



Per Capita Income Convergence among Provinces in China

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ABSTRACT

One increasingly important political and economic challenge of China's economy is income inequality. In the past two decades, a series of regulations and policies were enacted to promote its economic growth and reduce income inequality. In this empirical study, we examine the effectiveness of these regulations and policies on reducing the personal income gap at the provincial level in China and analyze the reasons behind the effectiveness: education expenses, infrastructure investments, and fixed asset investments. We test the per capita income data of 31 provinces over the periods 1999-2018 and our results show that the per capita income converges nationally and in most regions. The convergence in per capita income is supported by the convergence in per capita education expenses, infrastructure investments, and fixed asset investments. Without fundamental changes in economic policies, the current economic growth may not be sustainable. Our paper suggests that continuously increase investments in education expenses, infrastructure investments, and fixed asset investments in poor regions are necessary to reduce the income gap between rich and poor regions to foster long-term prosperity.

Keywords: Convergence Theory, Per Capita Income, Education Expense, Infrastructure Investments, Fixed Asset Investments

JEL Classifications: D31, F63, O47, R11

1. INTRODUCTION

The income convergence theory is the hypothesis that the underdeveloped countries or regions can outgrow the developed countries or regions in terms of income per capita due to the so-called catch-up effect. Over the recent decades, many studies have tried to answer this question: does the per capita income convergence theory hold on the national level, or regional level, or both? A large number of previous research projects have tried to examine the per capita income convergence theory in developed and developing nations in Europe and the Americas and found mixed results.

To our knowledge, there are much fewer studies examining the theory in emerging markets. The emerging markets are important cases to examine the theory because not only are they growing rapidly but also there are significant shake-ups among different regions and sectors within the dynamic economies. There are even

fewer studies looking into the distribution of income in China. China's reform and opening up policy in the late 1970s has led to not only remarkable economic growth in the country, but also large income inequality between the coastal regions and the inland regions, even though more resources and policies have been directed to facilitate the growth of inland regions. The relatively large income discrepancy and the dynamic economy in China provide a perfect medium for the study of per capita income convergence. On the one hand, the dramatic shift of economic status and the technological development have revolutionarily impacted the average Chinese daily life as the average income has grown many folds during the past three decades. On the other hand, the unequal economic development across different regions in China is a growing challenge to the economy and the policymakers.

Additionally, previous studies have largely used gross domestic product (GDP) per capita as the proxy for the per capita income in

their studies mainly due to the unavailability of per capita income data, such as Barro (2016) and Tian et al. (2016). A drawback of such substitution is that income per capita can be substantially different from GDP per capita. This distortion may be much larger in the case of China because the export industry in the coastal regions contributes more significantly to the regional GDP than to per capita income due to relatively lower labor costs and labor migration across regions in China. So simply using GDP per capita as the proxy in convergence study may overestimate the per capita income level, which not only weakens the robustness of the results, but also jeopardizes the results. Therefore, in order to provide insights for future policymaking, it would be of great importance for us to use provincial-level per capita income data to test the effectiveness of prior policies in promoting economic growth and reducing income disparity.

Motivated by the research gap in the literature, the lack of first-hand per capita income data in prior studies, and the significant implications of income distribution among different regions in China, we collect the provincial-level per capita income data during 1999-2018 to identify whether the income converges among the 31 provinces in mainland China. We find that, with the increase in per capita education expenses, infrastructure investments, and fixed asset investments, personal income in China converges at the national level and at most regional level during the study period, especially after 2008. We provide possible causes and policy implications for the convergence.

Our study contributes to the literature in the following ways. First, we collected first-hand data of the average annual income of workers in each province as the provincial income per capita. The newly available per capita income data is a much stronger data set than GDP per capita for the test of the income convergence theory in China. Second, we test and confirm the validity of the income convergence theory at the national and regional level, whereas most studies have tried to examine the convergence theory at the national level. While it is important to examine the effect of different national economic policies on national income level, it is also important to find out if income converges within a country when there are economic and social measures aiming specifically to balance the development of different domestic regions. Last, we analyze the provincial-level data of per capita education expenses, infrastructure investments, and fixed asset investments during the study period and identify the root causes and impacts of personal income convergence in China.

The remainder of the paper is organized as follows: Section 2 reviews the literature; Background information is provided in section 3; Section 4 summarizes the methodology and data; Section 5 discusses the results and robustness checks; Section 6 presents the conclusions.

2. LITERATURE REVIEW

Scholars have made great progress in examining the per capita income convergence theory during the past several decades. In his pioneering work, Baumol (1986) examines the convergence hypothesis at the international level and finds evidence to support it in long-run economic development.

Many researchers start to study the regional convergence theory in the 1990s. Barro et al. (1991) study the growth and dispersion of many states and regional-level personal income in the U.S. since 1880. The results support the convergence theory, as they find that the poor states tend to grow faster in per capita income compared with the rich states. Barro et al. (1991) later expand the research to all 48 continental states in the U.S. with personal income data since 1840. They conclude that most of their data supports the convergence theory in the U.S.

