & Gottlieb, J. D. (2009). *The wealth of cities: Agglomeration economies and spatial equilibrium in the United States* (No. w14806). National Bureau of Economic Research.

Glaeser, E. L., Ponzetto, G. A., & Tobio, K. (2014). Cities, skills and regional change. *Regional Studies*, *48*(1), 7-43.

Guo, R., & Guo, L. (2013). *Regional China: a business and economic handbook*. Palgrave Macmillan.

Grant, K. A. (2007). Tacit knowledge revisited–we can still learn from Polanyi. *The Electronic Journal of Knowledge Management*, *5*(2), 173-180.

Hong, L. (1999). A tale of two cities. A comparative study of the political and economic development of Chengdu and Chongqing. *Cities in China: Recipes for Economic Development in the Reform Era (London: Routledge Studies on China in Transition, 1999)*, 183-214.

Jarreau, J., & Poncet, S. (2012). Export sophistication and economic growth: Evidence from China. *Journal of development Economics*, *97*(2), 281-292.

Jiang, Y. (2011). Understanding openness and productivity growth in China: An empirical study of the Chinese provinces. *China Economic Review*, *22*(3), 290-298.

Jiang, Y., & Shen, J. (2010). Measuring the urban competitiveness of Chinese cities in 2000. *Cities*, *27*(5), 307-314.

Ke, S. (2015). Domestic market integration and regional economic growth—China's recent experience from 1995–2011. *World Development*, *66*, 588-597.

Krugman, P. (1998). What's new about the new economic geography?. *Oxford review of economic policy*, *14*(2), 7-17.

Krugman, P. (2011). The new economic geography, now middle-aged. *Regional Studies*, *45*(1), 1-7.

Li, D. D. (1998). Changing incentives of the Chinese bureaucracy. *The American Economic Review*, *88*(2), 393-397.

Li, C., & Gibson, J. (2013). Rising regional inequality in China: Fact or artifact?. *World Development*, *47*, 16-29.

Li, Y., & Wei, Y. D. (2010). The spatial-temporal hierarchy of regional inequality of China. *Applied Geography*, *30*(3), 303-316.

Lin, J. Y., Cai, F., & Li, Z. (2009). 13 The lessons of China's transition to a market economy. *Governing Rapid Growth in China: Equity and Institutions*, *78*, 325.

Liao, H. F., & Chan, R. C. (2011). Industrial relocation of Hong Kong manufacturing firms: towards an expanding industrial space beyond the Pearl river delta. *GeoJournal*, *76*(6), 623-639.

Liao, F. H., & Wei, Y. D. (2012). Dynamics, space, and regional inequality in provincial China: A case study of Guangdong province. *Applied Geography, 35*(1), 71-83.

Madariaga, N., & Poncet, S. (2007). FDI in Chinese cities: Spillovers and impact on growth. *The World Economy*, *30*(5), 837-862.

Marshall, A. (1890). Principles of political economy. *Maxmillan, New York*.

Montinola, G., Qian, Y., & Weingast, B. R. (1995). Federalism, Chinese style: the political basis for economic success in China. *World politics*, *48*(01), 50-81.

Myrdal, G. (1957). Economic Theory and Underdeveloped Regions (London: Duckworth, 1957). *Rich Lands and Poor*.

Naughton, B. (2007). *The Chinese economy: Transitions and growth*. MIT press.

Nee, V., Opper, S., & Wong, S. M. (2007). Politicized capitalism: developmental state and the firm in China. *On capitalism*, 93-127.

Nee, V., & Opper, S. (2012). *Capitalism from below*. Harvard University Press.

Ni, P. (2009). Blue Book of City Competitiveness: China Urban Competitiveness Report NO7. Beijing Social Sciences Academic Press.

Ni, P., Kresl, P., & Li, X. (2014). China urban competitiveness in industrialization: Based on the panel data of 25 cities in China from 1990 to 2009. *Urban Studies*, *51*(13), 2787-2805.

Romer, P. M. (1986). Increasing returns and long-run growth. *The journal of political economy*, 1002-1037.

Rodríguez-Pose, A., & Crescenzi, R. (2008). Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe. *Regional studies*, *42*(1), 51-67.

Simon, C. J., & Nardinelli, C. (2002). Human capital and the rise of American cities, 1900–1990. *Regional Science and Urban Economics*, *32*(1), 59-96.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics*, 65-94.

Sun, L., Hong, E., & Li, T. (2010). Incorporating Technology Diffusion, Factor Mobility and Structural Change into cross-region Growth Regression: An application to China. *Journal of Regional Science*, *50*(3), 734-755.

