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The Evolution and Differentiation of Economic Convergence of Resource-based Cities in Northeast China

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Abstract: A key target of the overall strategy implementation for regional development since the 18th Party Congress of China has involved taking measures to narrow regional disparities. This is because resource-based cities' economic development has fallen below general levels due to resource exhaustion and an unbalanced industrial structure, among other factors. Further, an economic gap has long existed between Northeast China's large number of resource-based cities and non-resource-based cities. This article comprehensively studies the economic convergence of Northeast China's resource-based cities and non-resource-based cities from 1996 to 2015 by using a dynamic panel to analyze not only the economic development of different industries and types of cities, but also the main factors that influence economic development. The empirical results demonstrate that economic convergence exists in both resource-based and non-resource-based cities, but the economic gap between them has clearly narrowed since the implementation of a strategy to revitalize the Northeast's old industrial base. Shrinking cities are the fastest to converge, as mature cities are slower and regenerating cities are the slowest; regarding industry structure, the secondary industry dominates the economy in mature and shrinking cities, and the tertiary industry in regenerating cities. The primary stimulus in resource-based cities' economic development involves upgrading the industrial structure and investing in human capital. As China faces a 'new normal' economy, resource-based cities in Northeast China should restructure the economy and perfect their market system to avoid again widening the economic gap.

Keywords: economic convergence; regional differences; resource-based cities; Northeast China

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1 Introduction

Uneven regional development is a popular topic in geography education. Moreover, a key target of the overall strategy implementation for regional development since the 18th Party Congress of China has involved taking measures to narrow regional disparities. Economists and geographers have conducted much exploratory work on the issue of uneven regional development; for example, new classical economists opine that poor regions have more rapid economic growth than wealthy ones (Jones, 1997). Thus, overall development achieves a state of equilibrium as time passes (Solow, 1956). The trickle-down approach argues that regional disparity will be corrected when advanced regions' production costs increase to a point higher than other regions (Golley, 2002). Further, Kaldor (1961) considers that increasing returns of scale gradually increase regional economic inequality. In fact, regional economic inequality continually oscillates, and economic convergence better

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reflects the volatility in regional economic inequalities (Ma et al., 2007) compared to general research approaches on regional economic inequality, such as the Gini coefficient (Dagum, 1997) and Theil index (Xu et al., 2005). Domestically, research on regional economic inequality using the economic convergence method is centralized on a national scale, and discusses the features and degrees of national economic differences using provincial data (Liu et al., 2004; Lin et al., 2005; Pan, 2010).

Northeast China is an old industrial base, with abundant natural resources and many resource-based cities. Fig. 1 illustrates this distribution. These resource-based cities have dedicated substantial raw materials to the country during their development processes, but a series of problems have appeared in their social and economic development with the exploitation of resources, such as slow economic growth, and imbalances in the industry's structure as well as the city's ecology (Guo, 2014). In 2003, the strategy to revitalize Northeast's old industrial bases was implemented and after that, Northeast China had maintained a high speed growth of economy from 2003 to 2013, an average of 12.7% which was higher than national average (Fan et al., 2016). The State Department issued a publication entitled 'Some Suggestions on the Implementation Strategy to Revitalize Northeast China and Other Old Industrial Bases', and made deployments to improve systems and mechanisms, promote structural adjustments, encourage innovation and entrepreneurship, and ensure and improve people's well-being. However, this document still did not focus on inner economic gaps, and especially the gap between resource-based cities and non-resource-based cities in Northeast China, such as the strategy to revitalize the Northeast's old industrial base. Some studies are available on Northeast China's economic convergence using all cities' spatial-temporal patterns (Han and Zhang, 2010; Yang et al., 2011; Lu et al., 2013; Du et al., 2015). From an economic convergence perspective, this paper discusses the following: convergence between the entire economy and different industries in resource-based and non-resource-based cities; the economic change and industrial convergence of different types of resource-based cities, both before and after the implementation of a strategy to revitalize the Northeast's old industrial base; and the laws of economic and industrial development in Northeast China's resource-based cities.