Mallick and Carayannis (1994) examine the convergence theory in Mexico; Coulombe and Lee (1995) study the per capita income and output from 1961 to 1991 in Canada, and Chatterji and Dewhurst (1996) focus on analyzing the convergence theory in the United Kingdom with income data from 1977 to 1991. All three studies have found evidence supporting the convergence theory that the poor regions in these nations seem to outgrow the rich regions in per capita income.

Some recent studies find that geographical locations may also play a significant role in the converging process. Rey and Montouri (1999) use spatial econometric methods in their study to consider the question of regional economic income convergence in the U.S., which is widely used in geography studies. They combine the econometric analysis and geographical analysis, which give us a new perspective of looking at the same issue. Later, Heckelman (2013) uses cross-sectional and time-series methods to analyze the convergence theory in the Rodrik (2013) finds that strong unconditional convergence exists in labor productivity within manufacturing industries. All of their results are consistent with the previous studies and support the convergence theory.

As China's economy continues to grow rapidly in the past several decades, scholars start to look at the convergence theory in the context of China. Barro (2016) analyzes the Chinese national-level GDP growth rate and compares it with other developed and developing nations, and he suggests that the convergence theory holds over the long run. Tian et al. (2016) examine the Chinese provincial-level per capita GDP growth data from 1978 to 2013 and find that the data supports the convergence theory.

3. REGIONAL DEVELOPMENT IN CHINA

China began its "reform and opening" economic reform in the late 1970s. The coastal provinces in southeastern China are the first ones opening up the so-called "economic zones" to receive foreign investments and conduct foreign trade. The continuing development of these coastal provinces has created three major economic centers around the Pearl River Delta, the Yangtze River Delta, and the Bohai Economic Rim in China and caused significant labor migration from inland provinces to these economic centers on an annual basis.

The preferential policy and the advantage of coastal locations promoted substantial regional development, but at the same time, it caused uneven income distribution between the coastal and inland provinces. According to the report from Huang (2010), "By 2005, the Coastal Region accounted for more than 90 percent of total exports and imports, and it received 85 percent of foreign direct

investment.” With the accumulation of resources, especially labor and capital, those coastal regions had outgrown other regions in many areas such as personal income and education expenses. The inland regions, especially the more rural western provinces, were left behind during that period. Although the average personal income in leading metro areas such as Beijing and Tianjin has already reached more than \$18,000 annually in 2018, China still had more than 600 million people earned less than \$140/month.

In the 1990s and early 2000s, the urbanization process in China has made urban development much faster than that in rural areas. The trendy city lifestyle, better opportunities, and more available public resources in the rich provinces have attracted the younger generation to relocate from poorer provinces to richer ones. During the same period, due to economic development and labor migration, more funds and resources from the central government are allocated to the richer provinces for infrastructure, education, etc. The brain drain and the uneven funding policy had both widened the income gap between rich and poor provinces.

The global economy was hit hard by the 2008 financial crisis, and China was no exception. To avert the potential recession, the Chinese government initiated a series of central and local expansionary fiscal policies and injected more than 4 trillion RMB (\$559 billion) into the economy. The stimulus funds went to many areas and industries, such as education, infrastructure, fixed assets, technology, artificial intelligence, social security programs, environmental protection, etc. More funds were also purposefully allocated to regions of low income. By the end of 2019, the high-speed railway mileage in China was about 22,000 miles which is the longest in the world. According to the news released from the Department of Commerce, the total foreign direct investment (FDI) flows into China was around \$136.71 billion in 2019, which increased more than 20 times when compared with that in 1999.

In summary, China has experienced rapid growth in the last four decades and different regions have achieved different levels of development. The economic policies before and after the 2008 financial crisis have affected regional development significantly. We expect to see some significant differences in the convergence patterns before and after the introduction of the stimulus plan in our analysis.

4. METHODOLOGY AND DATA SOURCES

4.1. Model Specification

We examine the per capita income convergence issue by using the model from Rodrik (2013). The model assumes that if the convergence theory holds, then the initial level should be negatively correlated with its growth rate. The regression model is listed below:

$$\widehat{y}_{jt} = \beta \ln y_{jt} + D_j + D_t + \varepsilon_{jt} \quad (1)$$

\widehat{y}_{jt} is the annual growth rate of per capita income in province j at time t . $\ln y_{jt}$ is the natural log of per capita income in province j at time t . D_j is a fixed effect variable which controls all the time-invariant omitted variables for province j , such as the impact of geographical location. D_t is a fixed effect variable which controls

all time-variant omitted variables that happened during time t , such as weather or unexpected shocks on the national level. ε_{jt} is the error term.

The key figure in our convergence empirical test is β . Convergence theory indicates that the per capita income growth rate in poor provinces should be higher compared with rich provinces, therefore poor provinces can eventually catch up on per capita income. If the convergence theory holds, then β should be negative and statistically significant in our study. That means for a poor province with low per capita income, the growth rate of its per capita income should be higher. The opposite is also true to a rich province with a high per capita income. The negative β in the results should be interpreted as after we have controlled both location-fixed effect and time-fixed effect, the convergence theory should still hold in our analysis. With the control of location-fixed effect and time-fixed effect, we test conditional convergence in our analysis.