Swan, T. W. (1956). Economic growth and capital accumulation. *Economic record*, *32*(2), 334-361.

Sørensen, P. B., & Whitta-Jacobsen, H. J. (2005). *Introducing advanced macroeconomics*. McGraw-Hill Education.

Weil D. *Economic Growth* (2005). Boston, Mass. : Addison-Wesley

Wen, Y. (2014). The spillover effect of FDI and its impact on productivity in high economic output regions: A comparative analysis of the Yangtze River Delta and the Pearl River Delta, China. *Papers in Regional Science*, *93*(2), 341-365.

Whalley, J., & Xin, X. (2010). Forthcoming."Regionalization, Changes in Home Bias, and the Growth of World Trade.". *Journal of Policy Modeling.*

World Bank (1993). The East Asian Miracle, Oxford University Press

Yao, S., & Zhang, Z. (2001). Regional growth in China under economic reforms. *Journal of Development Studies*, *38*(2), 167-186.

Ye, X., & Wei, Y. D. (2005). Geospatial analysis of regional development in China: the case of Zhejiang Province and the Wenzhou model. *Eurasian Geography and Economics*, *46*(6), 445-464.

Ying, L. G. (2000). Measuring the spillover effects: some Chinese evidence. *Papers in regional science*, *79*(1), 75-89.

Ying, L. G. (2003). Understanding China's recent growth experience: A spatial econometric perspective. *The Annals of Regional Science*, *37*(4), 613-628.

Zhang, L. Y. (2003). Economic development in Shanghai and the role of the state. *Urban Studies*, *40*(8), 1549-1572.

Appendix A

Table 5. *List of sample cities*

id	province	city	centre	centre300	centre200	centre100	tier 1	tier 2	tier 3
1	Beijing	Beijing	yes	0	0	0	yes		
2	Tianjin	Tianjin	yes	0	0	0	yes		
3	Hebei	Shijiazhuang City	-	0	0	0			yes
4	Hebei	Qinhuangdao City	-	1	0	0			yes
5	Liaoning	Shenyang City	-	0	0	0		yes	
6	Liaoning	Dalian City	-	0	0	0		yes	
7	Jilin	Changchun City	-	0	0	0			yes
8	Heilongjiang	Harbin City	-	0	0	0			yes
9	Shanghai	Shanghai	yes	0	0	0	yes		
10	Jiangsu	Nanjing City	-	1	0	0	yes		
11	Jiangsu	Wuxi City	-	1	1	0	yes		
12	Jiangsu	Xuzhou City	-	0	0	0			yes
13	Jiangsu	Changzhou City	-	1	1	0		yes	
14	Jiangsu	Suzhou City	-	1	1	1	yes		
15	Jiangsu	Nantong City	-	1	1	0			yes
16	Zhejiang	Hangzhou City	-	1	1	0		yes	
17	Zhejiang	Ningbo City	-	1	0	0		yes	
18	Zhejiang	Wenzhou City	-	0	0	0	yes		
19	Zhejiang	Jiaxing City	-	1	1	1		yes	
20	Zhejiang	Huzhou City	-	1	1	0			yes
21	Zhejiang	Shaoxing City	-	1	1	0		yes	
22	Zhejiang	Zhoushan City	-	1	0	0			yes
23	Zhejiang	Taizhou City	-	0	0	0			yes
24	Anhui	Hefei City	-	0	0	0			yes
25	Fujian	Fuzhou City	-	0	0	0			yes
26	Fujian	Xiamen City	-	0	0	0	yes		
27	Fujian	Quanzhou City	-	0	0	0		yes	
28	Jiangxi	Nanchang City	-	0	0	0		yes	
29	Shandong	Ji'nan City	-	0	0	0		yes	
30	Shandong	Qingdao City	-	0	0	0		yes	
31	Shandong	Yantai City	-	0	0	0			yes
32	Shandong	Weihai City	-	0	0	0			yes
33	Henan	Zhengzhou City	-	0	0	0	yes		
34	Hubei	Wuhan City	-	0	0	0	yes		
35	Hunan	Changsha City	-	0	0	0		yes	
36	Guangdong	Guangzhou City	yes	0	0	0	yes		
37	Guangdong	Shenzhen City	yes	0	0	0	yes		
38	Guangdong	Zhuhai City	-	1	1	0	yes		
39	Guangdong	Foshan City	-	1	1	1	yes		
40	Guangdong	Huizhou City	-	1	1	1			yes
41	Guangdong	Dongguan City	-	1	1	1	yes		
42	Guangdong	Zhongshan City	-	1	1	1		yes	
43	Hainan	Haikou City	-	0	0	0	yes		
44	Chongqing	Chongqing	-	0	0	0			yes
45	Sichuan	Chengdu City	-	0	0	0		yes	
46	Yunnan	Kunming City	-	0	0	0		yes	
47	Shaanxi	Xi'an City	-	0	0	0		yes	

