China’s lagging region development and targeted transportation infrastructure investments

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1 Introduction

The economic growth in China since the late 1970s has been spectacular. With an average annual GDP growth of almost 10% for 25 years, China has outpaced many developing countries and become one of the largest economic powers in the world. Accompanied by a moderate population growth, the GDP per capita increased 7 times from 153 USD in 1978 to 1067 USD in 2003 (constant 2000 US$).[1] This overall progress has made tremendous strides towards reducing poverty, helping to lift 400 million Chinese out of extreme poverty since 1981, which is by far the fastest and largest rate of poverty reduction ever recorded (World Development Report, 2005).

However, the unprecedented growth performance was accompanied by an increasing regional disparity. The western region, which covers more than 70% of the total surface and inhabits about 30% of the population, is lagging behind. Two decades after the reform, the GDP per capita of most western provinces is less than half of the national average. The widening of the regional gap undermines the long term growth potential and weakens the social stability of the entire Chinese economy. Combining growth with a more balanced distribution of income has become one of the guiding tenets of the development plans of the Government of China. In 1999, the Western Development Plan was launched to resume the preoccupation of “regional balanced growth” and to encourage the catching-up of the western region.

Infrastructure is at the core of the Western Development Plan. The rapid economic development generates large demand for infrastructure facilities. However, China’s investment in infrastructure has not kept pace with demand, and the shortage of

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[1] Data source: World Development Indicators, 2005.

transport facilities has been a major bottleneck that constrains economic growth for a long time.[2] Improving infrastructure network is critical to boost the catching-up of the lagging western region that suffers disproportionately high transport costs due to both their geographic remoteness and the poor infrastructure facilities.

However, transportation infrastructure investment policies that maximize the national growth may not have strong impacts in the west; and those privilege the west may not have satisfactory outcomes at the national level. This paper attempts to address the question on how to target transportation infrastructure investments and optimize the impacts of the limited fiscal resources to encourage the development of the western region without unnecessarily compromising the national growth.

This paper has three objectives i) measuring the role of the transportation infrastructure development in different locations on economic performance; ii) evaluating the optimal location choice of putting transportation infrastructures to rebalance regional growth; and iii) simulating the trade-offs between the effects on maximizing aggregate growth and reducing regional disparity to compare the alternative transportation infrastructure investment allocation policies.

Using the panel data at the provincial level in the period of 1978-2003, this paper develops the indicator "peripheral degree" to measure the effective remoteness of a province to the economic centers to take into account both the effects of distance and transport facility development, and studies its role in regional growth determination. The empirical analysis simulates the effects of the different transportation infrastructure investment allocation and examines the trade-offs between maximizing national growth and reducing regional disparities. The results show that additional infrastructure investments in coastal region may have the largest impacts on national aggregate growth at the expense of a widening regional gap; randomly putting infrastructure in the west will not have the optimal effects on enhancing growth or on reducing regional disparity. To effectively rebalance the regional development, it is important to target investments in central transportation hubs. Two reasons: first, improving the infrastructure facilities in transport hubs most effectively reduces the transport cost and enhances the market access

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[2] See Wu (1999).

of the western region to economic centers; second, investing in central provinces encourages their emergence as future economic centers and modifies the geo-economic structure mapping of the entire Chinese economy in favor of the remote lagging regions. The large infrastructure investments in the recent years would have been more effective in increasing national growth and reducing regional disparities if an appropriate amount were targeted in the central transportation hubs.

The paper is structured as follows: Section 2 reviews the spectacular growth performance, the increasing regional disparities, and the uneven development of transportation infrastructures in China. Section 3 studies the role of geo-economic position in regional growth determination. Section 4 simulates the induced growth impacts of putting transportation infrastructures in different provinces, and identifies the optimal investment location for regional balanced growth. Section 5 examines the trade-offs between maximizing aggregate growth and reducing regional disparity, and compares the effectiveness of the alternative transportation infrastructure investment policies on western development. Section 6 concludes.

2 Rapid economic growth, increasing regional disparity and uneven development of infrastructure facilities

Using the panel data at the provincial level in the period of 1978-2003, this section provides empirical evidence on the rapid economic growth, the increasing regional disparity and the uneven development of infrastructure facilities in China.

2.1 Rapid growth of the Chinese economy

The Chinese economy has grown rapidly since the reforms in 1978. With an average annual GDP growth of 9.5%, which translated to an 8% annual growth in per capita terms, the size of the economy has increased more than 9 times from 1978 to 2003. Such extraordinary growth performance significant outpaced that of many countries, including most South-East Asian countries that also enjoyed a miraculous growth (Table 1).

Table 1: GDP growth rate of some countries

	Average annual GDP growth rate (%)

	(1978-2003)
China	9.5
Korea, Rep.	6.84
Vietnam	6.57
Malaysia	6.38
Thailand	6.17
Indonesia	5.56
United States	3.08
Philippines	2.95
Japan	2.71
High income	2.8
Upper middle income	2.35
Lower middle income	3.92
Low income	4.25
World	2.91

Data source: World Development Indicators, 2005.

All provinces grew rapidly with an annual growth rate of at least 6% (table 2).[3] With a double-digit annual growth rate, some coastal provinces, such as Jiangsu, Zhejiang, Fujian, Shandong and Guangdong, increased their real GDP per capita more than 12 times in 25 years. Guangdong, Shanxi and Ningxia shared the similar development level in 1978, while thanks to the extraordinary economic performance in the past 25 years, the GDP per capita of Guangdong was more than twice that of its two inland partners in 2003.

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[3] Chinese provinces are classified into three categories: coastal, central, and west. The coastal region includes Liaoning, Hebei, Beijing, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Hainan; the central region includes Heilongjiang, Jilin, Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi; the western region includes Nei Mongol, Guangxi, Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, Chongqing, Sichuan, Yunnan, Guizhou, Xizang. The central region and the western region are considered as the inland regions. See annex 1 for more details. In this study, we exclude Xizang and Hainan (an island without direct highways/railways connections to the mainland) from the sample for their special characteristics.

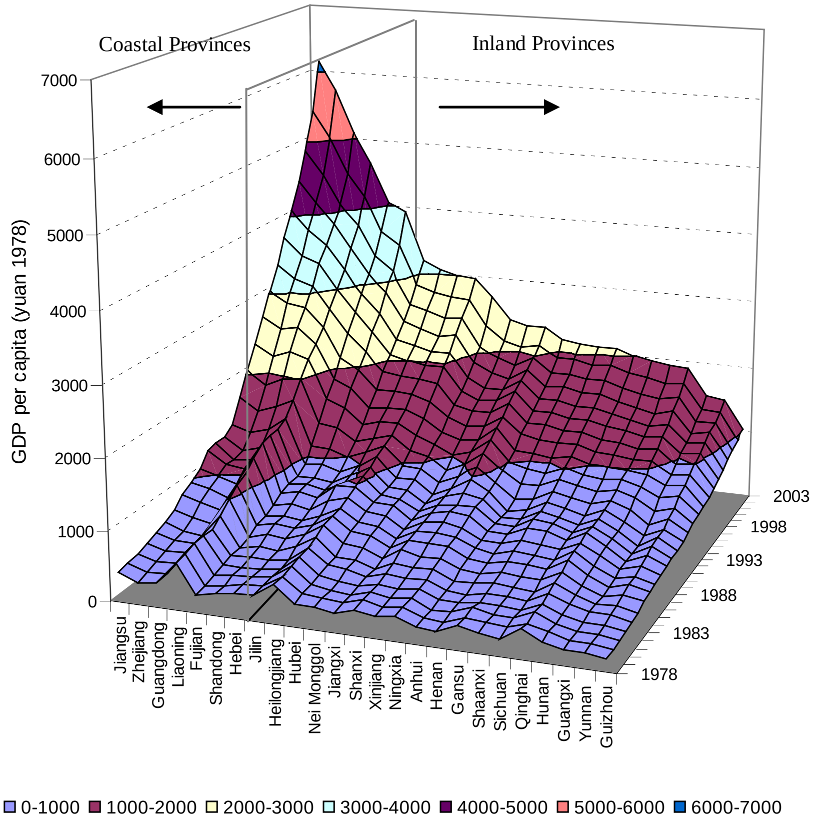
Table 2: Provincial GDP Per Capita and Annual Growth Rate

	Average GDP per capita (yuan 1978)				**Average annual GDP per capita growth rate**				
	78-84	*85-90*	*91-97*	*98-03*	*79-84*	*85-90*	*91-97*	*98-03*	*79-03*
Coastal region									
Beijing	1531	2444	4141	6832	7.65%	5.72%	9.14%	7.03%	7.46%
Tianjin	1403	2145	3401	6623	7.36%	4.16%	10.45%	9.95%	8.08%
Hebei	421	696	1342	2571	6.25%	6.74%	12.40%	8.79%	8.70%
Liaoning	786	1348	2181	3714	6.71%	6.55%	8.78%	8.59%	7.70%
Shanghai	2956	4519	7690	13766	6.13%	4.96%	10.96%	7.46%	7.52%
Jiangsu	562	1122	2376	4789	9.39%	9.07%	13.69%	10.01%	10.67%
Zhejiang	478	991	2213	4454	11.75%	8.39%	15.07%	9.86%	11.42%
Fujian	369	695	1638	3286	9.88%	8.56%	15.49%	8.59%	10.83%
Shandong	410	737	1541	3064	9.46%	6.67%	13.73%	9.91%	10.09%
Guangdong	479	963	2260	4078	8.63%	10.99%	13.72%	8.30%	10.54%
Central region									
Shanxi	446	712	1106	1847	8.50%	4.33%	8.64%	7.98%	7.41%
Jilin	470	840	1395	2486	8.33%	6.66%	9.66%	8.44%	8.33%
Heilongjiang	652	953	1440	2422	5.86%	5.22%	7.41%	8.30%	6.73%
Anhui	312	550	939	1754	9.31%	5.39%	11.94%	7.45%	8.66%
Jiangxi	346	568	1030	1885	7.61%	6.61%	11.33%	8.54%	8.64%
Henan	307	529	932	1695	9.38%	6.33%	11.02%	8.09%	8.80%
Hubei	436	750	1283	2424	9.31%	5.87%	11.10%	8.48%	8.78%
Hunan	345	536	880	1558	6.42%	5.67%	9.79%	8.11%	7.59%
Western region									
Nei Monggol	408	728	1162	2067	8.92%	6.89%	8.57%	9.95%	8.58%
Guangxi	265	375	717	1242	5.32%	4.88%	12.00%	7.68%	7.65%
Sichuan	323	550	914	1575	8.32%	6.40%	9.58%	8.29%	8.20%
Guizhou	224	375	550	864	9.49%	4.90%	6.97%	7.36%	7.17%
Yunnan	275	476	791	1255	7.68%	7.79%	8.28%	6.22%	7.52%
Shaanxi	346	609	953	1626	6.62%	7.64%	8.13%	8.41%	7.72%
Gansu	376	636	1018	1700	4.30%	8.36%	7.86%	8.07%	7.17%
Qinghai	465	691	935	1516	4.97%	4.17%	6.16%	8.68%	6.00%
Ningxia	429	720	1051	1744	6.34%	6.83%	7.18%	7.90%	7.07%
Xinjiang	404	739	1291	1960	8.94%	8.06%	8.90%	5.97%	8.00%

Data Source: China Statistical Yearbooks and author's calculations. The data of Chongqing are included in Sichuan for better coherence. We exclude Hainan and Xizang because of their special characteristics.

Since the mid 1990s, all the coastal provinces have become richer than the inland provinces (graph 1). Among the inland provinces, the remote western provinces lag further behind and lose their standing in the relative income ladder (see for example, Chen and Fleisher, 1996 ; Kanbur and Zhang, 1999 ; Lee, 2000 ; Kim and Knaap, 2001 ; Hu, 2002 ; Wu, 2002 ; Luo, 2003; Aziz and Duenwald, 2003).[4]

Graph 1 Widening development gap between coastal provinces and inland provinces 1978-2003 (Beijing, Tianjin and Shanghai excluded)



2.2 Widening regional development gap and twin-peak emergence

The unprecedented economic growth and poverty reduction in China have been accompanied by rapidly increasing inequality. At the sub-national level, the fruits of economic growth have not been evenly shared across the society. The ratio of average income of the richest decile of the population to that of the poorest decile has increased from 7 times in 1981 to 18 times in 2001 (Ravallion and Chen, 2004). The Gini coefficient increased 50% from 31 to 45 (graph 2). Rising inequality, which will result in the sub-optimal allocation of resources, will weaken the long-term growth potential. Using panel data of Chinese provinces of 1981-2001, Ravallion and Chen (2004) argue

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[4] Despite the rapid absolute growth compared with most economies worldwide, the inland provinces suffered a relative decline in the Chinese economy.

that the increasing inequality in opportunities will engender non-satisfaction, and undermine the social unity of the entire China.

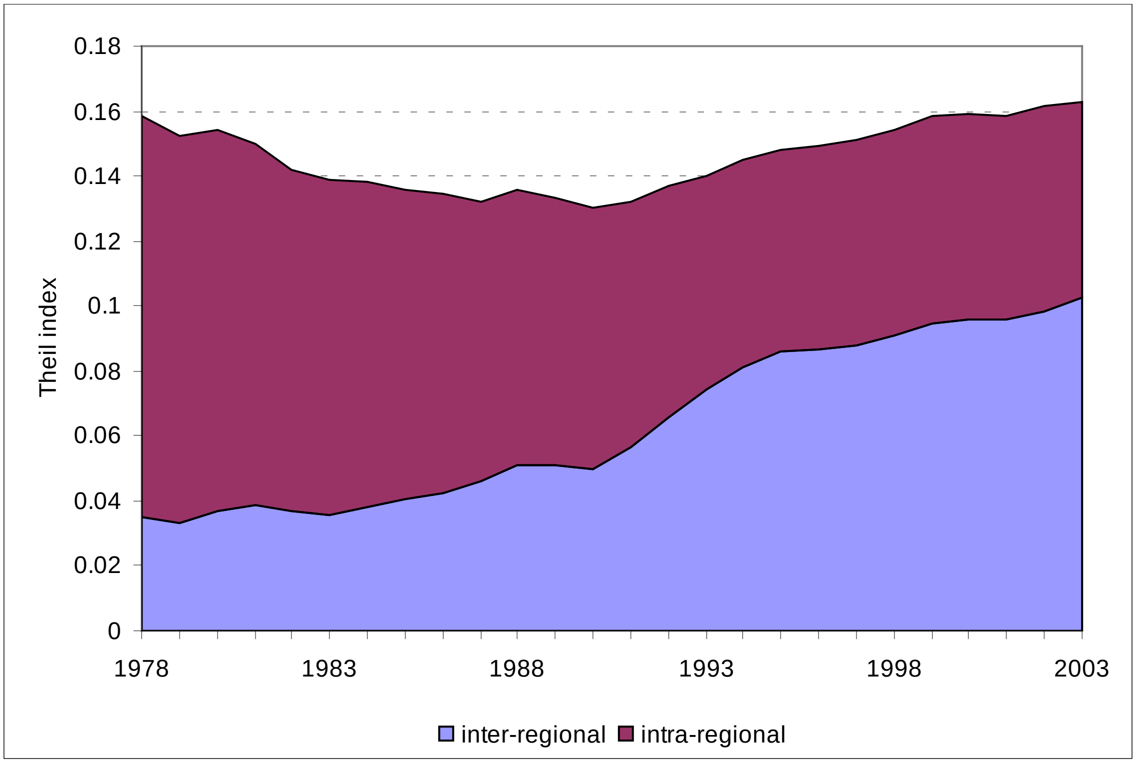
Graph 2: China’s poverty and inequality

Data source: Ravallion and Chen (2004) The national poverty measure is a population weighted means of the poverty measures in rural and in urban areas. The rural poverty line is 850 yuan per person per year in 2002, deflated by rural CPI; and the urban poverty line is 1200 yuan per person per year in 2002, deflated by urban CPI. The Gini coefficients here show the national income inequality without adjustments for cost of living difference in rural and urban areas.