Given the large scale of the 2008–09 Chinese stimulus plan, we split our sample data into two periods (1999–2007, 2008–2018) to test the impact of the stimulus plan on income convergence in China. One concern from economists is that by resorting to central and local government regulations and policies to prevent Chinese economy from sliding into recession in late 2008, the policymakers may unknowingly direct too many resources to some rich regions, hence let the personal income in those rich regions grow faster than poor regions. If that is the case, then we should see β becomes insignificant, or becomes positive in some cases.

Based on the suggestions from Rey and Montouri (1999) and Heckelman (2013), we also divide 31 provinces into six different regions and test whether those regions may converge or not in groups based on their geographical locations in China.

To find out the causes of the income convergence in China, we have also tested the convergence issue on per capita education expense, infrastructure investments, and fixed asset investments in our analysis by using the same model. We test the provincial-level education expense data. We use the length of the highway as a proxy for the infrastructure investments in each province. Fixed asset investments include all kinds of government, private, and foreign direct investments in each province. We divide those provincial data with their accommodated provincial population to get per capita data in our analysis.

That leads us to our research questions:

- Question 1. Does income convergence theory hold in China on the national level, or on the regional level, or both?
- Question 2. What causes income convergence and whether income convergence can be sustainable in the long run?

4.2. Data Sources

We collect the per capita income data from the China Statistical Yearbook¹ which is published by the National Bureau of Statistics of China, over the period from 1999 to 2018. The sample data

1 China Statistical Yearbook, <http://www.stats.gov.cn/english/Statisticaldata/AnnualData/>.

contains 31 provincial-level jurisdictions in mainland China including 22 provinces, 5 autonomous regions, and 4 national government direct-controlled municipalities (Beijing, Tianjin, Shanghai, and Chongqing) (Appendix Table A). For our analysis, we divide the country into 6 regions: (1) the North region (Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia); (2) the Northeast region (Liaoning, Jilin, and Heilongjiang); (3) the East region (Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, and Shandong); (4) the South Central region (Henan, Hubei, Hunan, Guangdong, Guangxi, and Hainan); (5) the Southwest region (Chongqing, Sichuan, Guizhou, Yunnan, and Tibet); and (6) the Northwest region (Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang).

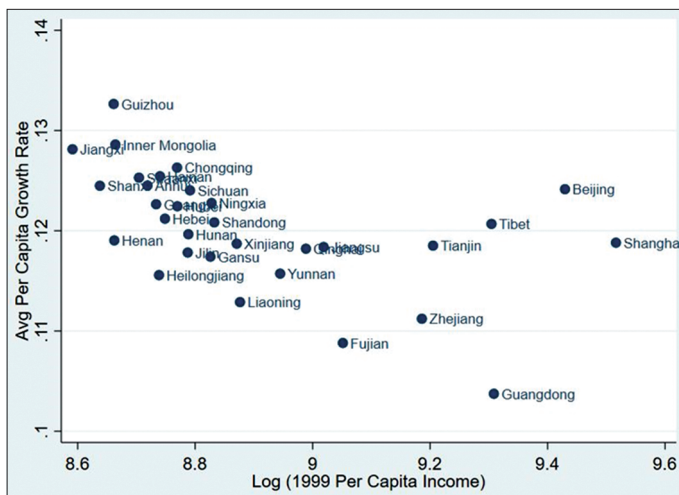
We also use the provincial population, education expense, length of the highway, and fixed asset investment data from the China Statistical Yearbook over the period from 1999 to 2018. The population data contain the total population of all ages in each province in each given year. Education expenses contain governmental appropriation, private funds, and other education funds on the provincial level. The length of highways includes expressway and class I to IV highways on the provincial level. The fixed asset investments include funds from the state budget, domestic loans, foreign investments, self-raising funds, and other funds on the provincial level.

RESULTS ANALYSIS

5.1. Income Convergence

We have summarized the per capita income data in Figure 1. Figure 1 is a scatter plot of the average provincial per capita income growth rate versus the log of the 1999 provincial per capita income in China. In this figure, we can see that there is generally a downward slopping trend. It shows that the average personal income growth rate and the initial level of per capita income are negatively correlated. In general, per capita income in poor provinces tends to grow faster compared with rich provinces,

Figure 1: Per capita income growth rate against original per capital income level. The horizontal axis is the logarithm of the per capita income level in 1999. The vertical axis is the average annual growth rate of per capita income over 1999-2018



which matches convergence theory. However, there are few outliers in the figure, such as Beijing, Shanghai, and Tianjin. Most of those outliers are national government direct-controlled municipalities.

Now let us answer our first research question: does convergence theory hold in China? Table 1 displays provincial-level per capita income data convergence theory test results from 1999 to 2018. Results in column 1 show that on the national level, β is negative and statistically significant at 1% level. It means that on the provincial level, the annual personal income growth rates are negatively related to the level of the personal income level of the same period. Economically, for poor provinces with low per capita income, their per capita income growth rate should be higher than that in rich provinces with high per capita income during the same period. That is consistent with the convergence theory.

The results of per capita income convergence tests on six regions are listed from column 2 to column 7. We find that β in the North, the East, the Southwest, and the Northwest regions are negative and statistically significant at least at 5% level. That shows the per capita income does converge inside those four regions. However, β in the Northeast and the South-Central regions are not significant, which means in our sample period, per capita income doesn't converge inside these two regions. In Table 1, we can see that on the national level, per capita income does converge over the sample period. On the regional level, the personal income also converges in 4 out of 6 regions in China.