2 Materials and Methods

2.1 Data source

The *National Plan for Sustainable Development of Resource-based Cities (2013–2020)* defines 21 resource-based cities in Northeast China, which accounts for a quarter of the entire country and covers all types: coal, oil, forestry, metallurgy, and integrated cities (General Office of the State Council of the People's Republic of China, 2013). This paper studies 37 prefecture-level cities in Liaoning, Jilin, and Heilongjiang provinces, and uses each industry's GDP per capita as its main index. Statistical data were predominantly obtained from the *China City Statistical Yearbook* (Department of Urban Surveys of National Bureau of Statistics of China, 1997–2016), *Liaoning Statistical Yearbook* (Liaoning Bureau of Statistics, 1997–2016), *Jilin Statistical Yearbook* (Jilin Statistical Bureau, 1997–2016), and *Heilongjiang Statistical Yearbook* (Heilongjiang Bureau of Statistics, 1997–2016). We compared the economic convergence of cities in different developing stages by dividing resource-based cities into four models: the growing, mature, declining, and regenerating models—according to *The National Plan for the Sustainable Development of Resource-based Cities*. Table 1 illustrates these classifications.

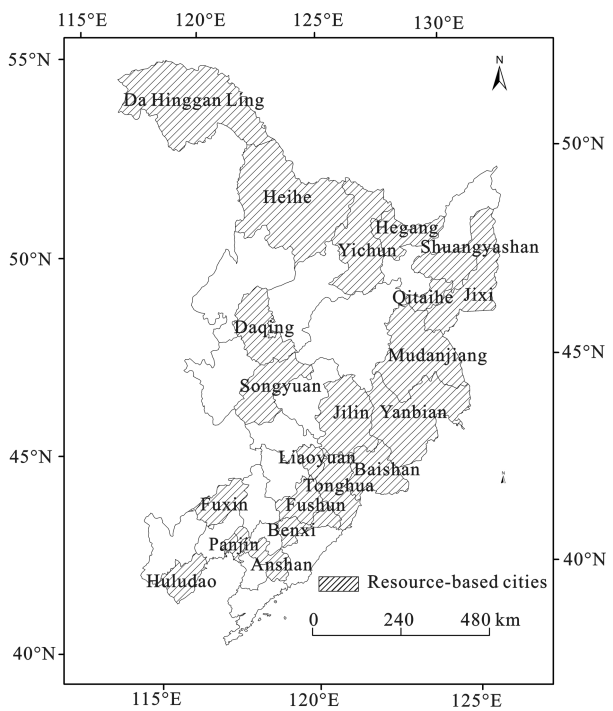

Fig. 1 Spatial distribution of resource-based cities in Northeast China

Table 1 Model of resource-based cities in Northeast China

Province	Growing Model	Mature Model	Declining Model	Regenerating Model	Subtotal
Liaoning		Benxi	Fuxin, Fushun	Anshan, Panjin, Huludao	6
Jilin	Songyuan	Jilin, Yanbian	Liaoyuan, Baishan	Tonghua	6
Heilongjiang		Heihe, Daqing, Jixi, Mudanjiang	Yichun, Hegang, Shuangyashan, Qitaihe, Da Hinggan Ling		9
Subtotal	1	7	9	4	21

2.2 Methods

Different convergence conditions in economic growth theory reveal three types of economic convergence hypotheses: α convergence, β convergence, and club convergence. First, α convergence reflects a gap in each economy's GDP per capita that narrows over time; thus, the standard deviation of GDP per capita provides an appropriate index by which to measure this gap (Barro and Sala-I-Martin, 1995). This convergence exists if the standard deviation tends to decrease, and vice versa. Second, β convergence is divided into absolute and conditional convergences. The former assumes that exogenous factors, such as the saving ratio, rate of population growth, and technological progress in each economy are the same, and subsequently, each economy's level of output will ultimately operate in sync (Ben-David, 1998). While exogenous factors in each economy will vary in reality, poorer economies will develop more rapidly due to the higher marginal returns of capital, all other things being equal. Therefore, each economy will converge to a steady state, called 'conditional convergence'. Club convergence involves different regions forming distinct 'clubs' due to initial conditions and those regions with similar condition will converge. We tested club convergence in Liaoning, Jilin, and Heilongjiang provinces by adding a dummy variable in our econometric model to find it failed this test; thus, we conclude no club convergence exists in Northeast China's resource-based cities. Given this, we primarily test for α convergence, absolute β convergence, and conditional β convergence. We will emphasize β convergence in this study as it can be more rigorously tested.