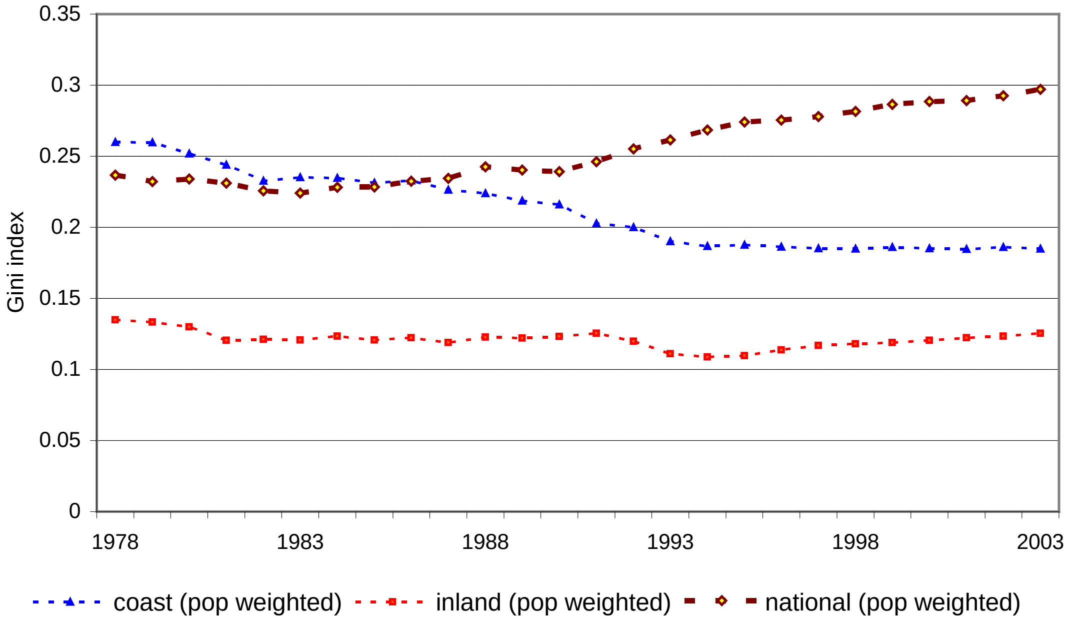
What leads to the rapid increase in inequality? Many studies argue that, although intra-regional inequality (mainly between rural and urban areas) is still significant, the inter-regional development gap between the coast and inland becomes more and more important (see for example, Kanbur & Zhang, 1999; Yao & Zhang, 2001). Suppose there is no intra-provincial inequality – each individual has the same income level that equals to the average level of the province where he or she lives. Based on the Theil index decomposition, the intra-regional inequality (between different provinces) represents for more than three quarters of the total inequality in 1978; while less than half in 2003 (graph 3A). Or, the intra-regional inequality decreases 50%, and the inter-regional inequality between the coast and the inland regions triples.

Graph 3 : The regional inequalities in China (1978-2003)

3A: Theil index decomposition (Coastal vs. inland regions)



3B Change in Gini at the national and regional levels



Based on the changes in Gini coefficients, the results of graph 3B echo that the widening regional gap between the coast and the inland is a major reason that leads to an increase in inequality at the national level. [5] At the sub-national level, inequalities decreased inside the coastal region and stayed almost unchanged inside the inland region. If each province is weighted by its population size, the value of the Gini coefficient decreases in the early 1980s and increases afterwards (with a slight trend downwards in the late 1980s and early 1990s).[6] We argue that the Household Responsibility System, which was implemented at the beginning of the reform, played a critical role in increasing the productivity in the agricultural sector. In general, the poor provinces were specialized in the agricultural production to a larger extent, and enjoyed more benefits from the agricultural reform. However, subject to various constraints, the increase in agricultural productivity decelerated since the mid 1980s. The rapid development of the secondary and tertiary sectors, which were more concentrated in relatively rich provinces, contributed to the widening the regional disparity.

The difference in annual growth results in the modification of the relative rankings of provincial development level. Here, we define the relative real GDP per capita $yr_{i,t}$ as:

$$yr_{i,t} = \frac{GDP_{i,t}}{population_{i,t}} \Big/ \frac{\sum_{i=1}^{n} GDP_{i,t}}{\sum_{i=1}^{n} population_{i,t}} \qquad i = 1,2,3...28$$

If $yr_{i,t}$ is superior to 1, the development level of province i is higher than the national average in year t; if $yr_{i,t}$ is inferior to 1, the development level of province i is lower than the national average in year t. Normalizing the GDP per capita of province i by the

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[5] Graph 3B shows the Gini coefficient of the GDP per capita across provinces, taking each province as an individual and assuming no intra-provincial inequality. Graph 1 shows the Gini coefficient of the household income (Ravallion and Chen, 2004). The value of the Gini coefficient in graph 1 is higher than that in graph 3B. One major reason that leads to this difference is the intra-provincial (mainly rural-urban) inequality. This paper examines the disparities across provinces, and neglects the inequality at the sub-provincial level.

[6] If each province is assigned the same weight, the value of the overall inequality is higher but the trend is similar. With a slightly longer period of decrease in inequality till the late 1980s, the Gini index value increases since then. Results are available upon request.

average national GDP per capita, we find that the three municipalities always have a much higher relative development level than the other provinces – Tianjin's development level is at least 2.5 times the national average, Beijing around 3 times, and Shanghai around 6 times. Given their special characteristics (such as high urbanization rates, special economic policies, etc.), we separate them from the others.

Using Epanechnikov Kernel density[7], graph 4 describes the growth trajectories of the Chinese provinces, where the width of the arrows in the graph is proportional to the number of the provinces that follow the particular development trajectory (the change in group rankings).[8] If the relative development level of many provinces is around 1, that is to say, near the national average level, the distribution is egalitarian; if the relative development level of a large number of provinces concentrates in one extreme and that of the others concentrate in the other extreme, the regional development is unequal.[9] Our results show that, apart from the three municipalities, in the late 1970s and the 1980s, the relative development levels of the provinces tended to cluster around the national average, few provinces were much poorer or richer than the others. Only the three provinces (Liaoning, Jiangsu, and Heilongjiang) had a relative GDP per capital ratio higher than 1.3; all the other 22 provinces clustered together with a peak value around the national average level[10]; however, in the 1990s and the early 2000s, the number of provinces whose development level is around the national average shrank, the poor group clustered together with a peak value around 0.65, and four provinces, Jiangsu, Zhejiang,

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[7] The estimation of Kernel density of a series X in point x is defined as $f(x) = \frac{1}{Nh}\sum_{i=1}^{N} K\left(\frac{x - X_i}{h}\right)$, where N stands for the number of observations, h the parameter of smoothness, and $K(\bullet)$ the function of Kernel where the integral is equal to unity.

[8] For the sake of simplicity and to smooth out the impact of short-term shocks, we examine the distribution of the provincial average relative GDP per capita of the first and the second half of our period of study (ie. 1978-1990 and 1991-2003). The change of annual relative provincial GDP per capita in the period of 1978-2003, is available from the author upon request.

[9] See Ben-David (1994; 1997), Quah (1996; 1997), Cozzi (1997).

[10] The values of the relative GDP per capita of three municipalities, Beijing, Tianjin and Shanghai, are at least 2.5 times of that of the national average. Hence, the mean value of the relative GDP per capita of the other 25 provinces illustrated in the graph is less than 1.

Guangdong and Liaoning developed as the rich group.[11] Graph 4 shows that (i) at the end of our period of study, all provinces belonging to the poorest group were inland provinces (most of them are western provinces); and all provinces belonging to the rich group were costal provinces[12]; (ii) during this period, all provinces that suffered a relative decline in rankings were inland provinces (among them, most are western provinces), and all the provinces that caught up were coastal provinces.

The Chinese provinces converged to different clubs – the coastal provinces clustered together to from the rich club, while the inland provinces declined to be the periphery. The emergence of the two-peaks, rich and poor, vividly demonstrates the center-peripheral development pattern in China.[13]

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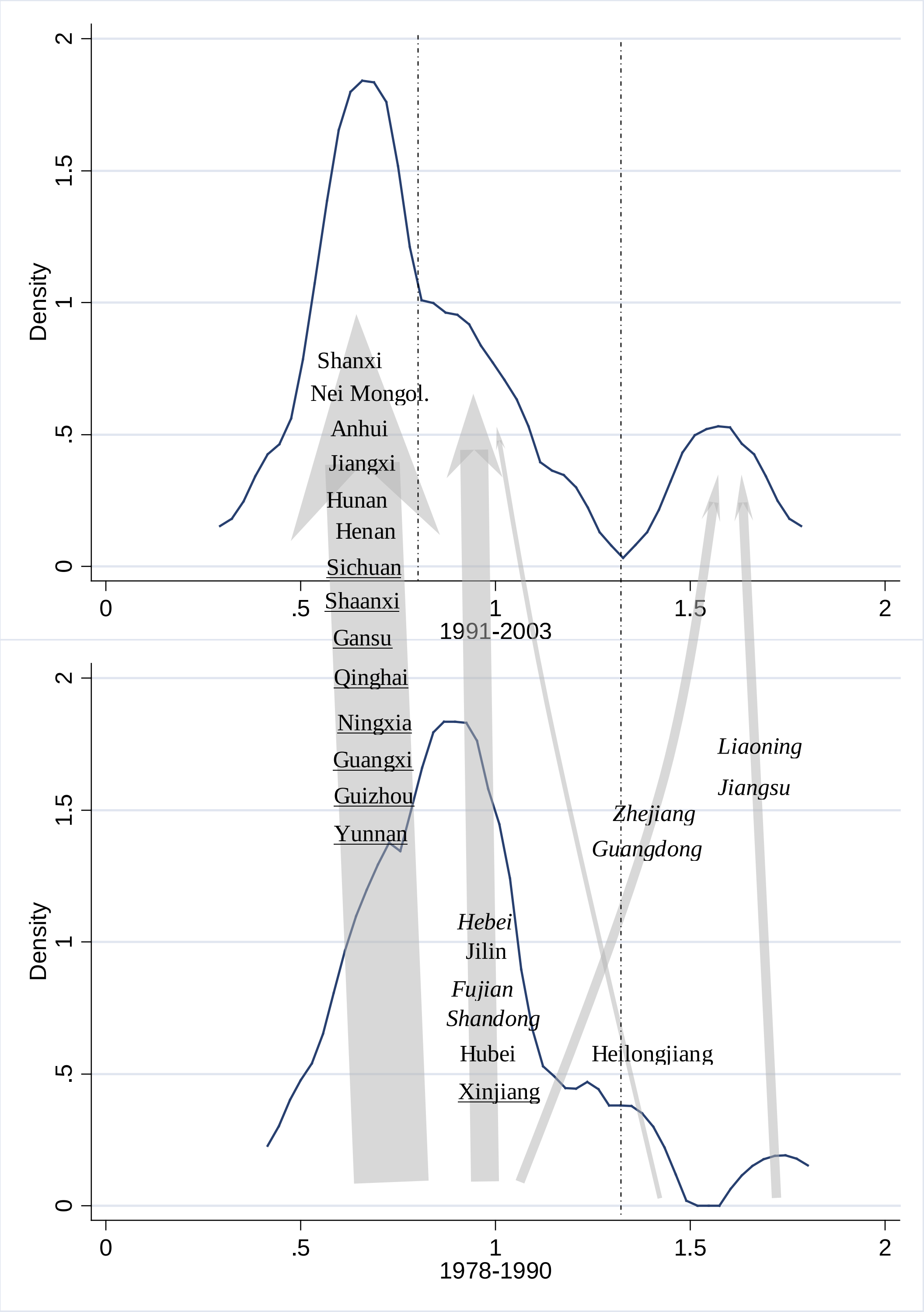
[11] The values of the relative GDP per capita of four provinces, Jiangsu, Zhejiang, Guangdong and Liaoning, are greater than 1.4 times the national average.

[12] The three municipalities are already separated as the richest group from the other provinces. For the reasons of readability, we do not illustrate these three provinces in Graph 4.

[13] See Quah (1997; 1999), Desdoigts (1999), Luo (2005).

Graph 4: Growth trajectories of Chinese provinces (1978-2003)



Note: Coastal provinces are marked in italic; western provinces are underlined.