Now we test the impact of the 2008-09 Chinese stimulus plan on personal income convergence theory in China. We split our sample data into two sub-sample data sets and apply the same econometric models on them. Table 2 covers the period from 1999 to 2008, and Table 3 covers the period from 2009 to 2018. In Table 2, we can see that on the national level, β is negative and statistically significant at 1% level. It shows that per capita income does converge on the national level in the first period. However, the results also show us that only β in the North and the Southwest regions are negative and statistically significant at least at a 5% level. That means personal income does not converge in 4 out of 6 regions in China.

Table 3 shows the results for 2009-2018. On the national level, β is still negative and statistically significant at 1% level. It indicates that per capita income converges on the national level in China during the second period, which is consistent with the results in the previous two tables. Compared with the β of -0.267 for 1999-2008 and the β of -0.165 for 1999-2018, the β of -0.409 for 2009-2018 shows that the income converges at a faster speed in this period. The results also show that β in the North, the East, the South Central, the Southwest, and the Northwest regions are negative and statistically significant at least at 5% level. The regional results reveal that per capita income during 2009-2018 converges in 5 out of 6 regions in China.

One important finding from the results in the first three tables is that the negative relationships between the per capita income and its annual growth rates become more significant during the second

Table 1: Per capita income results of all periods, 1999-2018

\widehat{inc}_{jt}	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lninc_{jt}$	-0.165*** (0.000)	-0.164*** (0.009)	-0.047 (0.626)	-0.099** (0.027)	-0.064 (0.146)	-0.265*** (0.003)	-0.174*** (0.007)
Constant	1.689*** (0.000)	1.660*** (0.005)	0.525 (0.540)	1.090** (0.011)	0.656* (0.090)	2.462*** (0.002)	1.638*** (0.004)
Observations	589	95	57	133	114	95	95
R ²	0.396	0.740	0.825	0.458	0.537	0.377	0.707
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table 2: Per capita income results 1st period, 1999-2008

\widehat{inc}_{jt}	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lninc_{jt}$	-0.267*** (0.000)	-0.218** (0.042)	-0.277 (0.186)	-0.164 (0.127)	-0.031 (0.762)	-0.641*** (0.001)	-0.118 (0.374)
Constant	2.676850*** (0.000)	2.180754** (0.033)	2.581737 (0.168)	1.718865* (0.095)	0.383957 (0.669)	5.756128*** (0.001)	1.147610 (0.323)
Observations	310	50	30	70	60	50	50
R ²	0.435	0.689	0.851	0.344	0.626	0.552	0.728
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

Table 3: Per capita income results 2nd period, 2009-2018

\widehat{inc}_{jt}	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lninc_{jt}$	-0.409*** (0.000)	-0.468*** (0.004)	-0.088 (0.409)	-0.434*** (0.000)	-0.367*** (0.000)	-0.647*** (0.001)	-0.334** (0.011)
Constant	4.549*** (0.000)	5.197*** (0.004)	1.010 (0.354)	4.816*** (0.000)	3.784*** (0.000)	6.722*** (0.001)	3.510*** (0.008)
Observations	279	45	27	63	54	45	45
R ²	0.375	0.654	0.800	0.732	0.620	0.437	0.608
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

period. Not only do more regions converge during 2009-2018, but also the annual per capita income growth rates of poor provinces with low per capita income is higher in the second period compared with that in the first period. The income convergence effect for the whole study period is mainly driven by income per capita growth in the second half of the study period.

5.2. What Causes the Income Convergence?

The income per capita is influenced by a variety of factors, for example, human capital, technology, fixed capital, etc. Numerous studies have found that increase spending in those areas can significantly increase people's livelihood and income. Fernandez and Rogerson (1996) find that increase spending in public education can significantly increase personal income for residents who live in poorer communities. Glomm and Ravikumar (2003) conclude that in the long run, public education can be a great tool to reduce income inequality. Calderón and Servén (2004) find that the development of infrastructure increases the economic growth rates, and income inequality decreases with the increase of infrastructure quantity and quality. Choi (2004) finds that the increase of bilateral FDI decreases income level and growth gaps

in both source and host countries during the sample period, and investments play an important role in income convergence and growth process. In this section, we will find out the factors that drive the income convergence in our study period, especially in the second half of the study period where income convergence is more prominent.

We test convergence theory in three separate areas: per capita education expense, per capita length of the highway, and per capita fixed asset investments. Per capita education expenses are directly related to the education level which improves human capital and hence production efficiency and income level. Per capita length of the highway is a proxy for infrastructure investment. Advanced infrastructure attracts business and provides a healthy environment for businesses to operate efficiently. Per capital fixed asset investment contributes to production directly.

