

Spatial Econometric Analysis of Debt Growth Convergence of China's Local Governments

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Abstract: Based on the data of urban investment bond panel data from 30 provinces in China from 2005 to 2014, this paper measured inter-provincial differences of China's local government debt growth through the uses of Gini coefficient, logarithmic dispersion mean and Theil index, constructed the spatial convergence model to analyze the convergence of China's local government debt growth. Results show that the scale of China's local government debt is on rising as a whole while showing an outstanding feature of inter-provincial differences. Particularly, local government debt mean of eastern coastal provinces are higher, but growth rates are lower. In contrast, local government debt mean of midwestern inland provinces are lower, but growth rates are at a higher level. According to Moran scatter plot and LISA cluster chart, China's local government debt, in terms of geographical space, has the significant features of autocorrelation and cluster trend. When taking spatial effects into accounts, one can find out that China's local government debt growth has both absolute β convergence and conditional β convergence. Meanwhile, the convergence speed of China's local government debt growth presents that the midwestern inland region is faster than that of in the eastern coastal region.

1. Introduction

At present, China's economy faces a major issue that local governments are gorging on debt. Particularly, since the international financial crisis in 2008, Chinese government has implemented a series of measures to stimulate economic development and created a boom for local financing platform. However, there have been some side-effects. Local government debt is on rising in a rapid speed. Some statistics show that average annual growth rate of China's local government debt has been kept at a level of above 40% from 2008 to 2016, which has vastly exceeded the same period of economic growth rate. By the end of 2016, local government debt balances were about 15.32 trillion RMB, accounting for about 21% of GDP (The author gets statistics through the calculation of data that are released by the Ministry of Finance of China). Local government debt is a "double-edged sword". It promotes economic development and accelerates the construction of social infrastructure while entailing huge financial risks [1-3]. From the long term, it will inevitably have a negative impact on China's economic growth. Therefore, it is of great significance to study the problem of China's local government debt growth to deepen the connotation of local government debt management and explore a path of debt governance.

China is a country of unitary government type, which means the administrative right of local governments should be empowered by the central government, including the right to borrowing. Before 2014, a year that new "Budget Law of the People's Republic of China" was enacted, China's local governments, actually, did not have the right to issue bonds. In order to get around the restriction of "issuing bonds being forbidden by law", "Urban Investment Bonds" are issued by investment and financing platform companies that are set up in the names of local governments in actual operation [4]. As the continuing expansion of urban investment bonds, the central government clearly defines that any local government cannot borrow debts from original urban investment companies and other financing platforms. Even though above-mentioned measures are taken, the circulation of China's urban investment bonds in 2016 reached 1.77 trillion RMB, an

increase of 4.1% compared with 2015. From this point of view, urban investment bonds become an important part of China's bond market. However, underlying risks that are brought by rapid expansion cannot be ignored.

It is worth mention that there is a big difference in local government debt growth from provinces to provinces as China is a country of vast territory and financial development of each province is at different levels. However, at the same time, there may be spatial correlation among different provinces in terms of local government debt scales. The mainly reason is that under promotion appraisal system with GDP as the main indicator, local governments compete with each other, which is called "top-up competition" [5]. Besides, some forms of competition such as taxation and fiscal expenditure have been clearly identified [6-8]. In other words, the local government debt growth of a province may be affected by the local government's debt situation in neighboring provinces. Such "spatial spillover effects" make local governments of neighboring provinces "imitate" each other in the aspect of borrowing, causing convergences in local government debt growth of all provinces. Therefore, it is possible to provide some reference of debt management for local governments through targeting to the problems of inter-provincial differences and convergences of China's local government debt growth from the perspective of geographical space.

Compared with previous studies, this paper may make contributions mainly to the following three aspects. Firstly, this paper extends the convergence theory to the research field of local government debt and analyzes the convergence of local government debt growth in 30 provinces in China. Secondly, on the basis of investigating the spatial correlation of local government debt growth, this paper makes use of spatial econometrics to analysis the convergence of China's local government debt growth and its main influencing factors. Thirdly, this paper enlarges the database of 30 provinces expanded from 2005 to 2016 so as to have a better view on the new features of China's local government debt growth.

The remaining parts of this paper are arranged as follows: the second part is the literature review; the third part analyzes the status quo and difference of local government debt growth; the fourth part introduces the spatial econometric analysis model, variables chosen and data sources; the fifth part carries on empirical tests and results discussion; the sixth part gets some conclusions and gives suggestions.