Why has the regional disparities widened after the reform? Many studies, see for example Yang (2002) and Kanbur and Zhang (2002), suggest that the gradual extension of the open-door policies from the coast to the inland is one of the major reasons that contribute to the widening of the regional gap.[14] Throughout the 1980s and early 1990s, the coastal provinces attracted disproportionately higher shares of foreign investments and trade, and developed as domestic economic centers. As shown in graph 5, in 1980, the first Special Economic Zones were established in four cities (Shenzhen, Zhuhai, Shantou and Xiamen) in the coastal provinces Guangdong and Fujian, to attract foreign direct investments. These two provinces are hometowns of many oversea Chinese investors. In order to scale up the success to the entire coastal region, the open-door policy extended to 14 coastal cities in 1984, to the delta of Yangtze, the delta of the Pearl River, and the delta of Minnan in 1985, and to Hainan in 1988. These special economic zones and coastal open areas had superior tax treatments and preferential resource allocations (Litwack & Qian, 1998). The open-door policies were further extended to many inland cities in the 1990s. This gradual extension of the open-door policies give the coastal regional tremendous first-mover advantages on attracting investments and generating growth, putting the non-coastal provinces at significant disadvantages (Fujita and Hu, 2001). Provinces with good access to the market are better suited to be platforms for producing manufactured exports, and are more attractive to foreign direct investments (Fujita and Hu, 2001 ; Zhang, 2001; Demurger et al., 2002; Jones, Li and Owen, 2003 ; Gao, 2004 ; Fu, 2004 ; Wen, 2004). For example, in 2003, the coastal provinces attract around 85% of the total foreign direct investments and represent more than 90% of the total foreign trade.[15]

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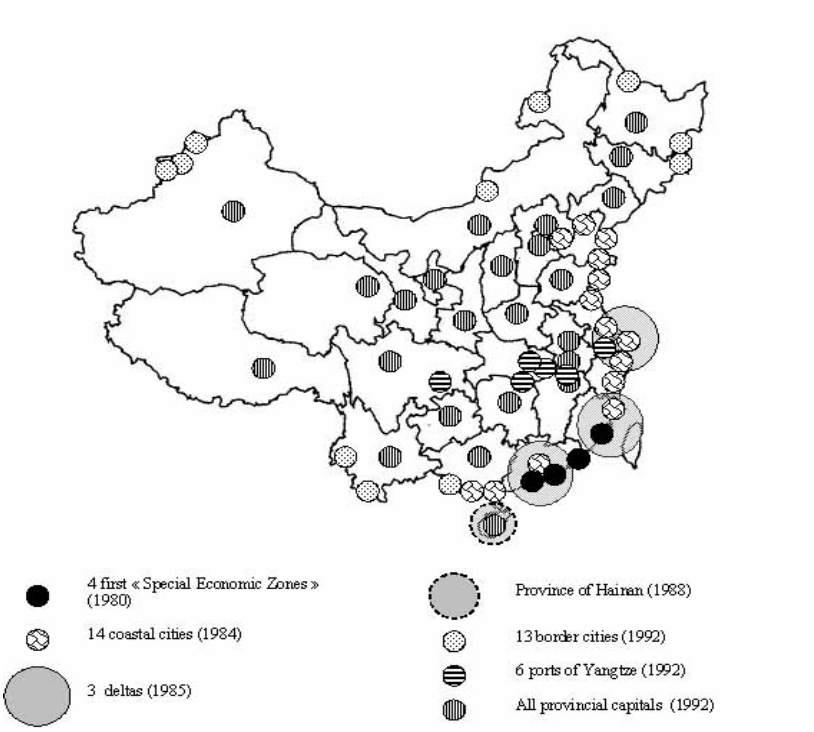
[14] See also Lin (1995) and Hu and Tan (1996) for a further discussion on the determinants of regional disparities.

[15] Data source: China Statistical Yearbook, 2004.

Graph 5: Spatial Gradualism of the open-door policies in China



Source : Luo (2003).

The attractiveness of a location to firms are not geographically-neutral. The proximity or easy access to economic centers strongly favors regional growth (Fleisher and Chen, 1997; Demurger, 2001). We argue that the favorable geographic conditions and the proximity to markets are the most important factors that lead to the emergence of the coastal provinces as economic centers.[16] Past experience, for example the "Third Front Program", shows that the investments distorted to geographically remote regions without appropriate transport facilities are costly and unlikely to be profitable. The proximity to markets (Hong Kong, Macao and Taiwan) is one major factor that contributes to the success of the Special Economic Zones in Guangdong and Fujian. Demurger et al. (2002) argue that the effects of the geographic position are greater than the preferential policies in encouraging the rapid growth of the coastal provinces. In the western region, the higher transport costs resulted from the unfavorable topographic features and the distance to coastal centers largely hinder economic growth. The

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[16] See Krugman (1991) for discussions on the role of first nature and second nature on regional growth.

underdevelopment of transport facilities limits interregional trade and lowers profit margins. Effective investments in transport networks and in communications, which may alleviate geographical obstacles to trade, are particularly critical to the economic performance of the remote areas.

2.3 Disparities in the distribution of transportation infrastructure facilities

Rapid economic development results in a surging demand for infrastructure. The transportation infrastructure facilities have long been in shortage in China. In 1978, for the entire China, in average, there were less than 6 meters railways in operation and 100 meters highways per squared kilometer![17] Through various channels, the underdevelopment of infrastructures hinders growth. Merchandise had to wait for weeks (or sometimes months) before being shipped because of the limited capacity of railway transportation. Information could not be exchanged timely because of the insufficiency (or inexistence) of telephone lines and internet services. In particular, the infrastructure development is of great importance for the export-led development strategy. For example, large investments in transport facilities (in particular in port capacity) have played an important role in the rapid development of the Special Economic Zones. In the absence of the upgraded infrastructure facilities, their competitiveness in attracting FDI would have been much weakened. The remote provinces suffer disproportionately from the shortage in transport facilities. The high transport costs (and the unpredictability of the delivery time) largely contribute to the fragmentation of the domestic market. The costs for transporting merchandises from inland exporter to the coast represent a high ratio of the total transport costs (Carruthers, Bajpai and Hummels, 2003). The insufficiency of infrastructure facilities reduces the competitiveness and productivities of the inland firms.[18]

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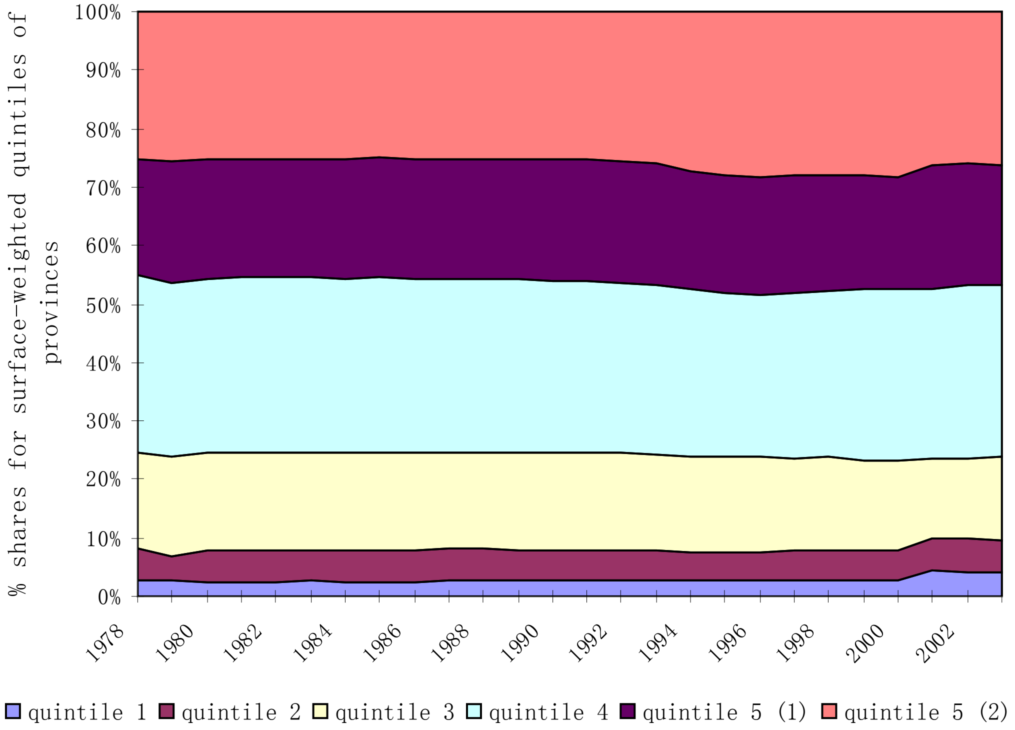
[17] Data source: China Statistical Yearbooks. The length of highways refers to the length of highways which are built in conformity with the grades specified by the highway engineering standard formulated by the Ministry of Communications, and have been formally checked and accepted by the departments of highways and put into use. The length of railways in operation refers to the total length of the trunk line under passenger and freight transportation (including both full operation and temporary operation). Here, we exclude Xizang and Hainan from the sample.

[18] See Li (2005) for econometric evidence on the social surplus gain of infrastructure investments in China.

The infrastructure facilities are not only insufficient, but also unevenly distributed – take the density of highways and/or railways per square kilometers as an example.[19] Suppose that highways (railways) distribute evenly inside each province. Graph 6 shows that a quarter of the total length of highways (railways) concentrate in the 10% surface that are best endowed with infrastructures. Although infrastructure investments jumped in the late 1990s, less than 10% of the total length of highways (railways) locates in the 40% surface that is the most poorly endowed in transport facilities. This uneven distribution changes hardly over time.

Graph 6 Uneven distributions of highways (railways) in Chinese provinces



Note: The figure groups provinces by quintile from poorest (quintile 1) to richest (quintile 5), with quintile 5 divided into two deciles.

In the pre-reform period, the distribution of infrastructure investments mainly depended on the central development strategy planning. The emphasis on the

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[19] Here, we focus on the density of the highways/railways, and neglect the inland waterways and air transports and other infrastructure facilities. If the "density" of highways/railways is measured in per capita basis, the regional disparity of the endowments of infrastructure facilities is different. For example, given the low density of population, some northwest provinces with a very sparse transport network, have a highways/railways per capita level twice the national average (See Naughton, 2004).

development of the heavy industries disproportionately favored the investments in extending the railway network over upgrading the existing roads. A large part of infrastructure investments was disproportionately allocated through the central planning system to the northeastern provinces, where concentrated the (state-owned) heavy industries.[20] For the entire China, infrastructure facilities were in great shortage. Since the 1980s, driven by the market forces, large investments have been switched towards building roads and upgrading the existing system. In the 1990s, infrastructure investments were reasserted as one major priority for long-term development and articulated in the Western Development program (State Council, 2000). The central government increased commitment of budgetary resources to the western provinces. During the first two years of the Western Development Plan (2000-2001), more than 20 large scale investment projects begun in the western region, with a total budgeted investment of over 400 billion yuan, almost 5 percent of national GDP. The transport and energy related projects are the major components of the infrastructure investments of the Western Development Plan.[21] In particular, highways development is the priority of the transport projects. In 2000-2001, more than 130000 kilometers highways were built or upgraded to the highway engineering standards in the western provinces.[22]

There exists a strong association between the economic development level and the density of the transport network. The coastal provinces have witnessed rapid improvements in transport facilities (especially highways). For example, the transport network in Guangdong, one of the most dynamic coastal provinces, has improved drastically – the density of highways more than doubled from less than 3000 kilometers per 10000 square kilometers to more than 6000. However, the shortage of infrastructure facilities remained as a major bottleneck for growth, especially for the remote western provinces to integrate to the domestic and international market (graph 7).

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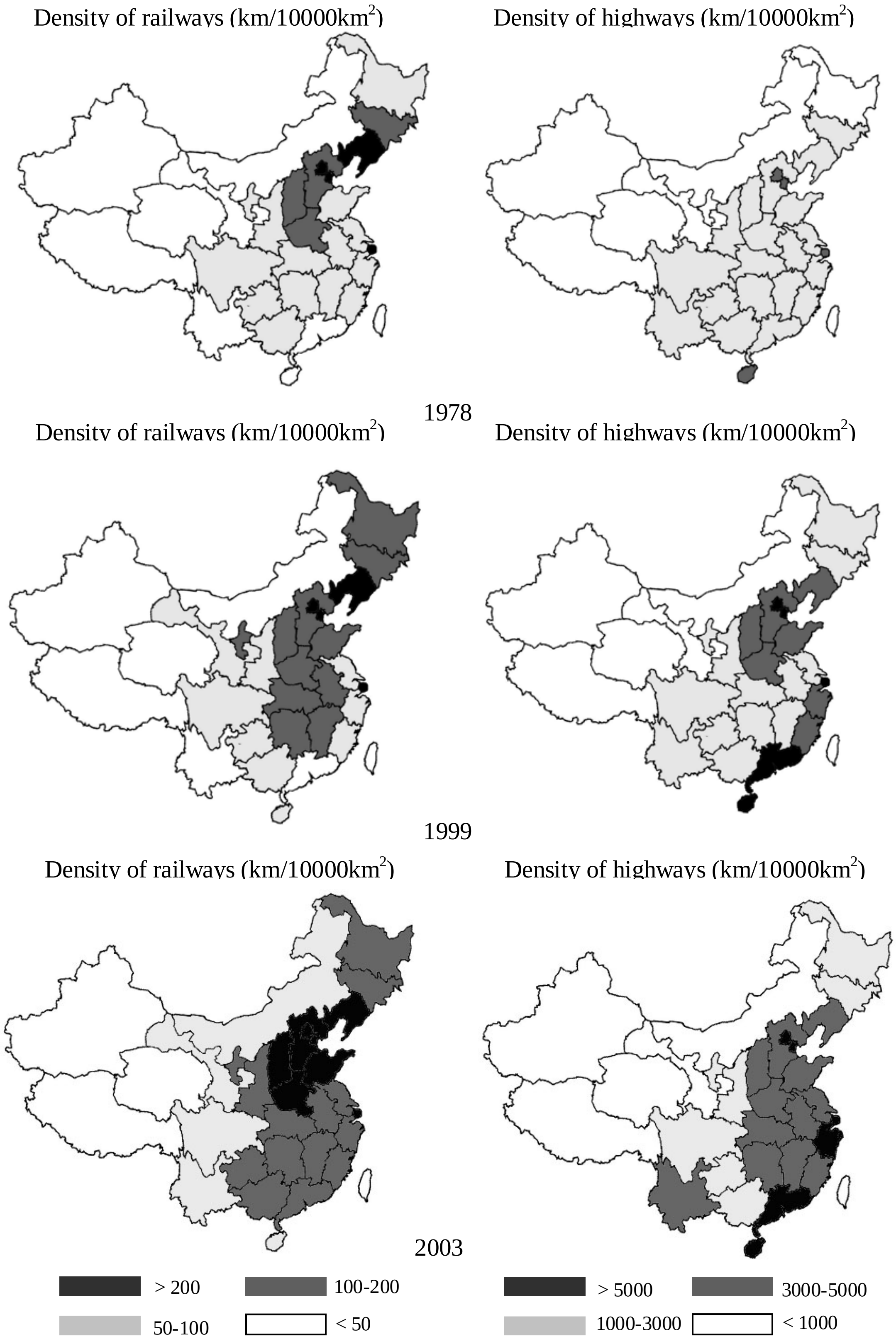
[20] See also Naughton (2004).

[21] The WDP covers a broad range of sectors, such irrigation, urban construction, and environmental restoration, etc.

[22] Data source: China Statistical Yearbooks.