Table 4 displays provincial-level per capita education expense convergence theory test results from 1999 to 2018. Results show that on national level, β is negative and statistically significant at 1% level. That means per capita education expense does

converge on the national level during our sample period. We find that β in the South Central, the Southwest, and the Northwest regions are negative and statistically significant at least at 10% level. That means per capita education expense does converge in those regions in China during the sample period. Table 5 displays per capita education expense convergence test results in the first period from 1999 to 2008, and Table 6 displays test results in the second period from 2009 to 2018. Comparing results in these two tables, we can see that on the national level, per capita education expense converges in both periods. On the regional level, in the first period, per capita education expenses only converge in the South central and the Southwest regions. In the second period, per capita education expenses converge in all regions except the Northeast region. When we compare results from Tables 4-6, we can see that not only per capita education expenses become more likely to converge inside each region, but the magnitude of convergence also increased significantly. The results supported our initial arguments that the 2008-09 stimulus plan has a huge impact on convergence issues in China, not only on per capita income but also on per capita education expenses.

Table 7 displays the provincial-level per capita length of highway convergence test results from 1999 to 2018. Results show that on national level, β is negative and statistically significant at 1% level. That means the per capita length of the highway does converge on the national level during our sample period. We also find β in all six regions are all negative and statistically significant at least at 10% level. That means the per capita length of highway does converge in all regions during the sample period.

Table 8 displays the per capita length of highway convergence test results in the first period from 1999 to 2008, and Table 9 displays test results in the second period from 2009 to 2018. On the national level, per capita length of highway converges in both periods. In the first period, per capita length of highway converges in the North, the East, and the Northwest regions. In the second period, per capita length of highway converges in the East, the South Central, and the Southwest regions. The regional level convergence test results match the infrastructure investment patterns in China during the past two decades. During the first period, the government initiated a series of infrastructure investments in the North and the East regions to upgrade existing infrastructures, such

Table 5: Per capita education expense results 1st period, 1999-2008

\widehat{edu}_{jt}	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lnedu_{jt}$	-0.155*** (0.001)	-0.020 (0.895)	-0.279 (0.230)	-0.134 (0.190)	-0.501*** (0.006)	-0.287*** (0.005)	-0.120 (0.556)
Constant	1.195*** (0.000)	0.251 (0.811)	1.698 (0.184)	1.005 (0.139)	2.609*** (0.004)	1.628*** (0.002)	0.784 (0.463)
Observations	310	50	30	70	60	50	50
R ²	0.489	0.400	0.739	0.493	0.549	0.753	0.601
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

Table 6: Per capita education expense results 2nd period, 2009-2018

\widehat{edu}_{jt}	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lnedu_{jt}$	-0.379*** (0.000)	-0.520*** (0.001)	-0.117 (0.539)	-0.376*** (0.000)	-0.524*** (0.000)	-0.247* (0.063)	-0.704*** (0.000)
Constant	3.036*** (0.000)	4.148*** (0.001)	1.000 (0.444)	2.927*** (0.000)	3.562*** (0.000)	1.852** (0.037)	4.957*** (0.000)
Observations	279	45	27	63	54	45	45
R ²	0.664	0.713	0.871	0.810	0.774	0.625	0.773
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

Table 7: Per capita length of highway results of all periods, 1999-2018

$\widehat{highway}_{jt}$	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lnhighway_{jt}$	-0.210*** (0.000)	-0.170** (0.025)	-0.388*** (0.007)	-0.304*** (0.000)	-0.195*** (0.006)	-0.162* (0.064)	-0.444*** (0.001)
Constant	0.348*** (0.000)	0.507*** (0.001)	0.878*** (0.007)	0.229*** (0.004)	0.492*** (0.004)	0.493** (0.028)	1.110*** (0.001)
Observations	589	95	57	133	114	95	95
R ²	0.617	0.559	0.958	0.755	0.598	0.506	0.682
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

as highway and railroads, to support the 2008 Beijing Olympic Games. Some experts estimated that the initial expenses on the 2008 Beijing Olympic Games were at least \$40 billion, and most of those expenses were focused on infrastructure investments. With so much infrastructure investments in such a short period on few provinces, some of those investments were also flown to surrounding less-rich provinces due to the spillover effect.

The short-term intense infrastructure investments is not sustainable, as it may take decades for the government to balance

its budget and get its money back from those projects. That explains the different infrastructure investment patterns we have seen in the second period. During that period, the government shifts its focus from investing in rich regions to poor regions. For example, in 2008, China only has 78 miles of high-speed railway which links Beijing and Tianjin. By the end of 2019, the high-speed railway mileage in China was around 22,000 miles. The exponential growth of those infrastructure investments was mostly concentrated in poor regions. That explained why the per capita length of the highway converged in some regions in the

Table 8: Per capita length of highway results 1st period, 1999-2008

$\widehat{highway}_{jt}$	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$inhighway_{jt}$	-0.342*** (0.000)	-0.488** (0.011)	-0.477 (0.119)	-0.451*** (0.002)	-0.146 (0.352)	-0.268 (0.203)	-0.680*** (0.002)
Constant	0.650*** (0.000)	1.169*** (0.004)	1.083 (0.123)	0.408** (0.013)	0.423 (0.202)	0.735 (0.124)	1.641*** (0.002)
Observations	310	50	30	70	60	50	50
R ²	0.614	0.586	0.957	0.749	0.590	0.491	0.706
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