2. Literature Review

The convergence theory is an important part of modern economic growth theory. As the theory develops, scholars have applied the convergence theory to government debt fields. According to the definition of government debt, it can be divided into two parts, namely central government debt and local government debt. At present, researches on the convergence of central government debt are mainly targeted on testing methods and convergence conditions. Among them, co-integration test is widely used in the test of convergence in central government debt. The convergence of revenue and expenditure difference is determined by the long-term equilibrium between central government fiscal expenditure and fiscal revenue [9-11]. Scholars that hold the view of classicism argue that the scale of central government debt must converge because convergence directly determines whether a country or a government will bankrupt or not. Domar (1944) [12] mathematically gives convergence conditions of debt ratios of a country as a result of issue debt continuously. Based on the former researches that are conducted by Domar, Zhang Xian (2003) [13] has proved that the burden rate of China's central government debt has the characteristics with stable convergence and has pointed out the dynamic conditions of proper scale of central government debt. Based on the government borrowing constraints model, Bohn and Henning (2005) [14] propose that the scale of central government debt can be anchored through analyzing the impact of microcosmic subjects' expectations and preferences on some key macro variables such as interest rates, taxes and deficits. He Daixin (2015) [15] take a further step to set up a theoretical model of the moderate scale of central government debt, considering that central government debt scale satisfying government financing needs can emerge convergence with economic fluctuation.

When considering local government debt convergence, scholars mostly emphasize the existence

of convergence mechanisms and convergence paths. Peng Qinghui (2010) [16] pointed out that there is a convergence mechanism for the debt that China's local government through raising funds for infrastructure construction by investment and funding platform. Due to different fiscal rules restrictions, the path of local government debt accumulation is different, and then will converge to different equilibrium values in the long run. More specifically, in the economic downturn for the consideration of stimulating the economy, the bad results of China's local government debt financing are more likely to be the debt accumulation, the phenomenon of borrowing new debt to pay the old, and the possibility of an indefinite divergence in the debt burden ratio is extremely high. However, when economy is in a normal state or in boom, the better finance will lead a right way to converge for local government debt [17-19]. Zhang Xiaodi (2014) [20] emphasize that the dynamic way of China's local government debt convergence depends mainly on the ratio between population growth rate and capital return rate, and on fiscal revenue and expenditure situation. Only when the surplus of fiscal revenue and expenditure and the population growth rate are higher than the interest rate, the convergence of local government debt can be kept in a long term balance. On the contrary, debt will not be able to balance and even continue to accumulating, causing harm to the sustainability of public finance.

In terms of the spatial dependence of local government debt, scholars have made great studies in the spatial effects of local government debt growth. Scholars such as Hong Yuan et al. (2014) [21], Li Meng (2016) [22] and Huang Chunyuan (2016) [23] have corroborated that due to spatial continuity of regional economic activities, local governments will not only take regional financial performance into consideration, but will refer to fiscal expenditure scale of neighboring provinces as well when deciding on the scale of borrowing. This will lead to the spread effects, or spatial spillover effects, of neighboring provinces' debts increase brought by the debt increase of a province. Furthermore, the spatial spillover effects between provinces will directly influence spatial distribution differences of local government debt growth. Considering from the perspective of spatial correlation, the inter-provincial difference of local government debt growth in China can be attribute to the difference of gross national product (GNP), fixed asset investments and urbanization rates [24,25]. Meanwhile, the competition of fiscal expenditure, investment attraction and tax revenue between local governments will also increase spatial differences of local government debt growth [26,27]. Furthermore, there are other factors that lead to the growth, such as loans, the level of opening-up and population density [28,29].

To sum up, existing literatures have conducted thorough analysis of central government debt convergence which have reached great results and qualitative analysis of convergence mechanism and convergence path of local government debt growth. However, few papers have in-depth argumentations and quantitative analysis of the convergence of local government debt growth, and seldom take geographical and spatial factors into the convergence model of local government debt in particular. In practice, there are strong spatial dependencies of institutional change, government behavior, regional development, and so on. Therefore, in analysis of China's local government debt convergence, the particularity of local government debt growth cannot be accurately reflected without taking spatial dependency into consideration. This paper, based on the traditional convergence model, brings geographical and spatial factors into the convergence model of China's local government debt growth by the use of spatial econometric methods. It analyzes features of inter-provincial distribution and spatial convergence of China's local government debt from spatial perspectives so that local government debt risks will be under control. Besides, this paper tries to provide policy supports for China to control the growth of local government debt and research basis for the sustainable development of China's economy.