Graph 7 Densities of railways and highways in Chinese provinces

(1978, 1999 and 2003)



Can putting transportation infrastructures in the west help balancing regional growth? Past experience shows that simply throwing money in lagging regions will not efficiently fuel economic development. In the western region, infrastructure investment and maintenance costs are high and economic profitability is low because of the disadvantageous geographic, topological, and climatic features, and the fragmented and dispersed economic activity. Given the high marginal return of infrastructure investments in other regions, putting all investments in the west may not be the optimal choice. Privileging the development of the intra-regional transportation facilities may fail to link the west to the domestic economic centers and render its economy more inward-looking. In the following sections, we will examine the impacts of the infrastructure development in each province on the catching-up of the western region, and simulate the tradeoffs between maximizing economic growth and reducing regional disparities of the alternative regional infrastructure investment policies.

3 Role of the geo-economic position in regional growth performance

Given the fact that climate and topology play an important role in influencing disease burdens and agricultural productivity, and location in transport costs, it is not surprising that the distribution of economic activities is spatially uneven (Gallup *et al.*, 1999; Henderson *et al.*, 2000). The homogeneity among the adjacent regions shows that geographical position may be an important factor that conditions economic growth, as detailed in Baumont *et al.* (2000) and Davis and Weinstein (1997).

The attractiveness of a geographic position is determined not only by its proximity to economic centres, but also by its transport convenience. It is the transport costs, which is a function of distance and the transport facility development level of the itinerary that links the region to the economic centres (major trade partners), that condition regional growth. This section constructs an indicator "peripheral degree" to measure the effective remoteness of the province in question to economic centers (in our case, the coastal provinces), and examines its role in regional growth.[23]

3.1 Construction of "peripheral degree"

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[23] This indicator "peripheral degree" was developed in Luo (2004).

We consider the coastal provinces as the domestic economic centers. The influence of the demand from a partner province on the economic performance of the province in question is positively correlated to the economic mass of the former. To take into account the relative importance of the economic size of different coastal provinces, we define its peripheral degree, noted as PD, as the weighted sum of the adjusted distance between this province and all the coastal provinces.[24] To capture the relative importance of the effective remoteness, the adjusted distance between the province in question (i) and a coastal province (j) is weighted by the economic mass of the latter relative to that of coastal provinces in total. The reason lies in that the farther away is the province in question from a great size coastal province, the more serious is the disadvantage that it suffers from its geographical position. In other words, we suppose that, other things being equal, the structure of demand is similar among different regions, namely, the percentage of demand satisfied by local production (and thus that satisfied by the production of other provinces) is the same, as suggested by Courcier and Laffay (1972). The indicator peripheral degree is defined as follows:

$$PD_{i,t} = \sum_j (DistA_{ij,t} \times \frac{GDP_{j,t}}{\sum_j GDP_{j,t}})$$

where $PD_{i,t}$ represents the peripheral degree of province i at time t; $DistA_{ij,t}$ represents the real distance between province i and province j adjusted by the development level of infrastructure of the itinerary that connects these two provinces at time t, namely the adjusted distance between province i and province j at time t suggested by Luo (2001)[25]; $GDP_{j,t}$ represents the real GDP of province j at time t. Here, j represents the coastal provinces, including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong and Guangdong.[26]

3.2 Relation between "peripheral degree" and regional economic growth

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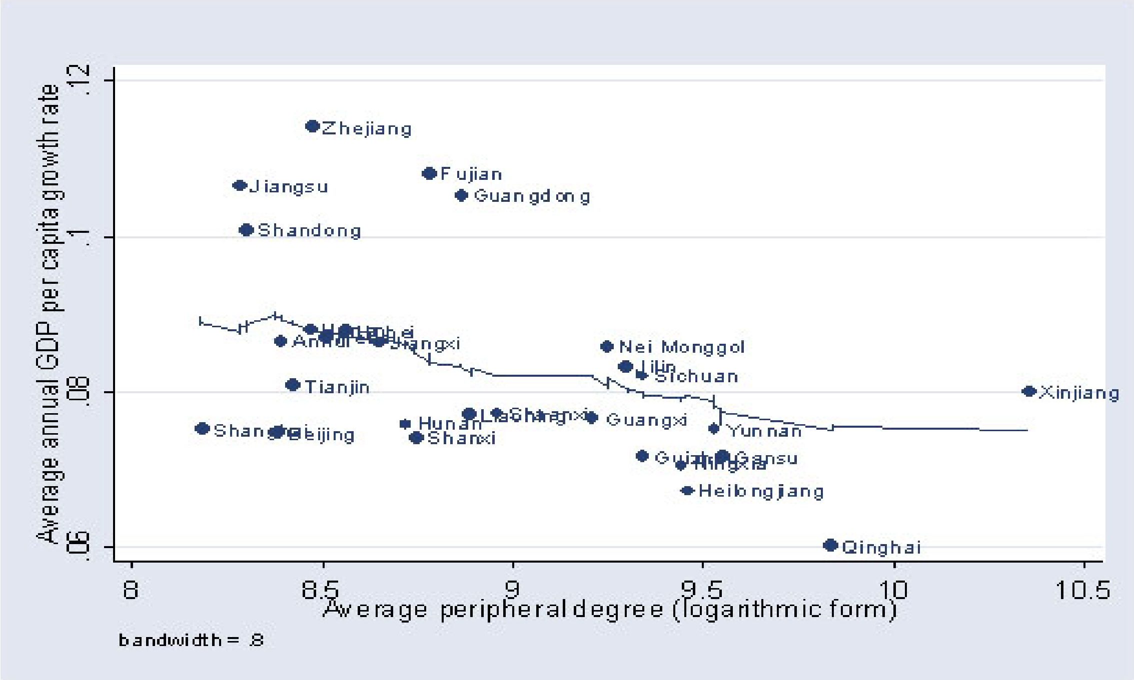
[24] In the case of China, all important harbors situate in coastal provinces. The relative remoteness to coastal provinces is positively correlated to the relative remoteness to international markets.

[25] See annex 2 for the construction of the adjusted distance.

[26] We exclude Hainan from our sample for its unique island characteristics.

The provinces close to economic centers have higher growth rate (graph 8). As Chinese economy becomes more and more market-oriented, the geographical position plays a more and more important role in regional development. At the beginning of the economic reform, in the late 1970's, Chinese economy was distorted by the inefficient allocation of resources and regional development level did not well reflect the development capacity. [27] As the economic reform deepens, regional comparative advantages become an important factor that determines the production structure. Favored by the better access to foreign markets and benefited from the opening-up policies, coastal provinces grow much faster than inland ones (Woo, 1998). Given the geographical economic position of a province will not modify much in the absence of fundamental external policy change, it is reasonable to predict that the core-peripheral development pattern will continue. Appropriate policies may be important to rebalance regional development.

Graph 8. Relation between peripheral degree and annual growth rate of Chinese provinces (1978-2003)



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[27] Pursuing the sake of "political security" and being aware of the "critical threat from the foreign capitalists", the Chinese government allocated a great deal of its industrial investment in the inland provinces during its "planned-economy" period. Subordinated to the "political goal", the comparative advantages of various provinces were not well considered before economic reform.

Using the panel data of "Chinese Statistic Yearbooks", "Comprehensive Statistic Data and Materials on 50 Years of New China", and the distance data from "Map of communication facilities of China", this section studies the determination of annual growth of Chinese provinces during the period of 1979-2003, emphasizing the role of geographical position. In light of the Solow-Swan growth theory, we estimate the growth determination at the provincial level, introducing the independent variables $\ln(y_{i,t-1})$ (the initial GDP per capita level), $\ln(PD_{i,t})$ (peripheral degree), $\ln(S_{i,t})$ (fixed investment rate), $\ln(n_{i,t})$ (population growth rate), and $dummy_t$ (year-dummies):[28]

$$\ln(y_{i,t})-\ln(y_{i,t-1})=\alpha+\rho\ln(y_{i,t-1})+\theta\ln(PD_{i,t})+\gamma\ln(s_{i,t})+\zeta\ln(n_{i,t})+\sum_{t=1979}^{2002}\chi_t dummy_t+\varepsilon_{i,t}$$

Table 3 – Provincial growth determination – the role of peripheral degree (1978-2003)

Dependent variable : $\ln(y_{i,t})-\ln(y_{i,t-1})$

	(1)	(2)	(3)
$\ln(y_{i,t-1})$	-0.049***	-0.065***	-0.056***
	(-5.00)	(-5.6)	(-5.07)
$\ln(PD_{i,t})$		-0.084***	-0.075***
		(-2.54)	(-2.34)
$\ln(s_{i,t})$			0.050***
			-2.31
$\ln(n_{i,t})$			-1.206***
			(-6.92)
Constant	0.491***	1.324***	1.166***
	-6.3	-3.93	-3.57
R square	0.4844	0.4895	0.5681
Observation number	700	700	700

Note: t-students are in brackets. * significant in 10% ; ** significant in 5% ; *** significant in 1%. $\ln(y_{i,t-1})$ stands for initial real GDP per capita in logarithmic form; $\ln(PD_{i,t})$ peripheral degree in logarithmic form; $\ln(s_{i,t})$ physical investment ratio in logarithmic form; $\ln(n_{i,t})$ population growth rate in logarithmic form. For simplicity, the time dummies are not represented in the table.

The results of table 3 suggest the liabilities of being remote to economic centers. The effective remoteness of a province to the economic centers not only lowers its economic growth rate, but also reduces its long term development capacity. Distance

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[28] See annex 4 for details of the growth determination estimations.

between two locations will not change over time. Without major targeted improvements in transport facilities, the lagging western region will suffer lower performance.

4 Targeted transportation infrastructure investments and policy alternatives

The key question we will address here is where to put transportation infrastructures can most effectively rebalance regional growth. Many studies suggest a strong correlation between public capital and regional development (Aschauer, 1989; Mundell, 1990; Morrison and Schwartz, 1996). Fernald (1999; 2004), Fabrizio et al. (2005), and Li (2005) argue the causations from transport network improvements to productivity gains. Fan and Zhang (2004) identify the specific role of rural infrastructure in regional productivities in China. Infrastructure facilities in a province can directly promote local growth through forward and backward linkages, and indirectly encourage the development of other provinces through reducing transport costs. In this section, we will simulate the impacts of hypothetical transport facility improvements in each province, and rank their effectiveness in promoting growth at the national and regional levels to evaluate the potential trade-offs between maximizing aggregate growth and minimizing regional disparities.

4.1 Rationales of simulations

The peripheral degree, by construction, is determined by the distance between the province in question and the national economic center and by the infrastructure development level of the transit economies. A similar improvement of transportation facilities in different provinces leads to different modifications of peripheral degree in different provinces. As shown in the following box, an increase of transportation network density in one province does not only lead to the change of its own peripheral degree; it also leads to that of the other concerned provinces. [29]

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[29] As to a province i, all modification of the transportation network locates in a province v, which situates in its itinerary to the coastal provinces, will lead to a modification of its peripheral degree. As to a province v, an improvement of its transportation infrastructure favors all provinces i that cross it to join the coastal provinces. The heavier the traffic is that transits through province v, in which case province v is considered as a transportation hub, the more provinces will benefit from its transportation facility improvement, and the greater are its effects on the reduction of the peripheral degree of the concerned provinces. See annex 3 for details on the methodologies of simulations.

Box -- Transportation Network Density and Peripheral Degree

The change of the length of highways/railways in province v leads to the change of its transport network density ($D_{v,t}$), which in turn leads to the modification of the peripheral degree of the concerned provinces i ($PD_{i,t}$).

$$D_{v,t} = a_{1t} \times \frac{highways_{i,t}}{surface_i} + a_{2t} \times \frac{railways_{i,t}}{surface_i}$$

$$D_{v,t} = a_{1t} DR_{v,t} + a_{2t} DF_{v,t}$$

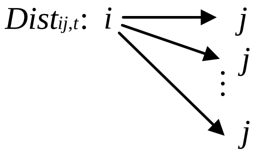
$$D_{ij,t} = \frac{\sum_{v=1}^{n} D_{v,t}}{n}$$

$$DistA_{ij,t} = \frac{Dist_{ij,t}}{D_{ij,t}}$$

$$PD_{i,t} = \sum_{j} \left(DistA_{ij,t} \times \frac{GDP_{j,t}}{\sum_{j} GDP_{j,t}} \right)$$

$$i \rightarrow v \rightarrow \cdots \rightarrow j$$

n provinces



$$Dist_{ij,t} = a_{1t} DistR_{ij,t} + a_{2t} DistF_{ij,t}$$

We will simulate the impacts of the hypothetical transport facility improvements in each province in the decentralization scenario and the centralization scenario.

4.2 Decentralization scenario

In the decentralization scenario – if the provincial governments provide a large share of the infrastructure investment funding – the capacity of a province to make additional investments is closely related to its existing infrastructure endowment (measured by transport network densities). We examine the growth effects of a 10% increase in transport network density in each province.[30]

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[30] Under this hypothesis, the new transport network density in each province equals 110% of its real density: $Dnew1_{v,t} = 110\% \times D_{v,t} = 110\% \times (a_{1t} DR_{v,t} + a_{2t} DF_{v,t})$.