Table 9: Per capita length of highway results 2nd period, 2009-2018

$\widehat{highway}_{jt}$	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$inhighway_{jt}$	-0.246*** (0.000)	-0.147 (0.103)	-0.185 (0.355)	-0.238*** (0.001)	-0.235** (0.014)	-0.415*** (0.000)	-0.138 (0.109)
Constant	0.553352*** (0.000)	0.352552* (0.097)	0.593891 (0.349)	0.383506*** (0.002)	0.754930** (0.013)	1.526492*** (0.000)	0.545159* (0.077)
Observations	279	45	27	63	54	45	45
R ²	0.476	0.461	0.342	0.503	0.429	0.766	0.551
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

Table 10: Per capita fixed asset investments results of all periods, 1999-2018

$\widehat{fixedinv}_{jt}$	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lnfixedinv_{jt}$	-0.049*** (0.001)	-0.096*** (0.006)	-0.043 (0.651)	-0.043** (0.034)	-0.050 (0.113)	-0.124* (0.054)	-0.175** (0.010)
Constant	-0.074** (0.015)	-0.100* (0.089)	-0.027 (0.855)	-0.120*** (0.002)	-0.013 (0.833)	-0.110 (0.342)	-0.159 (0.192)
Observations	589	95	57	133	114	95	95
R ²	0.484	0.658	0.683	0.652	0.679	0.419	0.617
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

Table 11: Per capita fixed asset investments results 1st period, 1999-2008

$\widehat{fixedinv}_{jt}$	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$lnfixedinv_{jt}$	-0.053* (0.091)	-0.014 (0.817)	-0.024 (0.831)	-0.039 (0.538)	0.031 (0.699)	-0.268** (0.022)	-0.026 (0.807)
Constant	-0.052 (0.111)	-0.055 (0.297)	0.047 (0.762)	-0.096** (0.040)	0.167 (0.284)	-0.334 (0.104)	0.115 (0.558)
Observations	310	50	30	70	60	50	50
R ²	0.553	0.704	0.834	0.652	0.685	0.451	0.534
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

Table 12: Per capita fixed asset investments results 2nd period, 2009-2018

$\widehat{fixedinv}_{it}$	(1) National	(2) North	(3) Northeast	(4) East	(5) South Central	(6) Southwest	(7) Northwest
$\ln fixedinv_{jt}$	-0.114*** (0.001)	-0.448*** (0.004)	-0.016 (0.913)	-0.265*** (0.000)	-0.394*** (0.000)	-0.142 (0.195)	-0.760*** (0.004)
Constant	0.242*** (0.000)	0.484*** (0.000)	0.218 (0.154)	0.175*** (0.000)	0.323*** (0.000)	0.335*** (0.000)	0.442*** (0.000)
Observations	279	45	27	63	54	45	45
R ²	0.565	0.681	0.635	0.807	0.903	0.575	0.731
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses. ***p<0.01, **p<0.05, *p<0.1. FE: Fixed effect

first period, but not in the second period. In general, convergence theory still holds in per capita infrastructure investments section.

Table 10 displays provincial-level per capita fixed asset investment convergence test results from 1999 to 2018. Results show that on national level, β is negative and statistically significant at 1% level. That means per capita fixed asset investments do converge on the national level during our sample period. We also find β in the North, the East, the Southwest, and the Northwest regions are negative and statistically at least at 10% level. That means per capita fixed asset investment converges in those regions.

The results in Tables 11 and 12 show us a more complicated picture of convergence issue in fixed asset investments. Table 11 displays per capita fixed asset investment convergence test results in the first period from 1999 to 2008, and Table 9 displays test results in the second period from 2009 to 2018. On the national level, per capita fixed asset investment converges in both periods. However, we can see that β in the first period is only significant at 10% level, while in the second period it is significant at 1% level, which reveals that the convergence process not only turns out to be more obvious but also becomes more progressive in the second period.

On the regional level, significant convergence in per capita fixed asset investments only happened in the Southwest region during the first period. However, in the second period, the fixed asset investment converges in the North, the East, the South Central, and the Northwest regions. The dramatic shift in regional per capita fixed asset investment convergence patterns match our expectation. In the 1990s and early 2000s, most fixed asset investments were concentrated on projects located in a few coastal regions. That may explain why fixed asset investments did not converge in most regions before 2008.

The 2008-09 stimulus plan has a significant impact on the fixed asset investments on both the regional and national level. The primary goal of this stimulus plan was to prevent the Chinese economy from sliding into a potential decade-long recession. Some of those 4 trillion-yuan funds were channeled to support small- to mid-size enterprises (SME), build research and development (R&D) labs, and invest in some real estate projects. When the Chinese government injected so much liquidity into the economy in such a short period, we do expect that per capita fixed asset investments start to converge on both the national and regional levels.

Can per capita income convergence movements in China be sustainable in the long run? Our study shows that the government can reduce income inequality by making and implementing policies to balance education, infrastructure, and fixed asset investment across the country. With support from education, infrastructure, and investments, the per capita income convergence in China is not temporary, but rather can be sustainable in the long-term.

5.3. Robustness Check

In our robustness check section, we use an alternative econometric model by examining the β -convergence in per capita income convergence test. The economic model is based on the assumption of the Neoclassical growth model which is used in the study of Barro et al. (1991). The Neoclassical growth model is for the closed economies, and those economies are similar in respect to preferences and production technologies. If all the assumptions hold, then the poor economies should grow faster than rich the ones, which means that there is a force to push economies to the convergence in the long run.