2.2.1 α convergence

First, α convergence is identified by each city's standard deviation of GDP per capita. If the standard deviation decreases, α convergence is considered to exist, and vice versa. The standard deviation is calculated with Equation (1).

$$\sigma_t = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\ln y_{i,t} - \overline{\ln y}\right)^2} \tag{1}$$

where $y_{i,t}$ is the GDP per capita of city i in year t; n is the number of cities.

2.2.2 Absolute β convergence

We test absolute β convergence by using Barro and Martin's approach (Barro and Sala-I-Martin, 1992), and the calculating equation is:

$$\frac{1}{T}\ln\left(\frac{y_{i,t+T}}{y_{i,t}}\right) = c + \beta \ln y_{i,t} + \varepsilon_{i,t} \tag{2}$$

where $y_{i,t}$ is the GDP per capita of city i in year t; C is the specific constant term; β is the parameter of the argument; T is the year span and $\varepsilon_{i,t}$ is the perturbation error term. While Equation (2) uses cross-sectional data and does not easily reflect the dynamic process of economic development process, the value of T equals one to analyze dynamic change and obtain more reasonable results. Thus, Equation (2) transforms to:

$$\ln\left(\frac{y_{i,t+1}}{y_{i,t}}\right) = c + \beta \ln y_{i,t} + \varepsilon_{i,t} \tag{3}$$

The real GDP per capita is calculated by the real GDP divided by the population, and the real GDP is reconciled by the GDP from 1996 to 2015 and the price index. This paper used EViews 9.0 software to perform the panel data regression.

2.2.3 Conditional β convergence

Control variables must be added to the model to test each economy's conditional β convergence, such as technics, policy, and culture. As this paper aims to analyze changes in economic convergence—both before and after the strategy to revitalize Northeast China's old industrial base—and these factors influence convergence, we added several major strategy measures into the model as control variables. These include industrial restructuring, the promotion of technological progress,

strengthening the construction of infrastructure, deepening reforms, and opening up. Equation (4) calculates the conditional β convergence.

$$\ln\left(\frac{y_{i,t+1}}{y_{i,t}}\right) = c + \alpha \ln y_{i,t-1} + \beta Inv_{i,t} + \gamma Indu_{i,t} + \delta Edu_{i,t} + Open_{i,t} + \varepsilon_{i,t} \quad (4)$$

where *Inv* is the investment in physical capital, calculated by the proportion of fixed investment in GDP; *Indu* is the upgrading of industrial structures, calculated by the proportion of tertiary industrial output value in the GDP; *Edu* is the investment in human capital, calculated by the educational investment in the total local finance expenditures; and *Open* is openness, calculated by the proportion of real foreign investment in GDP. The dollar (US) is used as the unit of real foreign investment, and must be converted to yuan (RMB) according to the current year's exchange rate.

3 Results and Analysis

3.1 Results of α convergence

Fig. 2 reflects the convergence and divergence in the entire sample of resource-based and non-resource-based cities in Northeast China from 1996 to 2015. As can be observed in the table, the economic development in the entire sample, including resource-based and non-resource-based cities, is convergent from 1996 to 2009, but uneven from 2009 to 2015. A comparison of the performance of resource-based and non-resource-based cities reveals that resource-based cities' standard deviation of GDP per capita is greater than non-resource-based cities before 2002, but the converging speed had accelerated from 2002 to gradually overtake non-resource-based cities, and especially from 2002 to 2009. Thus, it can be observed that the economic gap among resource-based cities obviously narrowed after the implementation of the strategy to revitalize the Northeast's old industrial base, and those cities with slow development began to accelerate. This also demonstrates the stronger support for the strategy for resource-based cities, and narrowed the economic gap between resource-based and non- resource-based cities.

However, the economic disparities in Northeast China began to fluctuate after 2009, with a substantial fluctuation in resource-based cities' standard deviation of GDP per capita that revealed an irregular state. A high increase in economic disparity among each city especially appeared after 2013, which coincided with the 'New Northeast Phenomenon' period. Currently, the Chinese economy's speed of growth has shifted from a sprint to a jog, and has become the 'new normal'. Moreover, the Northeast's economic development immediately fluctuated. In the context of increasing pressure from a domestic economic downturn; this reveals that although the strategy played an important role in developing and transforming resource-based cities, high vulnerability exposed an unstable situation, and the virtually high economic growth was unsustainable.