Table 4 – Regional growth induced by 10% hypothetical transport network density increase in different provinces (province in question included)

National		Coastal		Inland		West	
Province	$gaeff\,0(v)m$	Province	$gaeff\,1(v)m$	Province	$gaeff\,2(v)m$	Province	$gaeff\,3(v)m$
Qinghai	0.01	Shanxi	…	Qinghai	0.03	Jilin	…
Xinjiang	0.01	Nei Monggol	…	Xinjiang	0.04	Heilongjiang	…
Nei Monggol	0.05	Jilin	…	Nei Monggol	0.13	Qinghai	0.08
Ningxia	0.11	Heilongjiang	…	Ningxia	0.26	Xinjiang	0.09
Gansu	0.14	Guangxi	…	Gansu	0.34	Nei Monggol	0.32
Yunnan	0.18	Sichuan	…	Yunnan	0.44	Ningxia	0.68
Heilongjiang	0.22	Guizhou	…	Heilongjiang	0.53	*Tianjin*	*0.78*
Guangxi	0.27	Yunnan	…	Guangxi	0.63	Gansu	0.89
Guizhou	0.29	Shaanxi	…	Guizhou	0.69	Yunnan	1.14
Jilin	0.53	Gansu	…	*Tianjin*	*0.82*	Jiangxi	1.18
Shanxi	0.69	Qinghai	…	*Beijing*	*1.24*	*Beijing*	*1.19*
Shaanxi	0.70	Ningxia	…	Jilin	1.27	Guangxi	1.68
Sichuan	0.78	Xinjiang	…	Shanxi	1.64	Guizhou	1.83
Tianjin	*1.21*	Jiangxi	0.48	Shaanxi	1.66	Shanxi	2.11
Jiangxi	1.36	Anhui	0.56	*Fujian*	*1.81*	*Fujian*	*2.22*
Beijing	*2.04*	*Tianjin*	*1.62*	Sichuan	1.85	*Liaoning*	*2.29*
Anhui	2.61	**Hubei**	**1.80**	Jiangxi	2.62	*Shanghai*	*3.00*
Hunan	**3.37**	**Hunan**	**1.84**	*Shanghai*	*3.01*	*Zhejiang*	*3.54*
Fujian	*3.88*	**Henan**	**1.90**	*Liaoning*	*4.36*	*Shandong*	*4.13*
Liaoning	*4.09*	*Beijing*	*2.83*	*Zhejiang*	*4.82*	Jiangsu	4.16
Hubei	**4.32**	*Liaoning*	*4.24*	*Guangdong*	*5.05*	Shaanxi	4.37
Henan	**4.50**	*Fujian*	*5.80*	*Shandong*	*5.11*	Sichuan	4.55
Shanghai	*4.60*	*Shanghai*	*6.20*	*Jiangsu*	*5.16*	Anhui	4.82
Guangdong	*6.04*	*Guangdong*	*7.26*	Anhui	5.50	*Guangdong*	*5.22*
Zhejiang	*6.51*	*Zhejiang*	*8.32*	**Hunan**	**5.66**	*Hebei*	*5.32*
Hebei	*7.63*	*Hebei*	*8.95*	*Hebei*	*6.73*	**Hunan**	**6.31**
Jiangsu	*8.87*	*Jiangsu*	*12.46*	**Hubei**	**7.96**	**Henan**	**7.12**
Shandong	*9.02*	*Shandong*	*12.78*	**Henan**	**8.27**	**Hubei**	**8.83**

Note : Figures are presented in 1/10000. " … " stands for the figures inferior to....0000005. For example, a 10% increase in the transport network density in Shandong province leads to a 9.02×10^{-4} increase of the growth rate of the whole China. Coastal provinces are marked in italic, transport hubs are marked in bold.

Following the simulation methodologies, we calculate the average induced effects of putting this additional transportation infrastructure in each province on the growth of the entire China and different regions (table 4). The first column "national" shows that if the objective is to generate the largest impacts on the (weighted average) growth of the entire China, we should put transportation infrastructures in the coastal provinces, in particular, in Shandong, Jiangsu, and Hebei.[31] However, such favourable growth effects concentrate mainly in the coastal region, as shown the second column "coastal."[32] Even though this growth pattern might be an efficient way to maximize national growth, the rapid growth in coastal provinces will further widen the regional development gap.

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[31] Given the economic size of the coastal provinces and their role as economic centers, it is not surprising that the improvement of the transportation network in these provinces results in substantial effects on the weighted average growth of the entire China.

[32] Here we have not yet counted for the great multiplier effect of infrastructure investment on local growth.

Table 4 bis – Regional growth induced by 10% hypothetical transport network density increase in different provinces (province in question excluded)

National		Coastal		Inland		West	
Province	$gaeff\,0(v)m$	Province	$gaeff\,1(v)m$	Province	$gaeff\,2(v)m$	Province	$gaeff\,3(v)m$
Nei Monggol	...	Shanxi	...	Nei Monggol	...	Nei Monggol	...
Heilongjiang	...	Nei Monggol	...	Heilongjiang	...	Jilin	...
Yunnan	...	Jilin	...	Yunnan	...	Heilongjiang	...
Xinjiang	...	Heilongjiang	...	Xinjiang	...	Yunnan	...
Qinghai	0.01	Guangxi	...	Qinghai	0.02	Xinjiang	...
Sichuan	0.02	Sichuan	...	Sichuan	0.04	Qinghai	0.05
Guangxi	0.07	Guizhou	...	Gansu	0.16	Sichuan	0.14
Gansu	0.07	Yunnan	...	Guangxi	0.17	Gansu	0.42
Ningxia	0.08	Shaanxi	...	Ningxia	0.19	Guangxi	0.49
Guizhou	0.16	Gansu	...	Guizhou	0.38	Ningxia	0.51
Jilin	0.33	Qinghai	...	*Tianjin*	*0.82*	*Tianjin*	*0.78*
Shanxi	0.35	Ningxia	...	Jilin	0.82	Guizhou	1.08
Shaanxi	0.40	Xinjiang	...	Shanxi	0.85	Jiangxi	1.18
Tianjin	*0.77*	Jiangxi	0.48	Shaanxi	0.98	*Beijing*	*1.19*
Jiangxi	0.97	Anhui	0.56	*Beijing*	*1.24*	Shanxi	2.11
Beijing	*1.26*	*Tianjin*	*0.79*	Jiangxi	1.72	*Fujian*	*2.22*
Anhui	2.01	*Beijing*	*1.39*	*Fujian*	*1.81*	*Liaoning*	*2.29*
Hunan	**2.75**	**Hubei**	**1.80**	*Shanghai*	*3.01*	Shaanxi	2.82
Shanghai	*2.78*	**Hunan**	**1.84**	Anhui	4.23	*Shanghai*	*3.00*
Fujian	*3.39*	**Henan**	**1.90**	**Hunan**	**4.32**	*Zhejiang*	*3.54*
Liaoning	*3.40*	*Shanghai*	*2.81*	*Liaoning*	*4.36*	*Shandong*	*4.13*
Hubei	**3.47**	*Liaoning*	*2.86*	*Zhejiang*	*4.82*	Jiangsu	4.16
Henan	**3.53**	*Fujian*	*4.95*	*Guangdong*	*5.05*	*Anhui*	*4.82*
Guangdong	*4.89*	*Guangdong*	*5.15*	*Shandong*	*5.11*	*Guangdong*	*5.22*
Zhejiang	*5.61*	*Zhejiang*	*6.74*	*Jiangsu*	*5.16*	*Hebei*	*5.32*
Hebei	*7.03*	*Hebei*	*7.87*	**Hubei**	**6.21**	**Hunan**	**6.31**
Jiangsu	*7.58*	*Jiangsu*	*10.49*	**Henan**	**6.25**	**Henan**	**7.12**
Shandong	*7.74*	*Shandong*	*10.78*	*Hebei*	*6.73*	**Hubei**	**8.83**

Note : Figures are presented in 1/10000. " … " stands for the figures inferior to....0000005. For example, a 10% increase in the transport network density in Shandong province leads to a 7.74×10^{-4} increase of the growth rate of the whole China when Shandong itself is excluded. Coastal provinces are marked in italic, transport hubs are marked in bold.

In fact, the impacts on national and regional growth of putting transportation infrastructure in a province consist of two parts: the impact on the growth of the province in question, and the impact on the growth of other provinces.[33]

The rankings of the provinces do not change much when the impacts on its own growth are excluded (table 4 bis). Putting transportation infrastructures in the coastal provinces and in the central transportation hubs have large impacts not only on the growth of themselves but also on the growth of other provinces, which reinforces our

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[33] To study the effects of an improvement of transportation network density in one province on the growth of the other provinces, and verify the robustness of our simulation results, we calculate the same ratios excluding the province in question, $gaeff(v)_t=\sum_i^n [gadif(v)_{i,t}\times\frac{PIB_{i,t}}{\sum_i^n PIB_{i,t}}]$ for all $i\neq v$, to purge the effects of the investment on local growth. If the province v is not a member of the group in question, the value of the ratio in table 4 bis is the same as the one in table 4.

arguments that putting transportation infrastructures in Hubei, Henan and Hunan have the largest impacts on the growth of the western region.

The last columns "west" in both table 4 and table 4 bis show that to stimulate the economic performance of the western provinces, which are actually lagging behind, we should put transportation infrastructures in the central transportation hubs of Hubei, Henan, and Hunan.[34] Putting transportation infrastructures in some western provinces might yield lower effects on the growth of the entire western region than targeting infrastructures in some coastal and central provinces (such as Hebei, Guangdong, and Anhui), even though infrastructure investments will strongly stimulate economic growth of the hosting provinces.

4.3 Centralization scenarios

Why the hypothetical additional infrastructure investments in the coastal provinces and those in the central transportation hubs have larger impacts? Would their higher initial transport network density, which implies a higher level of density increase in absolute sense than in the other inland/western provinces, be the major reasons? What will be the rankings of the induced growth effects if the additional infrastructure investments allocated to different provinces are not related to their initial transport facility development level? For example, in the centralization scenario – if it is the central government that provides a large proportion of the policy funding, and a similar amount of additional infrastructure investments is to be allocated to different provinces – where to put the additional investments can maximize the growth impact in the entire China and in different regions? To test the robustness of the argument – putting transportation infrastructures in the coastal provinces maximize national growth and putting transportation infrastructures in the central transportation hubs most effectively favours the western region – we will simulate two controlling scenarios where the additional investment is unrelated to the initial transport density of different provinces at the absolute levels.

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[34] Putting transportation infrastructures in these central hubs also have large effects on the growth of the inland provinces, as shown in the third columns.

Table 5 – Regional growth induced by hypothetical 10% increase of average national transport network density in different provinces (province in question included)

National		Coastal		Inland		West	
Province	$gaeff\,0(v)m$	Province	$gaeff\,1(v)m$	Province	$gaeff\,2(v)m$	Province	$gaeff\,3(v)m$
Qinghai	0.07	Shanxi	...	Qinghai	0.17	Jilin	...
Xinjiang	0.10	Nei Monggol	...	Xinjiang	0.24	Heilongjiang	...
Ningxia	0.11	Jilin	...	*Tianjin*	0.25	*Tianjin*	0.24
Yunnan	0.14	Heilongjiang	...	*Beijing*	0.27	*Beijing*	0.26
Nei Monggol	0.17	Guangxi	...	Ningxia	0.27	Qinghai	0.43
Guangxi	0.21	Sichuan	...	Yunnan	0.33	Xinjiang	0.60
Guizhou	0.21	Guizhou	...	Nei Monggol	0.41	Ningxia	0.69
Gansu	0.24	Yunnan	...	Guangxi	0.49	Jiangxi	0.73
Heilongjiang	0.27	Shaanxi	...	Guizhou	0.49	*Shanghai*	0.74
Tianjin	0.37	Gansu	...	Gansu	0.57	*Fujian*	0.85
Shanxi	0.39	Qinghai	...	Heilongjiang	0.64	Yunnan	0.88
Beijing	0.44	Ningxia	...	*Fujian*	0.70	Nei Monggol	1.02
Jilin	0.44	Xinjiang	...	*Shanghai*	0.75	*Liaoning*	1.11
Shaanxi	0.47	Anhui	0.30	Shanxi	0.94	Shanxi	1.20
Sichuan	0.58	Jiangxi	0.30	Jilin	1.04	Guangxi	1.30
Jiangxi	0.84	*Tianjin*	0.49	Shaanxi	1.11	Guizhou	1.30
Shanghai	1.14	*Beijing*	0.62	Sichuan	1.37	Gansu	1.48
Anhui	1.40	**Hubei**	0.85	Jiangxi	1.63	*Zhejiang*	1.51
Fujian	1.49	**Hunan**	0.85	*Guangdong*	1.76	*Shandong*	1.75
Hunan	1.55	**Henan**	0.88	*Zhejiang*	2.06	*Guangdong*	1.83
Liaoning	1.97	*Shanghai*	1.53	*Liaoning*	2.11	*Jiangsu*	2.07
Hubei	2.04	*Liaoning*	2.04	*Shandong*	2.18	Anhui	2.58
Henan	2.09	*Fujian*	2.22	*Jiangsu*	*2.57*	*Hebei*	*2.73*
Guangdong	2.09	*Guangdong*	2.51	**Hunan**	**2.61**	**Hunan**	**2.91**
Zhejiang	2.78	*Zhejiang*	3.54	Anhui	2.95	Shaanxi	2.91
Shandong	3.84	*Hebei*	4.56	*Hebei*	3.44	**Henan**	**3.30**
Hebei	3.89	*Shandong*	5.45	**Hubei**	3.77	Sichuan	3.36
Jiangsu	4.39	*Jiangsu*	6.16	**Henan**	**3.83**	**Hubei**	**4.19**

Note : Figures are presented in 1/10000. " … " stands for the figures inferior to....0000005. For example, a 10% increase of average national transport network density in Shandong province leads to a 4.39×10^{-4} increase of the growth rate of the whole China. Coastal provinces are marked in italic, transport hubs are marked in bold.

First, we will simulate the same increase in absolute density in each province disregarding its initial transport facility endowment. Here, suppose this absolute level is 10 percent of the national average transportation network density.[35]

$$Dnew2_{v,t} = D_{v,t} + 10\% \times \left(\frac{\sum_{i}^{n} Highways_{i,t}}{\sum_{i}^{n} surface_{i}} \times a1_{t} + \frac{\sum_{i}^{n} Railways_{i,t}}{\sum_{i}^{n} surface_{i}} \times a2_{t}\right)$$

Following the same methodologies, we rank the impacts of putting transportation infrastructures in different provinces on national and regional growth. The rankings in table 5 are similar to those in table 4 – if the objective of putting transportation

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[35] If under a strong assumption that the costs of building railways (highways) are similar in each province, this scenario actually stands for the case where a same amount of monetary increase (in yuan, for example) in infrastructure investments per surface units (per square kilometer) in each province on national growth and on regional growth.

infrastructures is to maximize national growth effects, we should invest in coastal provinces, such as Jiangsu, Hebei and Shandong. But if the objective is to achieve higher growth in inland/western regions, investing in the central transportation hubs (Henan, Hubei and Hunan) are most effective. If we consider putting transportation infrastructures in western provinces, good choices would be Shaanxi and Sichuan (the western regional hubs).