Simply speaking, the equation can be written as below:

$$\log[y(t)] = \log[y(0)]e^{-\beta t} + \log(y^*)(1 - e^{-\beta t}) \quad (2)$$

where y is the output per labor, y^* is y at steady state. The β represents the speed of convergence. Thus, the average growth rate of y over the period from 0 to T can be expressed as:

$$\frac{1}{T} \log \left[\frac{y(T)}{y(0)} \right] = x + \frac{1 - e^{-\beta T}}{T} \log \left(\frac{y^*}{y(0)} \right) \quad (3)$$

The average growth rate between two points in time, t_0 and t_0+T , the equation can be expressed as follows:

$$\frac{1}{T} \log \left[\frac{y_{i,t_0+T}}{y_{i,t_0}} \right] = B - \frac{1 - e^{-\beta T}}{T} \log(y_{i,t_0}) + u_{i,t_0,t_0+T} \quad (4)$$

The u_{i,t_0,t_0+T} is the distributed lag of error terms between the period from 0 to T . x is the rate of exogenous labor augmenting the technological process. The constant term in the equation is $B = x + \left[\frac{1 - e^{-\beta T}}{T} \right] [\log(y^*) + x_{t_0}]$, which is independent of i , as we assume that $y_i^* = y^*$ and $x_i = x$.

The β represents the annual rate of convergence. The main focus of our research is on the β -convergence. If the convergence theory holds, then β should be higher for the poor economies than the rich ones. The convergence requires that $0 < \beta < 1$. This kind of convergence is called conditional convergence which means for any given x and y^* , the growth rate is higher when $y(0)$ is low.

Theoretically, β for poor regions should be higher compared with those in rich regions. However, one concern from economists is that after issuing new regulations and government policies, they are afraid that the policymakers may unknowingly direct too many resources to some rich regions; hence let the personal income in those rich regions grow faster than poor regions. If that is the case, then we should see higher β for some rich regions when compared with poor regions.

We estimate the convergence equation and use the non-linear regression command in STATA. We analyze the β -convergence issue by using the 3-year gap on the province-level and regional-level data in the robustness check section.

First, we examine β -convergence by using a 3-year gap in our regression. Table 13 presents the results of β in 31 provinces and the

Table 13: Cross-sectional tests for province β -Convergence on per capita income 1999-2018

Province	1999 per capita annual income (Yuan)	β	P-Value	Significant
Beijing	12,451	0.0339	0.000	***
Tianjin	9946	0.0296	0.001	***
Hebei	6302	0.0166	0.106	
Shanxi	5641	0.0424	0.003	***
Inner Mongolia	5792	0.0355	0.004	***
Liaoning	7161	0.0326	0.001	***
Jilin	6551	0.0091	0.321	
Heilongjiang	6238	0.0130	0.079	*
Shanghai	13,580	0.0247	0.007	***
Jiangsu	8256	0.0268	0.000	***
Zhejiang	9759	0.0440	0.001	***
Anhui	6117	0.0275	0.042	**
Fujian	8531	0.0044	0.661	
Jiangxi	5384	0.0119	0.143	
Shandong	6854	0.0175	0.009	***
Henan	5781	0.0354	0.007	***
Hubei	6436	0.0062	0.553	
Hunan	6558	0.0167	0.004	***
Guangdong	11,032	0.0154	0.001	***
Guangxi	6208	0.0214	0.008	***
Hainan	6248	0.0013	0.876	
Chongqing	6433	0.0238	0.001	***
Sichuan	6577	0.0144	0.035	**
Guizhou	5775	0.0090	0.230	
Yunnan	7667	-0.0060	0.134	
Tibet	10,987	0.0484	0.217	
Shaanxi	6029	0.0250	0.036	**
Gansu	6809	0.0089	0.250	
Qinghai	8011	0.0274	0.003	***
Ningxia	6822	0.0350	0.004	***
Xinjiang	7121	0.0127	0.202	
National	7135	0.0211	0.001	***
No direct	7004	0.0201	0.002	***

***p<0.01, **p<0.05, *p<0.1

national level. From the table, we can see that 20 out of the 31 provinces have β statistically significant at least at 10% level. For those provinces with β that are not statistically significant from zero, one of them is located in the North, one is located in the Northeast, two are located in the East, two are located in the South Central, three are located in the Southwest, and two are located in the Northwest. The national average β is statistically significant at 1% level. We also include the national average β excluding all national government direct-controlled municipalities and it is listed at the end of Table 1. The national average β is 0.0211 and is statistically significant at 1% level.

We have several interesting findings in our results. Those municipalities under the direct control by the national government management, such as Beijing and Shanghai, have much higher β compared to national average β . The findings here match the patterns in Figure 1, which shows that Beijing and Shanghai are outliers. We can see that β of Beijing and Shanghai, which are 0.0339 and 0.0247 respectively, are much higher than β in some poor provinces.

To test whether those municipalities have significantly pushed national average β upward, we estimate new national average β excluding all the government direct-controlled municipalities. The new national average β is 0.0201 which is lower than the old one but still statistically significant. It proves that those municipalities are outliers. Once we remove them from our analysis, the remaining 27 provinces yield a lower national average β .