3.2 Results of absolute β convergence

3.2.1 Overall results

The period from 1996 to 2015 is divided into three parts to analyze the influence of the Northeast China strategy: the whole period, 1996 to 2003, and 2004 to 2015. 2003 is taken as the time node because it was the beginning of the strategy to revitalize the Northeast's old industrial base, and it is convenient to analyze the influence of the strategy. We initially conducted a T-test and Hausman's test, the results of which revealed that the fixed effect regression is a proper method for the data. Table 2 illustrates the regression result, which reveals that the coefficients of y_{it} for the whole sample, including resource-based and non-resource-based cities, are all negative and pass the 10% significance test, which means that convergence exists. A comparison of the size of the coefficients reveals that the speed of convergence is faster for resource-based cities than non-resource-based cities, and the economic gap between them has narrowed. From

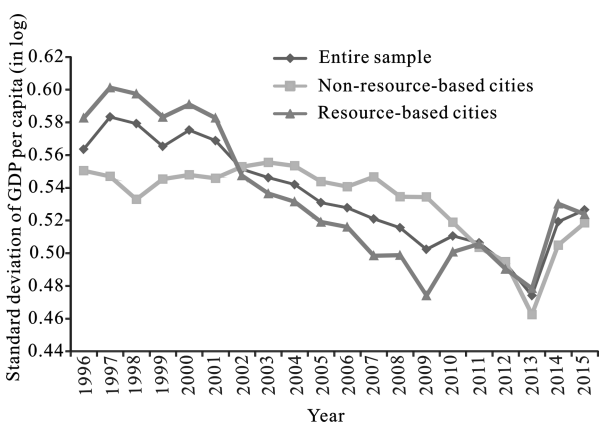

Fig. 2 Change in α convergence in Northeast China

Table 2 Basic regression results of economic convergence

Period	1996–2015			1996–2003			2004–2015		
	Entire Sample	Resource-based Cities	Non-resource-based cities	Entire Sample	Resource- based Cities	Non-resource-based cities	Entire Sample	Resource- based Cities	Non-resource-based cities
c	5.169***	6.702***	1.856***	0.556***	0.987**	0.261***	11.863***	11.655**	10.169***
	(10.756)	(9.331)	(3.550)	(9.949)	(1.839)	(8.112)	(11.682)	(2.136)	(2.792)
$\ln y_{i,t}$	–0.517***	–0.670***	–0.179***	–0.456***	–0.092**	–0.013***	–1.118***	–1.102**	–0.962***
	(–11.08)	(–9.570)	(–3.850)	(–10.085)	(–1.944)	(–8.200)	(–11.932)	(–2.324)	(–3.007)
Adjusted R^2	0.315	0.339	0.428	0.379	0.279	0.509	0.518	0.505	0.572

Note: significance levels are *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$; t-values are listed in the brackets below the estimated coefficient

the time perspective, the absolute value of the convergent coefficient from 1996 to 2003 is smaller than 2004 to 2015, which means the strategy took effect on narrowing the economic gap between each city.

Table 3 illustrates the regression results for each province. The regression coefficients demonstrate that the convergent speed of Heilongjiang is the fastest (9 of its 12 cities are resource-based), followed by Jilin Province (6 of its 9 cities are resource-based); Liaoning Province is the lowest, as 6 of its 12 cities are resource-based. This reveals that the province with the highest percentage of resource-based cities converges more quickly.

Table 4 notes the regression results for each type of resource-based city, except the growing type; as only one city is considered a growing type, this is impossible to test. A comparison of the coefficients' sizes reveals the speed of convergence for the shrinking type of cities is the fastest, followed by the mature type, and the regenerating type is the lowest. This may be partially because shrinking and mature cities faced more severe issues in the social and economic status quo before the strategy was implemented; thus, the government gave strong support, such as sustainable investments or tax reductions, which provided a powerful guarantee of healthy social and economic development in those cities. Compared to shrinking and mature cities, regenerating cities had already eliminated resource dependence,

Table 3 Different provinces' regression results

Province	Liaoning	Jilin	Heilongjiang
c	0.544**	1.454***	8.974***
	(1.666)	(3.919)	(3.721)
$\ln y_{i,t}$	–0.043*	–0.135**	–0.922***
	(–1.379)	(–2.169)	(–2.835)
Adjusted R^2	0.722	0.482	0.446

Note: significance levels are *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$; t-values are listed in the brackets below the estimated coefficient

Table 4 Regression results for different types of resource-based cities

City type	Mature cities	Shrinking cities	Regenerating cities
c	6.915***	8.382***	0.483
	(7.826)	(4.848)	(1.145)
$\ln y_{i,t}$	–0.708***	–0.830**	–0.037
	(–7.955)	(–5.015)	(–1.213)
Adjusted R^2	0.489	0.307	0.610

Note: significance levels are *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$

but apparent differences were noted on the times and development paths among these cities, which led to a result of inconspicuous convergence.