Table 6 – Regional growth induced by hypothetical 1% increase of national road and railway length in different provinces (province in question included)

National		Coastal		Inland		West	
Province	$gaeff\,0(v)m$	Province	$gaeff\,1(v)m$	Province	$gaeff\,2(v)m$	Province	$gaeff\,3(v)m$
Xinjiang	0.05	Shanxi	…	Xinjiang	0.12	Jilin	…
Qinghai	0.08	Nei Monggol	…	Qinghai	0.20	Heilongjiang	…
Nei Monggol	0.12	Jilin	…	Nei Monggol	0.29	Xinjiang	0.31
Yunnan	0.29	Heilongjiang	…	Yunnan	0.70	Qinghai	0.50
Gansu	0.44	Guangxi	…	Gansu	1.04	Nei Monggol	0.72
Heilongjiang	0.47	Sichuan	…	Heilongjiang	1.13	Yunnan	1.85
Guangxi	0.71	Guizhou	…	Guangxi	1.70	Gansu	2.71
Sichuan	0.85	Yunnan	…	Sichuan	2.01	Jiangxi	3.47
Guizhou	0.96	Shaanxi	…	Guizhou	2.29	Guangxi	4.52
Ningxia	1.29	Gansu	…	Ningxia	3.05	Sichuan	4.94
Shaanxi	1.86	Qinghai	…	Shaanxi	4.42	*Fujian*	*5.56*
Jilin	1.91	Ningxia	…	Fujian	4.50	*Liaoning*	*6.02*
Shanxi	2.04	Xinjiang	…	Jilin	4.55	Guizhou	6.06
Jiangxi	4.01	Jiangxi	1.44	Shanxi	4.83	Shanxi	6.17
Hunan	**6.03**	Anhui	1.74	Jiangxi	7.74	Ningxia	7.97
Anhui	8.02	**Hunan**	**3.32**	*Guangdong*	*7.91*	*Guangdong*	*8.22*
Hubei	**8.95**	**Hubei**	**3.74**	*Beijing*	*9.50*	*Shandong*	*9.15*
Guangdong	*9.51*	**Henan**	**4.28**	**Hunan**	**10.14**	*Beijing*	*9.29*
Fujian	*9.76*	*Liaoning*	*11.19*	*Tianjin*	*11.09*	*Tianjin*	*10.76*
Henan	**10.12**	*Guangdong*	*11.49*	*Shandong*	*11.39*	**Hunan**	**11.27**
Liaoning	*10.82*	*Fujian*	*14.59*	*Liaoning*	*11.57*	Shaanxi	11.57
Beijing	*16.80*	*Hebei*	*19.73*	*Hebei*	*14.80*	*Zhejiang*	*11.63*
Hebei	*16.80*	*Beijing*	*23.85*	*Zhejiang*	*15.76*	*Hebei*	*11.69*
Tianjin	*18.35*	*Tianjin*	*25.50*	**Hubei**	**16.51**	Anhui	14.74
Shandong	*20.17*	*Zhejiang*	*27.41*	Anhui	16.79	*Jiangsu*	*15.75*
Zhejiang	*21.39*	*Shandong*	*28.66*	**Henan**	**18.57**	**Henan**	**15.99**
Jiangsu	*33.72*	*Jiangsu*	*47.44*	*Jiangsu*	*19.55*	**Hubei**	**18.38**
Shanghai	*84.10*	*Shanghai*	*118.27*	*Shanghai*	*48.97*	*Shanghai*	*50.61*

Note : Figures are presented in 1/10000. " … " stands for the figures inferior to....0000005. For example, a 1% increase of national railway and highway length in Shanghai leads to a 84.1×10^{-4} increase of the growth rate of the whole China. Coastal provinces are marked in italic, transport hubs are marked in bold.

Second, we will simulate a same increase in absolute length of railways and highways in each province disregarding its initial transport facility endowment. Here, suppose this absolute level is 1 percent of the total length of the national transport network.[36] $Dnew3_{v,t} = D_{v,t} + 1\% \times (\frac{\sum_{i}^{n} Highways_{i,t} \times a1_t + \sum_{i}^{n} Railways_{i,t} \times a2_t}{surface_i})$. Under this scenario, the increase in the length of highways (railways) can be considered equal in each province disregarding its initial transport facility development level and disregarding its surface.[37]

The results in table 6 echo that putting transportation infrastructures in coastal provinces have the largest impacts on encouraging national growth. However, to encourage the catching-up of inland/western provinces, it is more effective to target infrastructure investments in central transportation hubs than to randomly allocate investments in western provinces.[38]

In short, our results show that, under different hypothetical scenarios, it is the infrastructure improvements in central transportation hubs that generate the highest effects on regional balanced growth; and those in coastal provinces that maximize the effects on national growth.

5 Potential trade-offs between maximizing aggregate national growth and reducing regional disparity

Infrastructure is at the core of the “Western Development Plan”. There is no doubt that additional infrastructure investments have beneficial effects on the western development. The key question here is whether putting transportation infrastructures in the west is the most effective infrastructure investment policies to develop the west.[39] This section examines the effects of some alternative infrastructure investment allocation choices and evaluate the trade-offs between maximizing national aggregate growth and reducing regional disparity.

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[36] The length of the transport network is considered as the weighted average of the lengths of highways and railways.

[37] If under a strong assumption that the costs of building railways (highways) are similar in each province, this scenario actually stands for the case where a same monetary amount of infrastructure investments (in yuan) in each province on national growth and on regional growth.

[38] Here, the large impacts of putting infrastructures in Shanghai are closely associated with its limited surface (a same level of increase in transport network length implies a much higher level of increase in density).

[39] Given their specific characteristics, for example desserts in Xinjiang, it might not be optimum for some western provinces to have dense transport network.

5.1 Impacts of the heavy infrastructure investments after 1999

Four years after the implementation of the Western Development Plan, the total length of highways increased a third (from 131 thousand kilometres in 1999 to 175 thousand kilometres in 2003), and the total length of railways increased a quarter (from 5.8 thousand kilometres to 7.2 thousand kilometres). In the same period, the western region had witnessed a slightly higher rate of increase in the length of highways, and a similar rate of increase in the length of railways. From 1999 to 2003, the total length of highways in the western region increased from 51 thousand kilometres to 70 thousand kilometres, and the total length of railways increased from 2.1 thousand kilometres to 2.7 thousand kilometres – each represented more than 40% increase in the total length.[40] The investments in infrastructure have promoted local growth through various channels, such as through the employment creation and transport facilitation.

How much do these heavy investments in infrastructure in the last five years encourage the development of the entire China and that of the western region in particular? How would the growth performance have been different in the absence of these heavy infrastructure investments? Empirical evidence suggests that transport network density in each province increased over time. The increase in transport network density after 2000 consists of two parts (see the following figure): part I, the "normal" level of increase, which can be "predicted" by the predicted linear trend between "transport network density" and "year" before 1999; and part II, the "extra" level of increase, which equals the difference between the actually increase and the increase predicted by the linear trend (the distance between the rectangles that stand for the actual levels and the corresponding diamonds that stand for the predicted levels).

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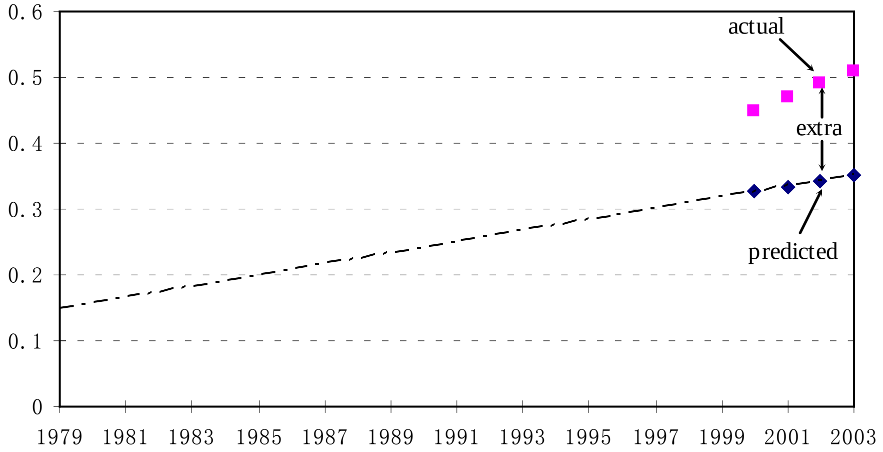
[40] Data source: China Statistical Yearbooks.

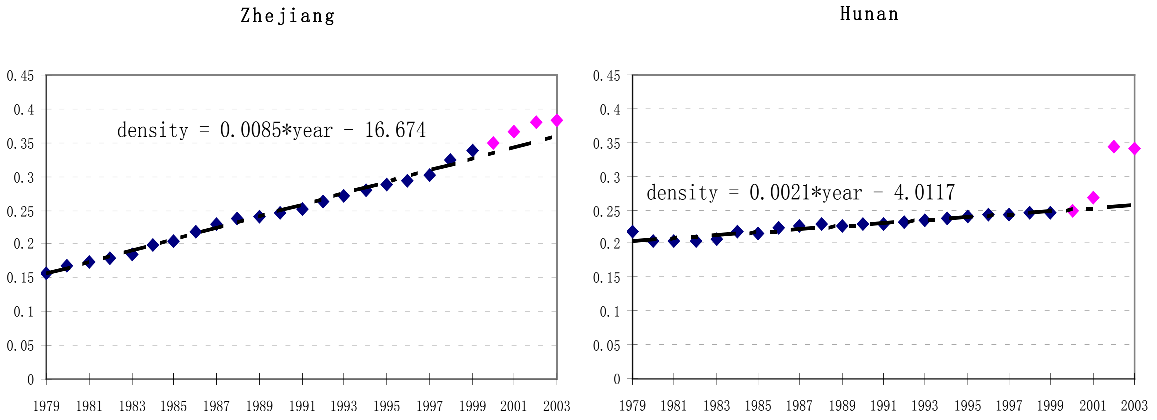
Figure: Illustration of the predicted and extra investments in infrastructure (2000-2003)



For example, in 1979, the density of transport network in Zhejiang, one of the rapid-growing coastal provinces, was lower than that in Hunan, one of the most important central transportation hubs. But the density in Zhejiang had increased much faster (graph 9).

Graph 9: Change in the density of transport network (1979-2003)

Case of Zhejiang and Hunan


Zhejiang

Hunan

Following the simulation methodologies discussed above, we examine the hypothetical national and regional growth in the absence of the extra investments in infrastructure, and compare the difference between the hypothetical scenarios and the real case.[41] In the absence of the extra investments in infrastructure in each province, the national growth rate would have been 1.46% lower in the period of 2000-2003 in average (table 7).[42] The inland/west region would have suffered slightly more from this absence of extra investments than the coastal region. The results suggest that the heavy investments in infrastructure since 1999 do have contributed to the national growth, although their impacts in narrowing development gap between the coastal region and the inland/western region are limited.[43]

However, are the impacts on the growth of the western region mainly resulted from the extra investments in the West? What would be the case if no extra investments were put in the coastal and central provinces? The results of the second part of table 7 suggest that, if only the west region had had extra investments after 1999, the national growth would have been 1.42% lower in average than the real scenario, and the growth of the western region would have been 1.32% lower. In short, if there were no extra investments in the coastal and central provinces, the growth impacts of the extra investments in the western region would have been negligible. In contrast, if only the western provinces had not had the extra investments in infrastructure, the national performance would not have suffered much (the third part of table 7). In other words, to develop the western provinces, putting transportation infrastructures in the central and coastal provinces to facilitate the transaction between the west and the rest of China is a must. For the west to reap the full benefit, it is important that infrastructure facilities in the west are also improved in an appropriate way.

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[41] The relation between transport network density and year in each province differs. For some provinces, the relation is not strictly linear. For the reasons of simplicity, we use the provincial specific linear relations to “define” the “extra investment” after 2000. Regression results for each province are available upon request.

[42] The impacts of the “extra investments” in infrastructures in each province on the national and regional growth vary over time. One major reason is that such “extra investments”, measured in the length of highways/railways, differ by year.

[43] In the absence of the “extra investments” in infrastructures in each province, the growth rate of the coastal region would have been 1. 4% lower, and that of the inland/western region would have been 1.54% lower in the period of 2000-2003 in average (Table 7).

Table 7 Impacts on growth of extra investments in infrastructures

If no extra investments in infrastructures nation-wide since 2000

	2000	2001	2002	2003	Average
National	-48	-170	-179	-185	-146
Coast	-45	-165	-172	-178	-140
Inland	-53	-176	-191	-195	-154
West	-57	-173	-191	-194	-154

If no extra investments in infrastructure in coastal and central provinces since 2000

	2000	2001	2002	2003	Average
National	-46	-166	-175	-180	-142
Coast	-45	-165	-172	-178	-140
Inland	-49	-167	-180	-184	-145
West	-47	-150	-164	-166	-132

If no extra investments in infrastructure in western provinces since 2000

	2000	2001	2002	2003	Average
National	-2	-3	-4	-4	-3
Coast	…	…	…	…	…
Inland	-4	-8	-9	-9	-7
West	-10	-19	-22	-23	-19

Note: Figures are presented in 1/10000. " 爊? example, if there is not extra investments in infrastructures nation-wide, the growth rate of the entire China would have been 1.85% lower than the real case in 2003.

5.2 Trade-offs between maximizing growth and reducing disparity

Infrastructure investments represent a large proportion of government expenditures. It is important to allocate them in an efficient way to achieve the regional development goal. Would putting transportation infrastructures differently better encourage growth and/or reduce regional disparity? The simulation results in the previous section suggest that putting infrastructures in some western provinces might not have the optimal effects on aggregate national growth or on regional disparity. In this section, we will simulate two hypothetical scenarios to numerically examine the potential trade-offs between the effects on maximizing national growth and reducing regional disparity if the infrastructures were allocated differently. Scenario 1, if half of the increase in transport network length in the western provinces after 1999 was put into the three coastal provinces (Shandong, Jiangsu and Hebei) where the effects on national aggregate growth were maximized; Scenario 2, if half of the increase in transport network length in the western provinces after 1999 was put into the three central transportation hubs (Hubei, Henan and Hunan) where the effects on reducing regional disparity are the largest.[44]

Table 8: Impacts on national and regional growth if moving highways and railways from the west to some coastal provinces and central hubs (2000-2003)

If half of the increase in length of the transport network in the western region were moved to Shangdong, Jiangsu and Hebei:

	2000	2001	2002	2003	Average
Nation	18.38	81.7	14.74	7.58	30.60
Coast	23.54	103.92	19.07	9.87	39.10
Inland	10.99	49.54	8.38	4.17	18.27
West	7.9	37.88	5.32	2.35	13.36

If half of the increase in length of the transport network in the western region were moved to Hubei, Henan and Hunan:

	2000	2001	2002	2003	Average
Nation	6.12	31.14	5.13	2.64	11.26
Coast	2.79	14.58	2.53	1.36	5.32
Inland	10.89	55.11	8.93	4.56	19.87
West	9.9	51.39	7.29	3.43	18.00

Note : Figures are presented in 1/10000. For example, if half of the increase in the length of railways and highways in the western region were moved to Shandong, Jiangsu and Hebei, it would have led to an 18.38×10^{-4} increase in the growth rate of the whole China in 2000.