3. The Analysis of Status Quo and Differences of Local Government Debt Growth in China

3.1 The analysis of status quo of local governments debt growth

Based on the data from the Statistical Yearbook of China and WIND database, this paper arranges and analyzes urban investment bond data of 30 provinces ① in China from 2005 to 2016

and plots the trend chart of local government debt growth in China from 2005 to 2016 (see Figure 1).

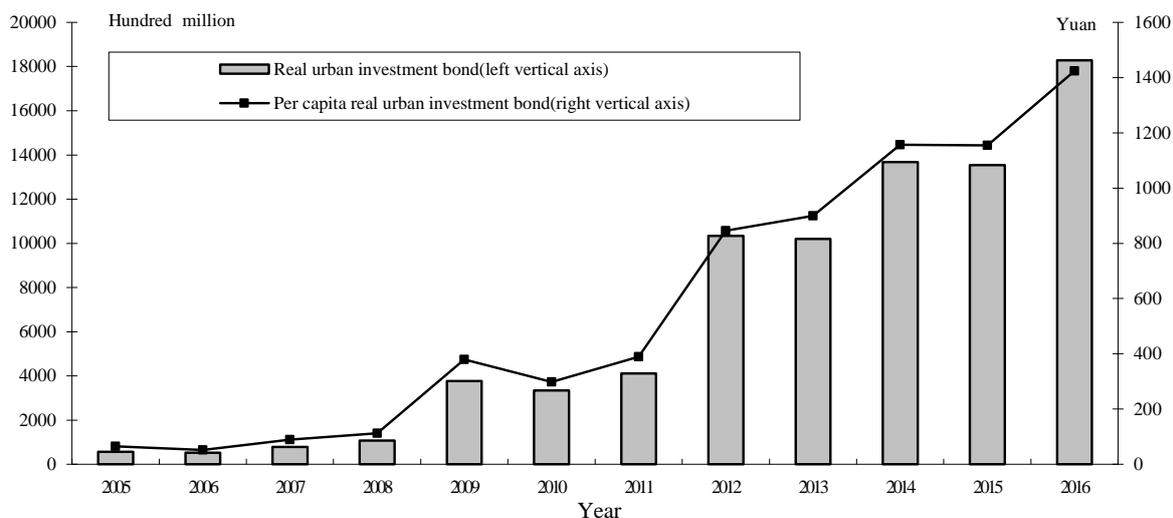


Figure 1 the trend chart of local government debt growth in China from 2005 to 2016

In terms of the overall trend of local government debt growth, the real urban investment bonds and the real urban investment bonds per capita present a remarkable growth trend, especially in 2009, 2012 and 2014 which witnessed greater increase. The reason for this kind of wave growth is that changes in the China's macro policy. First, the Chinese government initiated an economic stimulus plan called "Four Trillion" in order to combat global financial crisis in 2008. This plan would make rapid increase of local government debt in 2009. Second, from the end of the third quarter of 2011, China's National Development and Reform Commission's supervision towards urban investment bonds was milder than the China Banking Regulatory Commission's management of the loans to the financing platform, which caused the significant increase of urban investment bonds in 2012. Third, at the end of June 2013, China's National Audit Office released the National Audit Results of Government Debt. Relevant policies concerning urban investment bonds were relatively loose in the short term to further improve transparent financing of government financing platforms and ensure the repayment of large-scale due debts. This led to the expansion of urban investment bonds in 2014.

In order to have a better understanding of status quo of local government debt growth in each province in China, the paper calculates mean and average growth rate of actual urban investment bonds per capita in each province from 2005 to 2016 (see Figure 2). From Figure 2, there are seven provinces, namely Tianjin, Beijing, Jiangsu, Shanghai, Zhejiang, Fujian and Liaoning, which have higher mean of actual urban investment bonds per capita. These provinces are located in the coastal regions of East China. However, provinces that are located in the inland regions of Midwest China have lower mean of actual urban investment bonds per capita. These provinces are Hebei, Henan, Shanxi, Heilongjiang, Jilin, Guangxi, Gansu and others. Furthermore, also in Figure 2, these provinces that have higher mean of actual urban investment bonds per capita present lower average growth rates; on the contrary, these provinces having lower mean of actual urban investment bonds per capita present higher average growth rates. This is partly explained by the fact that as time goes on, debt levels of different provinces may have the trend of convergence as the growth rates of provinces that have lower initial debt levels are faster than that of provinces with higher initial debt levels.