3.2.2 Results of three industries

Fig. 5 displays the regression results for three industries, including resource-based and non-resource-based cities. All the results are significant except those regarding the tertiary industry in resource-based cities. The primary and secondary industries' results in resource-based cities are significant at the 1% level, and the coefficients indicate that the secondary industry converged faster than the primary industry. The results of three industries in non-resource-based cities are all significant at the 1% level, and the converging speed of the secondary industry is the fastest, with the tertiary industry taking second place, and the primary industry as the lowest. Moreover, the converging speed of the secondary industry in resource-based cities is faster than in non-resource-based cities. The secondary industry in resource-based cities accounted for a large proportion of the national economy, and the primary mission of the strategy had involved optimizing and upgrading the secondary industry.

Similar to the overall test, we conducted more detailed analyses on each industry regarding the different types of resource-based cities, and Table 6 illustrates the results. The results of the tertiary industry for mature and regenerating cities are significant at the 1% level, but the result for shrinking cities is not significant.

Table 5 Regression results of different industrial structures

City type	Resource-based cities			Non-resource-based cities		
Industry	Primary industry	Secondary industry	Tertiary industry	Primary industry	Secondary industry	Tertiary industry
c	4.097*** (12.435)	5.240*** (3.848)	6.972 (1.433)	1.091*** (10.859)	1.534*** (4.114)	1.193*** (3.500)
$\ln y_{i,t}$	–0.528*** (–12.797)	–0.581*** (–4.180)	–0.797 (–1.668)	–0.147*** (–11.081)	–0.185*** (–4.547)	–0.148*** (–3.867)
Adjusted R^2	0.335	0.364	0.377	0.329	0.389	0.297

Note: Significance levels are *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$; t-values are listed in the brackets below the estimated coefficient

Specifically, economic convergence did not occur in shrinking cities, most likely because the heavy reliance on resources and the large proportion of resource-related heavy industry impeded the tertiary industry's expansion, resulting in the 'resource curse'. A comparison of the coefficients reveals that the secondary industry rapidly converges in mature cities and shrinking cities, and the tertiary industry is fast in regenerating cities. This indicates that mature and shrinking cities' economic development still relies more on resource exploitation, while regenerating cities have already eliminated their dependence on resources and shifted to promoting the tertiary industry, achieving a somewhat successful urban transformation. The results also indicate that the urban transformation is highly relevant to the tertiary industry's development. On the one hand, the tertiary industry's prosperity helps the city eliminate its dependence on resources and increase economic dynamism; on the other hand, economic restructuring as well as resource endowment and comparative advantage can accelerate resource-based cities' development.

3.3 Results of conditional β convergence

Tables 7 and 8 separately display the regression results of the conditional β convergence of the total city samples and the resource-based cities. All the control variables are added into the equation, and insignificant variables are eliminated in Model 2. The regression results indicate that economic conditional convergence exists in both the total city sample and the resource-based cities in two periods; this further confirms the above research results. A comparison of the results for all cities and resource-based cities reveals that the resource-based cities converged more slowly than total cities from 1996 to 2003, and faster than total cities from 2004 to 2015. To some extent, this demonstrates the strategy's stimulation in resource-based cities.

The 'total cities' portion of Table 7 notes a positive effect from upgrading the industrial structure from 1996 to 2003, and the effect of educational investment is weakly negative; from 2004 to 2015, the effects of upgrading the industrial structure and educational investment are both positive, and the effect of investment in physical capital is negative. Table 8 pertains to resource-based cities, in that from 1996 to 2003 the effect of upgrading the industrial structure is positive and the investment in physical capital is negative. The effects of upgrading the industrial structure and educational investment are both positive from 2004 to 2015, while the effect of investment in physical capital is negative, the same as the total cities.