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[44] In year t ($t > 1999$), the “extra length”, $extralength_{v,t}$, of transport network length of a western province v is $extralength_{v,t} = (highways_{v,t} \times a1_t + railways_{v,t} \times a2_t) - predictedlength_{v,t}$, where $predictedlength_{v,t}$ is a linear function of the highways and railways length and year before 1999 (see note 39 and graph 9). Under the scenario that half of the increase in transport network length in the western provinces after 1999 was put into the three coastal provinces (Shandong, Jiangsu and Hebei), the density of transport network in a western province v, $Dnew4_{v,t} = D_{v,t} - \frac{1}{2} \times (\frac{extralength_{v,t}}{surface_v})$, and the density of transport network in each of the three coastal provinces c, noted as $D'_{c,t} = D_{c,t} + \frac{1}{3} \times \frac{1}{2} \times (\frac{\sum_{v}^{v=west} extralength_{v,t}}{surface_c})$. Under the scenario that half of the increase in transport network length in the western provinces after 1999 was put into the three central hubs (Hubei, Henan, and Hunan), the density of transport facility in a western province v, $Dnew5_{v,t} = Dnew4_{v,t} = D_{v,t} - \frac{1}{2} \times (\frac{extralength_{v,t}}{surface_v})$, and the density of transport facility in each of the three central hubs h, noted as $D'_{h,t} = D_{h,t} + \frac{1}{3} \times \frac{1}{2} \times (\frac{\sum_{v}^{v=west} extralength_{v,t}}{surface_h})$.

The results of table 8 suggest that if half of the increase in the length of railways and highways in the western region were “moved” to Shandong, Jiangsu, and Hebei, the induced national growth rate would have been higher (for example, in 2000, it would have been 0.2% higher).[45] However, in this first case, a large part of the induced growth would have been concentrated in the coastal region, and the growth impacts on the western region would have been limited. If half of the increase in the length of railways and highways in the western region were “moved” to Hubei, Henan and Hunan, the induced national growth would still be positive (for example, in 2000, it would have been 0.06% higher), although lower than the induced growth level in the scenario that the same mount of railways and highways were moved to the three coastal provinces. However, in this second case, the inland/western region would have benefited disproportionately.

Table 9 Impacts on changes in regional disparities if moving highways and railways from the west to some coastal provinces and central hubs (2000-2003)

If half of the increase in length of the transport network in the western region were moved to Shandong, Jiangsu and Hebei:				
Absolute change in Gini coefficient	0.03%	0.15%	0.03%	0.02%
Relative change in Gini coefficient	0.12%	0.52%	0.11%	0.05%
If half of the increase in length of the transport network in the western region were moved to Hubei, Henan and Hunan:				
Absolute change in Gini coefficient	-0.02%	-0.11%	-0.02%	-0.01%
Relative change in Gini coefficient	-0.08%	-0.40%	-0.06%	-0.03%

It is not surprising that moving some highways and railways from the west to the three coastal provinces will increase the regional disparities (upper part of table 9). What draws our attention is that, moving some highways and railways from the west to the three central transportation hubs will not only increase growth at the national level and at the different regional level, but also reduce regional disparities (lower part of table 9). In other words, relocating an appropriate amount of infrastructure investments from some western provinces to the central hubs will have better effects both on maximizing

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[45] The increase in the length of highways and railways in the western region differs over time, hence the value of the induced growth varies. For example, in 2000-2001, there was a large increase in the length of highways and railways in the west. If half of this increase were moved to the three coastal (or the three central) provinces, it would have higher effects on induced growth than in other periods.

national aggregate growth and on reducing regional disparities. As illustrated earlier, the market access of one province depends not only on its own infrastructure development but also on the infrastructure development of the transit provinces. Developing the infrastructure of the provinces that links many western provinces to the markets, namely, the transportation hubs, is an effective way to rebalance the regional economy in China.

5.3 Alternative transportation infrastructure investment policies

The development of western region may be unrealizable due to the lack of microeconomic foundations if the transportation infrastructure is too poor for local enterprises to have the minimum demand because of market segmentation. However, we argue that the political inclination to western regional development does not necessarily lead to the conclusion that all infrastructure investments should be located in the western region. Our simulation results suggest that putting transportation infrastructures only in the west will suffer a large expense of efficiency lost – even if we only focus on the induced growth in the west, the effects are mediocre. One reason of the inefficiency of putting transportation infrastructures in the West is, if we improve the transport network in a remote province, the growth impact will be limited to that province itself and the other western provinces may not be able to benefit from this infrastructure improvement; the other reason is that if we do not improve the transport facility that links the western provinces to the market, the intra-province transport improvement may lead to an inward looking production structure, and the limited size of the local market may not be able to trigger or support the economy of scale. Because western provinces are underdeveloped, their local demands are modest and their technology and management are less advanced. The separation of East and West renders the investment in the West much less efficient.

Putting transportation infrastructures in the coast have the largest impacts on national growth. Developing the growth poles may generate positive spillover effects and encourage the catching-up of the other provinces. However, further infrastructure developments within coastal regions may lead to the reinforcement of agglomeration, which will accelerate regional growth of coastal regions relative to the western ones. With the non-negligible multiplier effects of infrastructure investments on local economic development, the additional investments in the coastal provinces may aggravate the unbalanced development of China. The possible gains in economic growth may not always be able to justify the increasing social costs due to the widening of the regional gap.

If priorities are given to reducing regional disparity, it is more advisable to locate infrastructure investments in the central provinces of Henan, Hubei, and Hunan. Although they may be less developed compared with the coastal provinces, they are already relatively developed (in particular compared to the western provinces) at least in terms of transportation conditions. For the specialty of transportation infrastructure, some additional investments to a reasonably well-developed location generate greater positive effects than to less-developed places. This is not to conclude that we should neglect the development of remote border provinces because of their current relative less developed situations. What we argue here is that, it is important to develop the hubs to encourage the outward-looking production structure of the western region and facilitate the transfer of technology and management skills from more advanced regions.

Why the development of the infrastructure network in the central provinces Hubei, Henan and Hunan most effectively encourage the growth of the poor western provinces? In short, two reasons: 1. The central provinces serve as transportation hubs with largest volume of traffics from the western provinces. Investing in the transport network in central hubs most effectively reduces the transport cost from the west to the economic center, the coast; 2. Infrastructure investments have large multiplier effects on local development, which favors the emergence of the central hubs as the future economic center. As suggested by Fujita, Krugman and Venables (1999), as an economy develops, the effective economic area enlarges, the centrifugal forces may become stronger and some footloose activities may tend to move out of the original economic center to take advantage of the lower factor cost and to better serve the periphery (in which case, the economic hinterland also enlarges). Based on the balance of the centrifugal and centripetal forces, the new economic center tends to emerge between the original economic center and the periphery. In the case of China, the emergence of the new economic center in the central provinces, which situates between the coastal provinces and the western provinces, may modify the economic geographic structure of the Chinese economy in favor of the increased market accessibility of the western provinces.

However, one potential problem that we must consider is that when we strengthen infrastructures, say, the transportation network, from the West to the East, we improve the accessibility of the eastern provinces to western markets. While this improved accessibility accelerates the development of the West, it has inherent risks insofar as the coastal and central regions can supply better goods at lower prices. For the sake of long-term growth of the West and the entire China, some appropriate regional economic policies, such as appropriate regulations that reasonably protect the privileges of western local enterprises as infant industries, must be implemented to limit the negative effects. In addition, given the fact that the infrastructure development level of some western provinces is too poor to provide basic facilities of transportation and that infrastructure investment itself generates a large multiplier effect on local development, it is reasonable to locate some infrastructure investment there to help to break the vicious cycle. In particular, investments in the provinces Sichuan and Shaanxi are recommended, given their important role in regional development.

6 Conclusions

The widening regional disparity is one of the major concerns for the long-term sustainable development of the rapid-growing Chinese economy. The geo-economic remoteness to the markets lowers the growth performance and limits the development potentials of the lagging western region. Targeted allocation of transportation infrastructure investments in favor of the catching-up of the western region is important for the rebalance of regional development.

The paper studies the role of transportation infrastructure investments in different provinces in the economic growth performance at the national and regional levels, and simulates the effects of hypothetical allocations of infrastructure investments. The results shed light on the transportation infrastructure investment policy choices – if the objective is to maximize the impacts on aggregate national growth, infrastructures should be allocated in some coastal economic centers; if the priority is to maximize the impacts on regional disparity reduction, infrastructures should be allocated in some central transportation hubs. Without appropriate development of the transport facilities in the central and coastal regions, randomly putting all additional transportation investments in the West will not have optimal effects on encouraging growth or reducing disparity. Further investing in the coastal provinces maximizes national growth at the expense of widening regional disparity. To prioritize the catching-up of the western provinces without unnecessarily sacrificing much national growth, it is essential to target transportation infrastructure investments in the central transportation hubs.

Reference:

Aschauer D.A. (1989), “Is public Expenditure Productive?” Jounral of Monetary Economics, 23(2), pp.177-200.

Aziz J. Duenwald C. (2003), “China’s Provincial Growth Dynamics”, *IMF Working paper 01/03.*

Baumont C., P. P. Combes, P. H. Derycke, and H. Jayet. éds. (2000*). Economie géographique: les théories à l'épreuve des faits*. Paris: Economica.

Barro, R.J. (1991). "Economic Growth in a Cross Section of Countries." *Quarterly Journal of Economics* 106(2):407-43.

Barro, R.J., and X. Sala-i-Martin. (1992). "Convergence." *Journal of Political Economy* 100(2): 223-51.

Barro R.J., and X. Sala-i-Martin. (1996). *La croissance économique.* Collection sciences économiques, McGraw-Hill /Ediscience, Paris.

Ben-David D. (1994), "Convergence Clubs and Diverging Economies", *CEPR discussion paper 922.*

Ben-David D. (1997), "Convergence Clubs and Subsistence Economies", *NBER working paper 6267*

Carruthers R. Bajpai J. and Hummels D. (2003), “Trade and Logistics in East Asia: a Development Agenda”, *EASTR Working Paper No.3*, The World Bank.

Chen J., Fleisher B.M. (1996), "Regional Income Inequality and Economic Growth in China", *Journal of Comparative Economics*, Vol.22, pp. 141-164.

Cozzi G. (1997), "Exploring Growth Trajectories”, *Journal of Economic Growth*, Vol.2, No.4, pp.385-398.

Davis, D.R., and D. E. Weinstein. (1997). "Economic Geography and Regional Production Structure: an Empirical Investigation." *NBER Working Paper 6093*. Cambridge, Mass.

Démurger S. (2001). “Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China?”, *Journal of Comparative Economics* 29 (1):95–117.

Démurger S., Sachs J.D., Woo W.T., Bao S. Chang G. Mellinger A. (2002), “Geography, Economic Policy, and Regional Development in China”, *NBER Working Paper #8897*.

Desdoigts A. (1999), "Patterns of Economic Development and the Formation of Clubs", *Journal of Economic Growth*, Vol.4 (September), pp.305-330.

Fabrizio F., T. Wahl, P. Wandschneider (2005), “Evidence of the Effect of Infrastructure on Agricultural production and productivity: Implication for China”, *mimeo*, Washington State University.

Fan S., X. Zhang (2004), “Infrastructure and Regional Economic Development in Rural China”, *China Economic Review* 15(2), pp.203-214.

Fernald J.G. (1999), “Roads to Prosperity? Assessing the Link between Public Capital and Productivity”, *American Economic Review*, 89 (3), pp.619-638.

Fleisher, B M., Chen J. (1997). “The Coast-Noncoast Income Gap, Productivity and Regional Economic Policy in China”. *Journal of Comparative Economics* 25 (2):220–36.

Fu X., (2004), “Limited linkages from growth engines and regional disparities in China”, *Journal of Comparative Economics*, 32, 148-164.

Fujiata, M., P. Krugman, and A. J. Venables. (1999). *The Spatial Economy: Cities, Regions and International Trade."* Cambridge, Mass.: MIT Press.

Fujita M., Hu D., (2001), “Regional disparity in China 1985-1994 : the Effects of Globalization and Economic Liberalization”, *The Annals of Regional Science, 3*5, 3-37.

Gallup, J.L., J. D. Sachs, A. D. Mellinger. (1999). "Geography and Economic Development." *International Regional Science Review* 22(2):179-232.

Gao T., (2004), “Regional Industrial Growth : Evidence from Chinese Industries”, *Regional Science and Urban Economics*, 34, 101-124.

Henderson, J.V., S. Zhalizi, and A. J. Venables. 2000. "Geography and Development." *Policy Research Working Paper 2456.* The World Bank.

Hu C., Tan C. (1996). *Empirical Study on the Regional Economic Disparities in China*, DRC Report #42, State Council Development Research Center, Beijing.

Hu D., (2002), “Trade, Rural-urban Migration, and Regional Income Disparity in Developing Countries : a Spatial General Equilibrium Model Inspired by the Case of China”, *Regional Science and Urban Economics,* 32, 311-338.

Jones D.C., Li C., Owen A.L., (2003), “Growth and Regional Inequality in China during the Reform Era “, *China Economic Review*, 14, 186-200.

Kanbur, R., & Zhang, X. (1999). “Which Regional Inequality? The Evolution of Rural–urban and Inland–coastal Inequality in China from 1983 to 1995”. *Journal of Comparative Economics,* 27(4), pp. 686–701.

Kanbur, R., & Zhang, X. (2002). Fifty Years of Regional Inequality in China: a Journey through Revolution, Reform and Openness. *Manuscript,* Cornell University.

Kim T. J., Knaap G., (2001), “The Spatial Dispersion of Economic Activities and Development Trends in China : 1952-1985”, *The Annals of Regional Science,* 35, 39-57.

Krugman P. (1991), “First Nature, Second Nature, and Metropolitan Location”, *NBER Working Paper #3740.*

Krugman, P. (1995). "A Dynamic Spatial Model." *NBER Working Paper* # 4219. Cambridge, Mass.

Lee J., (2000), « Changes in the source of China’s regional inequality », *China Economic Review,* 11, 232-245.

Li Z. (2005), “Measuring the Social Return to Infrastructure Investments: a Natural Experiment in China”, *mimeo.*

Lin J. (1995), “The Evolution of China’s Regional Development Policies”. *Regional Development Studies* 1 (Winters), pp.55-81.

Litwack, J. M., & Qian, Y. (1998). “Balanced or Unbalanced development: Special Economic Zones as Catalyst for Transition”, *Journal of Comparative Economics*, 26, pp. 117–141.

Liu Z. (2004). Planning and Policy Coordination in China’s Infrastructure Development, *mimeo*, The World Bank.

Luo X. (2001), "L'accessibilité au marché des provinces chinoises: le rôle des 'hubs' de transport", *Revue Région et Développement*, No.14, pp.121-142.

Luo X. (2003), *Impact des investissements en infrastructure sur la croissance régionale : le cas des provinces chinoises*, Thèse de Doctorat, Université d’Auvergne Clermont 1.

Luo X. (2004), "The Role of Infrastructure Investment Location on China’s Western Development", *Policy Research Working Paper No.3345*, The World Bank.

Luo X. (2005), “Growth Spillover Effects and Regional Development Patterns: the Case of Chinese Provinces”, *Policy Research Working Paper*, The World Bank, *forthcoming.*

Mankiw, N.G., D. Romer, and D. N. Weil. (1992). "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics* 107(2):407-37.