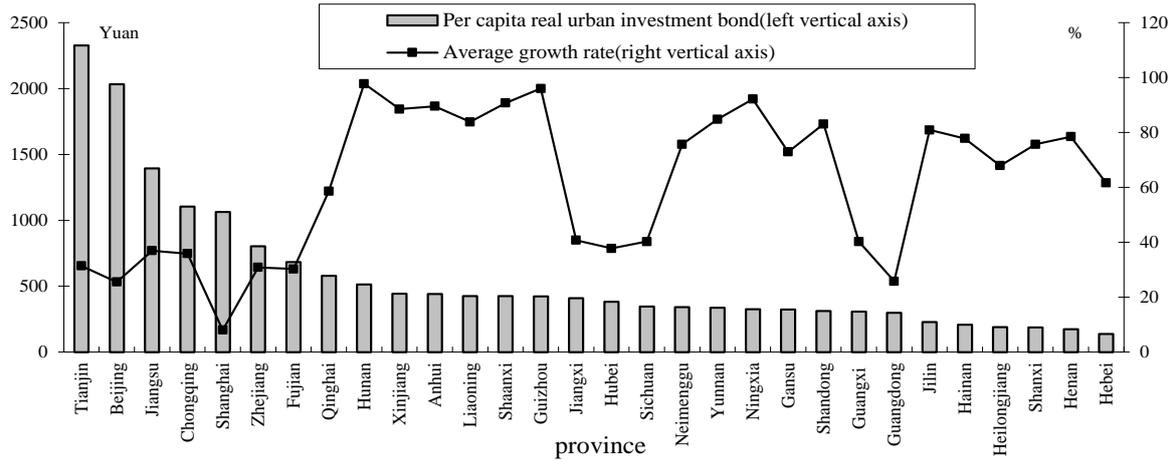


Figure 2 Mean and average growth rate of local government debt in China from 2005 to 2016

3.2 Inter-provincial Difference Analysis of Debt Growth in China’s Local Governments

3.2.1 The measure index of provincial differences in local government debt growth

From a statistical point of view, indexes concerning calculating provincial differences are coefficient of variation, Theil index, logarithmic dispersion mean and Gini coefficient. Among them, Gini coefficient is sensitive to middle level changes, and logarithmic dispersion mean and Theil index are respectively sensitive to lower level changes and upper level changes. This paper takes above three indexes into consideration with a view to more comprehensive measurement of local government debt growth and multi-angle understanding of the difference between provincial governments’ debt growth.

This paper uses the following formula to calculate the Gini coefficient of local government debt growth:

$$GINI = \frac{2}{n^2 \mu_e} \sum_{i=1}^n i e_i - \frac{n+1}{n} \quad (1)$$

In this formula, n represents the number of samples, namely the number of provinces. e_i stands for the local government debt of the i -th sample which is counted in ascending order. μ_e refers to the local government debt mean.

Logarithmic deviation mean (GE0) and Theil index (GE1) were proposed by economist Theil in 1967, which calculated the differences of local government debt levels under the guidance of entropy concept in information theory. The specific formulas are as follows:

$$GE0(e) = \frac{1}{n} \sum_{i=1}^n \ln \frac{\mu}{e_i} \quad (2)$$

$$GE1(e) = \frac{1}{n} \sum_{i=1}^n \frac{e_i}{\mu} \ln \frac{e_i}{\mu} \quad (3)$$

In these formulas, n represents the number of samples, namely the number of provinces. e_i represents the local government debt of the i -th sample which is counted in ascending order. μ_e refers to the local government debt mean.

3.2.2 Inter-provincial analysis of local government debt growth

According to formula (1), formula (2) and formula (3), Gini coefficient (GINI), logarithmic

dispersion mean(GE0) and Theil index(GE1) of local government debt growth of 30 provinces in China from 2005 to 2016 are worked out. The results are shown in the following Figure 3.