Table 6 Regression results of different industrial structures in different types of resource-based cities

City type	Mature cities			Shrinking cities			Regenerating cities		
industry	Primary industry	Secondary industry	Tertiary industry	Primary industry	Secondary industry	Tertiary industry	Primary industry	Secondary industry	Tertiary industry
c	7.183*** (5.648)	9.369*** (9.113)	9.787*** (3.167)	3.217*** (6.717)	4.603*** (9.725)	7.087 (0.651)	3.536*** (7.550)	1.844** (2.066)	1.906*** (3.062)
$\ln y_{i,t}$	–0.910*** (–5.758)	–1.059*** (–9.233)	–0.109*** (–3.383)	–0.420*** (–5.391)	–0.528*** (–10.886)	–0.335 (–0.797)	–0.458*** (–9.713)	–0.202** (–2.195)	–0.223*** (–3.258)
Adjusted R^2	0.374	0.433	0.364	0.375	0.433	0.527	0.412	0.599	0.294

Note: Significance levels are *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$; t-values are listed in the brackets below the estimated coefficient

Table 7 Regression results of conditional β convergence in Northeast China

Period	1996–2003		2004–2015	
	Model 1	Model 2	Model 1	Model 2
$\ln y_{i,\,t-1}$	–0.076* (–1.851)	–0.076* (–1.844)	–0.665*** (9.195)	–0.664*** (–9.168)
In*v*	0.047 (0.445)		–0.285*** (–3.498)	–0.268*** (–3.384)
In*du*	1.047** (3.129)	1.018*** (3.100)	0.670* (1.960)	0.757* (1.951)
Edu	–0.007* (–1.830)	–0.007** (–2.062)	0.509* (1.713)	0.501* (1.698)
Open	0.242 (0.378)		0.659 (0.900)	
Adjusted R^2	0.525	0.522	0.559	0.558

Note: significance levels are $^{***}P < 0.01$; $^{**}P < 0.05$; $^{*}P < 0.1$; *t*-values are listed in the brackets below the estimated coefficient

Table 8 Regression results of conditional β convergence in resource-based cities in Northeast China

Period	1996–2003		2004–2015	
	Model 1	Model 2	Model 1	Model 2
$\ln y_{i,t-1}$	–0.014* (–1.583)	–0.017* (–1.664)	–0.782*** (–7.856)	–0.776*** (7.807)
In*v*	–0.107* (–1.675)	–0.094* (–1.763)	–0.265** (–2.056)	–0.232* (–1.852)
In*du*	0.362* (1.738)	0.393* (1.719)	0.849* (1.793)	1.056* (1.685)
Edu	–0.002 (–1.108)		1.512** (2.171)	1.550** (2.230)
Open	0.375 (0.415)		1.524 (1.068)	
Adjusted R^2	0.373	0.370	0.510	0.497

Note: significance levels are $^{***}P < 0.01$; $^{**}P < 0.05$; $^{*}P < 0.1$; *t*-values are listed in the brackets below the estimated coefficient

This analysis reveals that upgrading the industrial structure is an important factor to both resource-based and non-resource-based cities, and the promoting function of investment in physical capital and the degree of openness to the economy are not obvious, and even negative. A comparison of the change between the two periods indicates that the promotion of educational investments became clear after the strategy's implementation. Education's influence on social and economic development is a long-term process, and often lags behind input time; thus, the effect may not be obvious in the short-term. Therefore, educational investors' roles should be evaluated over the long-term and coordinated with other government policies. Compared to non- resource-based cities, the stimulation of upgrading the industrial structure to the economic growth of resource-based cities is more obvious, as resource-based cities have industrial structures less varied than non-resource-based cities, which was a key factor that restricted economic development. After the strategy implementation, the impediment of investment in physical capital for economic development became more obvious. This might be because industrial restructuring was not complete, and industry competitiveness was insufficient; thus, a large proportion of investments were not optimally utilized. For instance, the size of investments in northeast China's steel, cement, and shipbuilding industries has continued to expand in recent years, but the severe excess capacity caused by heavy investment has interfered with the economy's health. This also indicates that increasing investments can certainly increase rates of economic development. The local government in Northeast China must improve the industry's supporting ability and maximize the effectiveness of investments

based on the enhancing of industry competitiveness and promoting restructuring.