Morrison C. J., A.E. Schwartz (1996), “State Infrastructure and productive Performance”, *American Economic Review,* 86(5), pp.1095-1111.

Mundell A. H. (1990), “How Does public Infrastructure Affect Regional Economic Performance?” in Mundell eds. *Is there a Shortfall in Public Capital Investment?* Boston, M.A, pp.69-103.

National Bureau of Statistics of China (1999), *Comprehensive Statistical Data and Materials on 50 Years of New China*, Beijing : China Statistics Press.

Naughton B. (2004), "The Western Development Program" in Naughton B. and D. Yang eds. *Holding China together: Diversity and National Integration in the Post-Deng Era*. Cambridge University Press.

Puga, D. (1999). "The Rise and Fall of Regional Inequalities." *European Economic Review* 43:303-34.

Quah D. (1996), "Twin peaks: growth and convergence in models of distribution dynamics", *Economic Journal*, Vol.106, pp.1045-1055.

Quah D. (1997), "Empirics for Growth and Distribution: Stratification, Polarization, and Convergence Clubs", *Journal of Economic Growth*, Vol.2, No.1, pp.27-59.

Quah D. (1999), "Ideas Determining Convergence Clubs", website*:* *http://econ.lse.ac.uk/staff/dquah/p/9907ccb.pdf*

Quah, D. (2001). "Some Simple Arithmetic on How Income Inequality and Economic Growth Matter." website *http://econ.lse.ac.uk/staff/dquah/p/0106iieg.pdf.*

Ricci, L.A. (1999). "Economic Geography and Comparative Advantage: Agglomeration versus Specialization." *European Economic Review* 43:357-77.

Ravallion M. , Chen S. (2004), "China's (Uneven) Progress against Poverty", *Policy Research Working Paper #3408,* The World Bank.

Solow, R.M. (1956). "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics* 70(1):65-94.

Swan, T.W. (1956). "Economic Growth and Capital Accumulation." *Economic Record*, 32: 334-61.

State Council (2000). *Circular of the State Council on Policies and Measure Pertaining to the Development of the Western Region*. Beijing: China Planning Press.

State Statistical Bureau of the People's Republic of China. *China Statistical Yearbook*. Beijing: China Statistics Press

State Statistical Bureau of the People's Republic of China, *China Statistical Yearbook of communication*, China Statistics Press, Beijing.

The World Bank (2004), *A better Investment Climate for Everyone*, World Development Report 2005.

The World Bank (2005), *World Development Indicators 2005*.

Venables, A.J. (2000). "Winners and Losers from Regional Integration Agreements." *Economic Journal*, 113:747-61.

Wen M., (2004), "Relocation and Agglomeration of Chinese Industry", *Journal of Development Economics*, 73, 329-347.

Woo, W.T. (1998). "Chinese Economic Growth: Sources and Prospects." In Michel Fouquin and Françoise Lemoine, eds., *The Chinese Economy*. London: Economica.

Wu W. (1999), "Reforming China's Institutional Environment for Urban Infrastructure Provision", *Urban Studies* 36(13), pp.2263-2282.

Wu Y., (2002), "Regional Disparities in China : an Alternative View", *International Journal of Social Economics*, 29, 7/8, 575-589.

Yang D.T. (2002). "What Has Caused Regional Inequality in China", *China Economic Review* 13, pp.331–334

Yao, S., & Zhang, Z. (2001). "On Regional Inequality and Diverging Clubs: a Case Study of Contemporary China", *Journal of Comparative Economics*, 29, pp.466-484.

Zhang W., (2001), "Rethinking Regional Disparity in China", *Economics of Planning,* 34, 1-2, 113-138.

Annex 1. Map of China

This map was produced by the Map Design Unit of The World Bank. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.

Annex 2 Construction of the indicator "Peripheral Degree"

The construction of the Peripheral degree of a province (province i) includes five steps:

1. For each province (noted as province v), we calculate its road density and railway density (per square kilometer), noted as $DR_{v,t}$ and $DF_{v,t}$ respectively. Then, to better reflect the importance of road transportation and the railway transportation, we weight them with the road transportation volume and the railway transportation volume to get the transportation network index of the province ($D_{v,t}$,):

   $$D_{v,t} = a_{1t} DR_{v,t} + a_{2t} DF_{v,t} = a_{1t} \times \frac{highways_{i,t}}{surface_i} + a_{2t} \times \frac{railways_{i,t}}{surface_i} .$$

   Where a_{1t} represents the percentage of the road transportation volume and a_{2t} represents that of the railway at time t. $a_{1t}+ a_{2t}=1$.

2. For each two provinces (province i and province j), we calculate the index of the transportation facility between them, noted $D_{ij,t}$. Suppose that to transport some goods from province i to province j, it should go through n provinces (province i and j included), we take the index $D_{ij,t}$ as the simple average of the value of $D_{v,t}$ of these n provinces:

   $$D_{ij,t} = \frac{\sum D_{v,t}}{n}$$

3. We define the real distance between province i and province j ($Dist_{ij,t}$) as the weighted sum of their road distance ($DistR_{ij,t}$) and railway distance ($DistF_{ij,t}$).

   $$Dist_{ij,t} = a_{1t} DistR_{ij,t} + a_{2t} DistF_{ij,t}$$

4. We define the adjusted real distance between province i and province j ($DistA_{ij,t}$) as the result of their real distance divided by the index of their transportation facility.

   $$DistA_{ij,t} = Dist_{ij,t} / D_{ij,t}$$

   For a given real distance, the adjusted real distance implies that, the better the transportation facility is, the less the adjusted distance is. The transportation facility “shortens” the economic distance between the two provinces by reducing the transportation cost. The adjusted real distance is a better proxy of the transportation cost. The shorter the adjusted real distance is, the less the trade obstacles between two partners and so the greater the volume of trade between them, other things being equal. The greater the trade volume is between two provinces, the better the market accessibility is to the other in the view of the province in question, and the influence of partner province’s demand on the local market is greater.

5. We define the peripheral degree of province i as the weighted sum of the adjusted distance between this province and the domestic economic centers (here, the coastal provinces).

   $$DP_{i,t} = \sum_j (DistA_{ij,t} \times \frac{GDP_{j,t}}{\sum_j GDP_{j,t}})$$

   We weigh the adjusted distance between the province in question (i) and a coastal province (j) by the economic mass of the latter relative to that of coastal provinces in total to approximate the relative importance of the effective remoteness. The reason lies in that the farther away the province in question is from a great size coastal province, the more serious the disadvantage is that it suffers. The higher is the peripheral degree, the lower the economic-geographic attractiveness of the location.

Annex 3 Methodologies of simulations – growth impacts of changes in transportation network density

Using the value of the peripheral degree that we have constructed with the observed values of the initial development level, the investment ratio, and the population growth rate, and applying the values of the coefficients ($\alpha, \rho, \theta, \gamma, \zeta, \chi_t$) that we have estimated, we calculate the estimated value of the dependant variable "$\ln(y_{i,t}) - \ln(y_{i,t-1})$", noted as $gaes_{i,t}$, using the third estimation in table 3:

$$\ln(y_{i,t}) - \ln(y_{i,t-1}) = \alpha + \rho \ln(y_{i,t-1}) + \theta \ln(PD_{i,t}) + \gamma \ln(s_{i,t}) + \zeta \ln(n_{i,t}) + \sum_{t=1979}^{2002} \chi_t dummy_t + \varepsilon_{i,t}$$

We then compare the difference between this original estimated value $gaes_{i,t}$ with the new estimated value $gaes(v)_{i,t}$, which is resulted from the hypothetical change of transport network density of province v,[46] noted as $gadif(v)_{i,t} = gaes(v)_{i,t} - gaes_{i,t}$. This difference captures the increase of the growth rate of province i in year t due to the hypothetical increase in the transportation network density of province v.

In order to take into account the difference of the economic size of each province, we calculate the weighted average growth effects due to the modification of the transport network density of province v ($D_{v,t}$), noted as $gaeff(v)_t$:[47]

$$gaeff(v)_t = \sum_i^n [gadif(v)_{i,t} \times \frac{PIB_{i,t}}{\sum_i^n PIB_{i,t}}]$$

Finally, to evaluate the effects of the change of $D_{v,t}$ in each province v on the growth of different groups of provinces and hence on the regional balanced growth, we calculate the following ratios:

1) $i \in$ all Chinese provinces, $gaeff(v)_t$ stands for the growth effects on the whole Chinese economy due to a 10 percent increase in the density of the transportation network in province v in year t, noted as $gaeff0(v)_t$

2) $i \in$ all coastal provinces, $gaeff(v)_t$ stands for the growth effects on the coastal region due to a 10% increase in the density of the transportation network in province v in year t, noted as $gaeff1(v)_t$

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[46] Under the hypothetical scenario, the transport network density of province v is modified, and the new value is noted as $D(v)_{v,t}$. We calculate a new value of $PD_{i,t}$, noted as $PD(v)_{i,t}$. Then we put the new value of $PD(v)_{i,t}$ into the equation in replace of $PD_{i,t}$ to calculate the new value of the estimated variable "$\ln(y_{i,t}) - \ln(y_{i,t-1})$", noted as $gaes(v)_{i,t}$.

[47] The underlying idea lies in the notion that the larger is the economic size of the province in question in comparison with that of the whole group, the greater are the effects of the improvement of its economic performance on the growth of the group.

3) $i \in$ all inland provinces, $gaeff(v)_t$ stands for the growth effects on the inland region due to a 10 percent increase in the density of the transportation network in province v in year t, noted as $gaeff2(v)_t$

4) $i \in$ all western provinces, $gaeff(v)_t$ stands for the growth effects on the western region due to a 10 percent increase in the density of the transportation network in province v in year t, noted as $gaeff3(v)_t$

For simplicity, we calculate the following variables to study the average induced effects on the whole period 1979-2003:[48]

$$gaeff0(v)m = \frac{\sum_{1979}^{2003} gaeff0(v)_t}{25}$$

$$gaeff1(v)m = \frac{\sum_{1979}^{2003} gaeff1(v)_t}{25}$$

$$gaeff2(v)m = \frac{\sum_{1979}^{2003} gaeff2(v)_t}{25}$$

$$gaeff3(v)m = \frac{\sum_{1979}^{2003} gaeff3(v)_t}{25}$$

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[48] The induced effects on the growth of different groups of provinces in each year are available upon request.

Annex 4 Estimation of growth model

The neo-classical growth model emphasizes the effects of physical investment rate and demographic growth rate. The higher is the ratio of physical investment to GDP, the higher is the productivity of effective labor in long run equilibrium, other things being equal. Trying to explain the enormous contribution of fixed capital in growth, augmented Solow-Swan model argues the importance of human capital. The importance of the increasing return to scale renders the homogeneity of production function in various regions questionable, as suggested by the theory of new economic geography (Krugman, 1991). Specialization and agglomeration amplify regional difference.[49] Other than demographic growth rate, Solow-Swan model argues that technologic progress rate and depreciation rate of fixed investments influence regional growth. However, not all parameters that condition long-term economic performance are available or measurable. The omission of regional specific characteristics that do not vary in time may lead to the bias in estimation results. Hence, panel data estimation is preferable to cross-section estimation for the former may capture the non-measurable specific characteristics in fixed effect model.[50] We also introduce year dummies to control for the short-term effects that are common to all provinces. Following the Barro-type framework, we introduce the "peripheral degree", the "investment to GDP ratio", and the "population growth rate" to account for the difference in the steady-state equilibrium.[51]

We start our estimation by testing the very simple hypothesis of absolute convergence (divergence) and estimate the following model:

$$\ln(y_{i,t}) - \ln(y_{i,t-1}) = \alpha + \rho \ln(y_{i,t-1}) + \sum_{t=1979}^{2002} \chi_t dummy_t + \varepsilon_{i,t} \tag{1}$$

The first equation in table 3 shows that the initial development level "$\ln(y_{i,t-1})$" plays a significant role on regional growth.[52] As we have shown in the preceding section that geographical position, which represents regional market accessibility, may play an important role in influencing economic performance, we introduce the variable "peripheral degree", noted as $PD_{i,t}$, into our estimation:

$$\ln(y_{i,t}) - \ln(y_{i,t-1}) = \alpha + \rho \ln(y_{i,t-1}) + \theta \ln(PD_{i,t}) + \sum_{t=1979}^{2002} \chi_t dummy_t + \varepsilon_{i,t} \tag{2}$$

In the second equation, as predicted, the variable $PD_{i,t}$ plays a negative role on regional growth. The omission of this pertinent variable biases estimation results. The variable $\ln(y_{i,t-1})$ continues to be significantly negative, which signifies conditional convergence.

According to Solow-Swan model, we suppose that production function is of the type of Cobb-Douglas:

$$\ln(y_{i,t}) - \ln(y_{i,t-1}) = \vartheta + \upsilon \ln(y_{i,t-1}) + \gamma \ln(s_{i,t}) + \eta \ln(n_{i,t} + g_{i,t} + \delta_{i,t}) + \varepsilon_{i,t}$$

where s stands for the ratio of physical investment to GDP; n the population growth rate; g the technology progress and δ the depreciation rate of physical investment. Many precedent studies on

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[49] See Ricci (1999), Krugman (1995), Puga (1999), Quah (2001) and Venables (2000).

[50] The Haussman test suggests that fixed effect estimations are superior to random effect estimations. The limited number of observations does not allow carrying out the SURE estimations. The results of the two-step GMM estimations with two year-lagged dependent variables as IV matrix do not suggest the superiority of the GMM estimations over the fixed-effects estimations.

[51] See Barro (1991), Barro and Sala-i-Martin (1992; 1996).

[52] Chinese provinces are heterogeneous. It is not reasonable to admit the hypothesis of their long-term steady state homogeneity – the premise of the existence of absolute convergence (divergence).

regional growth, such as that of Mankiw, Romer and Weil (1992), suppose that the sum of these two parameters is homogeneously equal to 0.05. However, in the case of China, it seems that this hypothesis is questionable given the fact that Chinese provinces are so different one from the others. Due to the data unavailability of g and δ, we prefer to leave their influences implicitly into fixed effects:

$$\ln(y_{i,t}) - \ln(y_{i,t-1}) = \alpha + \rho \ln(y_{i,t-1}) + \theta \ln(PD_{i,t}) + \gamma \ln(s_{i,t}) + \zeta \ln(n_{i,t}) + \sum_{t=1979}^{2002} \chi_t dummy_t + \varepsilon_{i,t} \tag{3}$$

The significance of the demographic growth rate and the investment ratio in the third equation is consistent to the prediction of growth theory. Labor supply is not the major constrain of economic growth in China. Provinces with high physical investments and low population growth have better economic performance.