Appendix B

The following table reports results from unit-root tests. The following tests were conducted: Levin-Lin-Chu (LLC), Im-Pesaran-Shin (IPS), Maddala and Wu (Fisher-test, MW), and Pesaran 2007 test (CIPS). In the LLC test the Adjusted t-statistic is reported. However, due to missing observations in some of the variables, this test could not be performed for all. The IPS test reports the W-t-bar statistic. In the MW test, the modified inv. Chi-squared Pm statistic is reported, due to large *n* and small *t*. The CIPS test reports the t-bar. All variables were found stationary in logged first differences, at a 1 per cent significance level.

Variables	**LLC**	**IPS**	**MW**	**CIPS**
d.lngdp	-9.6458***	-8.0888 ***	11.7797***	-3.241***
d.lnfixinv	-	-21.0106***	59.4084***	-18.346***
d.lnemp	-	-16.1741***	34.9478***	-10.093***
d.lnteachers	-	-43.8859***	126.9896***	-12.819***
d.lnwage	-16.2058***	-14.6043***	32.7899***	-3.090***
d.lnfdi	-	-14.3421***	34.2014***	-9.950***

*Notes: Hereafter, ***, ** and * indicate the significance level of critical value to test at 1 %, 5 % and 10 % respectively*

Table below reports the correlation matrix. Results show no alarming correlation when variables are in logged first differences. The second table reports centered VIF test results.

	d.lngdp	*d.lnfixinv*	*d.lnemp*	*d.lnteachers*	*d.lnwage*	*d.lnfdi*
d.lngdp	1.0000					
d.lnfixinv	0.1782	1.0000				
d.lnemp	0.2915	0.2174	1.0000			
d.lnteachers	0.0848	-0.1339	-0.0367	1.0000		
d.lnwage	0.0340	0.0355	-0.1384	0.1057	1.0000	
d.lnfdi	0.0807	0.1522	0.0777	0.0487	0.1218	1.0000

Variables	**VIF**	**1/VIF**
d.lnwage	1.78	0.562651
d.lnfixinv	1.57	0.635811
d.lnfdi	1.19	0.842423
d.lnemp	1.12	0.895520
d.lnteachers	1.07	0.932049
Mean VIF	1.35	

Appendix C

Table 6. Random Effects model (3)

	Tier 1	Tier 2	Tier 3
Dep. Var.	D.lngdp	D.lngdp	D.lngdp
D.lnfixinv	0.0329***	0.0231***	-0.000861
	(0.0117)	*(0.00561)*	*(0.0133)*
D.lnemp	0.0409***	0.0350***	0.0391***
	(0.00794)	*(0.00548)*	*(0.00963)*
D.lnteachers	0.132**	-0.0193	-0.0372
	(0.0535)	*(0.0385)*	*(0.0806)*
D.lnwage	0.214*	-0.00779	0.101
	(0.118)	*(0.107)*	*(0.0860)*
D.lnfdi	-0.0198	0.00724	0.0272**
	(0.0219)	*(0.0100)*	*(0.0134)*
centre100	0.0363**	0.0175	0.00860
	(0.0164)	*(0.0192)*	*(0.00823)*
Constant	0.111***	0.136***	0.118***
	(0.0137)	*(0.0145)*	*(0.0106)*
No. cities	16	16	15
Observations	217	204	200

*RE model, Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

Table 7. *Random Effects model (3) including time fixed effects*

	Tier 1	Tier 2	Tier 3
Dep. Var.	D.lngdp	D.lngdp	D.lngdp
D.lnfixinv	0.0161*	0.0167***	-0.00512
	(0.00907)	*(0.00415)*	*(0.0107)*
D.lnemp	0.0154**	0.00180	0.0165
	(0.00601)	*(0.00496)*	*(0.0159)*
D.lnteachers	0.163***	0.0457	0.0224
	(0.0465)	*(0.0918)*	*(0.122)*
D.lnwage	0.215**	0.0405	0.0383
	(0.0962)	*(0.0816)*	*(0.0625)*
D.lnfdi	-0.0202	0.00615	0.0237***
	(0.0177)	*(0.0102)*	*(0.00813)*
centre100	0.0319**	0.0123	0.00489
	(0.0147)	*(0.0153)*	*(0.00916)*
time fixed effects	*yes*	*yes*	*yes*
Constant	0.135***	0.142***	0.126***
	(0.0163)	*(0.0274)*	*(0.0275)*
Observations	217	204	200
No. cities	16	16	15

*RE model, Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

Appendix D

The following regression results are made on System GMM for robustness tests. The GMM corrects for serial and spatial endogeneity (Sun, Hong and Li, 2010). The models below use logged first differences and lags of the dependent variable as instrument, consistent with that by Sun, Hong and Li (2010). The lag specification chosen for the below analyses uses 1/5 lags of the dependent variable as instrument.