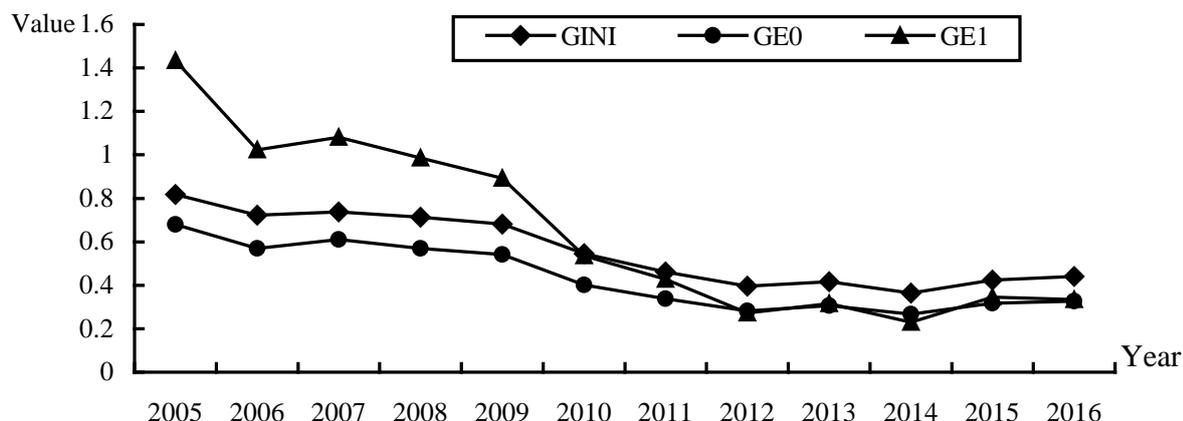


Figure 3 the results of inter-provincial difference index for debt growth of China's local governments from 2005 to 2016

It can be preliminarily judged by Figure 3 that, in general, Gini coefficient (GINI), logarithmic dispersion mean (GE0) and Theil index (GE1) present approximately same downward variation tendency. The fluctuation range between the three difference indexes becomes more and more small and shows the gradual tendency of convergence. More specifically speaking, Theil index (GE1) has the greatest variation, then logarithmic dispersion mean (GE0) and the last Gini coefficient (GINI). These phenomena show that from 2005 to 2014, there are no great changes in the internal structure of China's local government debt growth. However, in some years, the change ranges of the three difference indexes are different. For example, based on the statistics of 2009, the decline amplitude of Theil index in 2010 is significantly greater than Gini coefficient and logarithmic dispersion mean. This shows that in 2010, China's local government debt growth in the upper levels of the provinces have changed greatly, while the local government debt growth in the middle and lower levels of the provinces changed slightly. In the meantime, all three difference indexes have a larger negative growth rate in 2010. This shows that inter-provincial difference of China's local government debt growth shrink remarkably in 2010. It may be related to the four trillion economic stimulus plan initiated in 2009 in order to combat global financial crisis. Each and every of local government has actively taken part in enhancing infrastructure investment and construction. Local government debt growths generally and the inter-provincial differences of China's local government debt growth reduce significantly.

4. Data and methods

4.1 Estimation model

Convergence is an important concept in the theory of endogenous economic growth, indicating that the growth rate of income per capita is negative correlated to initial economic levels. Therefore, in the long run, economic levels in different regions will converge [30]. In the past 30 years, China has witnessed its miracle of economic growth. Local governments have play important roles in the growth and have formed a special modal of "debt-driven economic development". So, to a certain extent, the differences of regional local government debt growth determine the differences of regional economic development levels. In this case, it is no doubt that discussing the convergence of the regional government debt growth can enrich the outcomes of regional economic convergence.

4.1.1 Traditional convergence model

At present, absolute β convergence model and conditional β convergence model are commonly

used in the researches of convergence. The absolute β convergence model indicates that each and every of region will reach at a same steady growth level. The model is represented as follows:

$$GINI = \frac{2}{n^2 \mu_e} \sum_{i=1}^n i e_i - \frac{n+1}{n} \quad (4)$$

In the above formula, DEB_{i0} stands for the initial local government debt of each region. DEB_{iT} is the local government debt at the end of the period. T is the time span of the observation period. α is the constant term. β is the convergence coefficient. ε_i is the random error vector. If $\beta < 0$, there is absolute β convergence in regional local government debt; otherwise, there is divergence.

The conditional β convergence means that each region converges to a respectively steady state because of the difference of certain conditions. The model can be outlined as follows:

$$\frac{\ln(DEB_{iT}/DEB_{i0})}{T} = \alpha + \beta \ln DEB_{i0} + BX_{it} + \varepsilon_i \quad (5)$$

In the above formula, X stands for control variable group (include fiscal decentralization, financial development, FDI competition, investment demands, etc.). B represents the coefficient of the control variable. Generally, traditional convergence model can be estimated by ordinary least squares (OLS).