In those 27 provinces, there are 16 provinces with significant β , and their β fluctuates around new national average β . The poor provinces, such as Shanxi and Ningxia, yield β that is much higher than that β of rich provinces, such as Shandong and Guangdong. That means for those regions, the per capita income growth rates in poor provinces grow faster than that in rich provinces, and the convergence theory holds. However, 11 provinces yield β which are not statistically different from zero, among them are the least-developed provinces in China, such as Tibet and Guizhou. And most of those least-developed provinces are in the Southwest and the Northwest regions. We suspect the geographical locations of those poor provinces may have some significant impact on the regional β level. In general, our results show that the per capita income growth does converge among provinces in China. We conclude that our results are consistent with our results in the previous section.

Table 14 shows the impact of geographical locations on per capita income convergence issues. It listed results of regional β for 6 regions in China. We can see that all those 6 regions have regional β that

Table 14: Cross-sectional tests for regional β -convergence on per capita income 1999-2018

Region	β	P-Value	Significant
North	0.0304	0.003	***
Northeast	0.0209	0.014	**
East	0.0241	0.000	***
South Central	0.0204	0.002	***
Southwest	0.0107	0.045	**
Northwest	0.0193	0.036	**
National	0.0211	0.001	***
No direct	0.0201	0.002	***

***p<0.01, **p<0.05, *p<0.1

are statistically significant at least at 5% level. The β of the North region is higher than the national average β , as it contains two large direct-controlled municipalities in the nation, Beijing, and Tianjin. All three provinces in the Northeast region are poor provinces, but it has β that is just around national average β . The East region contains one government direct-controlled municipality, Shanghai, and the regional β is slightly higher than national average. The South Central region includes five poor provinces, such as Henan and Hubei, and one rich province, Guangdong. The average South Central regional β is a little bit lower than the national average β . The Southwest region contains one direct-controlled municipality, Chongqing, and four other provinces, such as Yunnan and Tibet. The average Southwest regional β is way much lower than the national average. The Northwest region comprises five poor provinces, such as Gansu and Xinjiang, and its regional β is slightly lower than national average. However, if we compare those regional β with new national average β (which is 0.0201) that does not contain four government direct-controlled municipalities, we can see that our regional β just fluctuates around the new national average β with little deviation.

The North region, which has two directed-controlled municipalities, has regional β which is significantly higher than new national average β . It shows that the per capita income growth in the North region is much higher than the national average, which is contributed mainly by the government direct-controlled municipalities. The regional β of the Northeast, the East, and the South Central regions all fluctuate around new national average β . It shows the geographical location, mainly caused by the location of those government direct-controlled municipalities in the east coast, has a significant impact on the regional per capita income convergence issues. Overall, we conclude the results in Table 14 are consistent with the results in Table 13.

One explanation the results in Table 14 is that during the sample period (1999-2018), the average GDP growth rate in China is around 9.5% which is much higher than that in the Organization for Economic Co-operation and Development (OECD) nations and other developing countries, which is around 1.5% to 2% annually. With such a high GDP growth rate, there should be a short-run deviation from the long-run equilibrium in the convergence process. In general, the per capita income growth rate still converges on the national level and inside each region in the long run. Therefore, we conclude that convergence theory still holds on per capita income in China. The results in Tables 13 and 14 are consistent with the results and analysis in the previous section.

6. CONCLUSION

In our empirical test, we find that the convergence theory on personal income level holds in China. The per capita income converges on both the national and regional levels during our sample period. The convergence theory also holds in education expenses, infrastructure investments, and fixed asset investment areas. We find that the 2008-09 Chinese stimulus plan does have a significant and long-lasting impact on convergence issues in China, as the 4 trillion-yuan investments do have a significant impact on both national and regional convergence progress. With support from the supply of high-end labor supply, the high-quality infrastructure, and the huge amount of cheap capital, the convergence of per capita income in

China can be sustainable in the long run. The unprecedented rapid economic growth in China during the past several decades may lead to short-term deviation from its long-term equilibrium, which is the main reason why provincial and regional personal income are not converging towards national average rates in some regions. However, with the economic transformation in China enters in the second phase, we believe that in the long run, the growth rate in China will move towards its long-term average with appropriate government policy; thus converge theory should hold in China in the long run.

Our study has two important policy implications. The first one is that policymakers should revisit their national development policies regularly, as the old policies may direct funding and resources to provinces and regions where the resources are not needed most. The potential benefits of those newly revised policies can be significant, as it may reduce the income inequality gap and make economic development more sustainable in the long run. The second one is that policymakers should not only focus on provincial developments, but also on balancing regional developments. The overall goal of those government policies should be focused on improving the living standard in poor regions and reducing the income inequality between rich and poor regions.

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APPENDIX**Table A: List of Provinces in China**

Beijing	Hubei
Tianjin	Hunan
Hebei	Guangdong
Shanxi	Guangxi
Inner Mongolia	Hainan
Liaoning	Chongqing
Jilin	Sichuan
Heilongjiang	Guizhou
Shanghai	Yunnan
Jiangsu	Tibet
Zhejiang	Shaanxi
Anhui	Gansu
Fujian	Qinghai
Jiangxi	Ningxia
Shandong	Xinjiang
Henan	