Table 8. *System GMM model (3)*

	(1) GMM	(2) GMM	(3) GMM	(4) GMM	(5) GMM	(6) GMM
	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2
Dep. Var.	D.lngdp	D.lngdp	D.lngdp	D.lngdp	D.lngdp	D.lngdo
D.l1_gdp	-0.0595	0.106***	-0.0618	0.111***	-0.0663	0.112***
	(0.0436)	*(0.0339)*	*(0.0444)*	*(0.0333)*	*(0.0437)*	*(0.0329)*
D.lnfixinv	0.116***	0.0491***	0.103***	0.0514***	0.105***	0.0513***
	(0.0404)	*(0.0112)*	*(0.0388)*	*(0.0111)*	*(0.0392)*	*(0.0110)*
D.lnemp	0.0838***	0.0669***	0.0855***	0.0620***	0.0863***	0.0613***
	(0.0286)	*(0.0229)*	*(0.0298)*	*(0.0231)*	*(0.0311)*	*(0.0233)*
D.lnteachers	0.0221	-0.545**	0.0528	-0.528**	0.0393	-0.528**
	(0.196)	*(0.253)*	*(0.173)*	*(0.255)*	*(0.185)*	*(0.251)*
D.lnwage	0.190	-0.113	0.153	-0.110	0.0919	-0.115
	(0.122)	*(0.160)*	*(0.155)*	*(0.171)*	*(0.182)*	*(0.177)*
D.lnfdi	-0.0891*	0.00284	-0.0847*	-0.000937	-0.0840*	-0.000301
	(0.0504)	*(0.0136)*	*(0.0500)*	*(0.0141)*	*(0.0503)*	*(0.0140)*
centre100	0.0838***	0.0571**	-	-	-	-
	(0.0266)	*(0.0234)*				
centre200	-	-	0.0591**	0.0324*	-	-
			(0.0296)	*(0.0174)*		
centre300	-	-	-	-	0.0623**	0.0263*
					(0.0308)	*(0.0148)*
time effects	-	-	-	-	-	-
Constant	0.102***	0.158***	0.104***	0.154***	0.107***	0.154***
	(0.0137)	*(0.0239)*	*(0.0190)*	*(0.0243)*	*(0.0203)*	*(0.0252)*
AR(1) p-value	0.006	0.017	0.007	0.016	0.008	0.016
AR(2) p-value	0.496	0.142	0.481	0.126	0.465	0.126
No. cities	16	16	16	16	16	16
No. instruments	68	51	68	51	68	51
Observations	186	173	186	173	186	173

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*

The results for first and second order serial correlation indicate that the above estimates do not have serially correlated error terms. AR1 received a negative and significant coefficient, whereas AR2 obtained a positive and insignificant coefficient, supporting that the moment conditions are well specified (Madariaga and Poncet, 2007).

Appendix E

Table 9. *2010 cross-sectional model (1)*

	1. 100 km	2. 200 km	3. 300 km
Dep. Var.	lngdp	lngdp	lngdp
lnfixinv	0.622***	0.642***	0.655***
	(0.0916)	*(0.0993)*	*(0.102)*
lnemp	0.336***	0.319***	0.322***
	(0.106)	*(0.111)*	*(0.116)*
tier2	-0.277**	-0.305**	-0.305**
	(0.111)	*(0.115)*	*(0.118)*
tier3	-0.313**	-0.335***	-0.349***
	(0.122)	*(0.123)*	*(0.129)*
centre	0.369**	0.243***	0.220**
	(0.161)	*(0.0883)*	*(0.0926)*
Constant	5.942***	5.654***	5.259**
	(1.620)	*(1.814)*	*(1.983)*
R-squared	0.875	0.869	0.866
Observations	47	47	47

*OLS estimation, Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*

In the above analyses the effects from economic centres demonstrate attenuation. The key findings are that the effects from centres are strongest within 100 km whereas another 100 km reports the steepest fall in power. Tier effects are in relation to tier 1. These coefficients are interpreted as cities within the given distance control from the growth centre exhibit on average the given coefficient effect on growth, in relation to tier 1. Thus, tier 2 and 3 experiences on average 30.5 and 33.5 per cent less power on growth compared to tier 1, when controlling for cities within 200 km from growth centres.