4 Discussion

Northeast China's economy greatly improved through more than 10 years of construction and revitalization, as the economic gap among the cities had narrowed over time and the economy became convergent. However, economic convergence is not stationary, but an economic state determined by certain technical conditions and intrinsic mechanisms. Although economic convergence appears to exist, this is not always caused by interregional economic interaction, but may be caused by geographic features, natural resources, and national policies, among other factors (Zhu et al., 2014). To experience steady, rapid growth, economies must not only eliminate their dependence on natural resources, but also transform depending on technics (Hansen and Prescott, 2002). Although the revitalization strategy in Northeast China has generated some achievements to accelerate the transformation of resource-based cities, the development is based more on the national policy supporting and external capital but not the economic interaction inside the region. In other words, this kind of convergence probably shows that the economic development of Northeast China is still kept in the initial state. In Zhu's research, there is little spatial correlation in the convergence in China except the east coastal region, which seems to bear it out to some extent (Zhu et al., 2014). Moreover, the 'new northeast' phenomenon reflects some new problems that have appeared in Northeast China under these new circumstances, including a sluggish economic recovery internationally and the Chinese 'new normal'. For instance, the energy, steel, and traditional equipment-manufacturing industries have been substantially impacted by weak domestic demand, and these industries are often leading industries in resource-based cities. If resource-based cities cannot solve these problems of overcapacity and an imbalanced industry structure, their economic development will be affected, which will subsequently cause widening internal diversity again. For instance, Heilongjiang Longmay Mining Holding Group, which is the biggest mining group in Northeast China and integrated quality resources of Hegang, Jixi, Shuangyashan and Qitaihe, experienced billions of losses from 2012 to 2015 and had no choice but transferred hundreds of thousands of employees to other enterprises. The economic gap among resource-based cities in Northeast China has again overtaken non-resource-based cities since 2013. Alternatively, the increasing trend of agglomerating economic development surrounding Harbin, Changchun, Shenyang, and Dalian is not beneficial to resource-based and remote cities (Wang and Du, 2016). The above analysis reveals that increasing investment is not an effective method to resolve a problematic, slow economic growth rate, and the economic bubble produced by massive investment and policy promotion is difficult to maintain when the economic environment changes and economic restructuring becomes increasingly difficult. The appearance of the 'new northeast' phenomenon is superficially the result of economic distortions, but in a deeper sense this involves institutional constraints, including an incomplete transformation from a planned economy to a market economy (Chu and Zong, 2017). Resource-based cities, under the premise of adjusting economic structure and perfecting the market mechanism, shall endeavor to resolve the problem of excess capacity, transform economic development patterns, and stimulate institutional innovation to narrow regional variations and realize healthy and sustainable economic development.

At the time 'new northeast' phenomenon, economic disparities again widened after 2013, and currently data is only available from 2013 to 2015. As this period is too short to obtain highly credible results by a panel data regression, we only use a qualitative analysis to discuss the economic development and changes in Northeast China. An important direction for future studies could include discussing and analyzing the long-term situation after 2013.

5 Conclusions

An analysis of northeast China's economic development and convergence of total and resource-based cities, both before and after the strategy to revitalize Northeast China's old industrial base, reveals the following conclusions:

(1) The economic development of both total and resource-based cities is convergent, and the speed of convergence accelerated after the strategy, and especially for resource-based cities. This implies that the strategy

played an important role in narrowing the economic gaps among cities, and especially in resource-based cities in Northeast China.

(2) Regarding provincial differences, Heilongjiang had the fastest economic convergence, Jilin took second place, and Liaoning was the slowest. This result is likely to relate to the proportion of resource-based cities, as the higher the proportion of resource-based cities contained therein, the faster the speed of convergence. Regarding city types, shrinking cities had the fastest convergence, mature cities took second place, and regenerating cities were the slowest. The national government gave more support to the first two types of cities, and convergence among the last city type was not obvious, as resource dependence was eliminated and different development paths were pursued. Regarding industries, secondary and tertiary industries were determinants of economic convergence; the secondary industry was dominant in mature and shrinking cities, and the tertiary industry was dominant in regenerating cities.

(3) Upgrading the industrial structure was the most important contributing factor that promoted economic development in Northeast China, and especially in resource-based cities both before and after the revitalization strategy's implementation. After the strategy, investments' function in human capital became clear: investment in physical capital and openness did not perform to their full capabilities.

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