4.1.2 The convergence model considering the spatial effects

Provinces will have some connections with neighboring ones because of “competition effect” and “demonstration effect”, resulting in a spatial correlation of local government debt growth [31]. This spatial correlation means that the local government debt growth of a province is caused by the local government debt growth of neighboring provinces and even of the whole system. In order to avoid biased estimation that is brought by not taking spatial correlation into consideration, this paper introduces absolute β convergence model and conditional β convergence model into the testing of the convergence of local government debt growth.

The spatial econometric model mainly includes Spatial Lag Model (SLM) and Spatial Error Model (SEM) [32]. Particularly, Spatial Lag Models of absolute β convergence and conditional β convergence are shown as follows:

$$\frac{\ln(DEB_{iT}/DEB_{i0})}{T} = \alpha + \beta \ln DEB_{i0} + \rho W \frac{\ln(DEB_{iT}/DEB_{i0})}{T} + \varepsilon_i \quad (6)$$

$$\frac{\ln(DEB_{iT}/DEB_{i0})}{T} = \alpha + \beta \ln DEB_{i0} + \rho W \frac{\ln(DEB_{iT}/DEB_{i0})}{T} + BX_{it} + \varepsilon_i \quad (7)$$

In these formulas, ρ is spatial lag coefficient, showing the spatial dependence of the observation value of the sample, that is, the adjacent provinces influencing the direction and extent of the tested province value. W stands for the spatial weight matrix of adjacent distance, i.e. the adjacent areas are set to 1 and the non-adjacent areas or itself are set to 0.

Spatial Error Models of absolute β convergence and conditional β convergence are listed as follows:

$$\frac{\ln(DEB_{iT}/DEB_{i0})}{T} = \alpha + \beta \ln DEB_{i0} + (I - \lambda W)^{-1} \mu_i \quad (8)$$

$$\frac{\ln(DEB_{iT}/DEB_{i0})}{T} = \alpha + \beta \ln DEB_{i0} + BX_{it} + (I - \lambda W)^{-1} \mu_i \quad (9)$$

In the above formulas, λ is the spatial error coefficient and μ_i is the random error term. Uniform estimation of parameters gotten in spatial econometric models can be worked out in some measures such as two-stage least squares (2SLS), maximum likelihood (ML) [33-35] and generalized moment method (GMM) [36]. Based on the systematic study of the estimating method of spatial econometric model which is conducted by Elhorst (2010) and combining the existing research results, maximum likelihood method (ML) is more effective than generalized moment method (GMM). Therefore, with the use of the measure that is proposed Elhorst (2010), this paper estimates the spatial convergence model by using the maximum likelihood method (ML) of error correction.

4.2 Variable selection and statistical description

4.2.1 Variable selection

Next, this paper will give a brief introduction to the selection basis for the control variables (the main factors that affect local government debt growth) in the above models:

(1) Fiscal Decentralization (DEC): China's fiscal decentralization system lead to an increase in administrative power and a decrease in financial power of local government. Therefore, it distorts the fiscal expenditure structure of local governments while providing more opportunities for local governments to develop economy through borrowing. Local government debts are expected to increase. The degree of fiscal decentralization is measured by the ratio of provincial budgeted fiscal expenditure per capita and central budgeted fiscal expenditure per capita.

(2) Financial Development (FIN): if a region has a higher level of financial development, it is easier for the local governments to borrow money from banks through investment and financing platforms. Expectedly, there is a positive impact on the debt increase of local governments. The financial development level is measured by the total loan balance of the bank accounting for the proportion of the province's GDP.

(3) FDI Competition (COM): FDI competition is the main form of local governments' competition in China. Local governments usually take advantage of tax relief, low-price transfers of land, etc., directly or indirectly, to increase fiscal expenditure with aims to participate in competitions. Local government debt will be expected to increase. FDI competition is measured by FDI attracted by every province accounting for the total national FDI of the year.

(4) Investment Demand (INV): increasing investment is a rational choice for local governments to develop local economy and get competitive advantages. Local governments usually get loans from banks by means of investment and financing platforms to meet local investment demand. This is how the local government debt comes into being. The investment demand is measured by investments in fixed assets accounting for the province's GDP.

4.2.2 Descriptive statistics

The data of this paper are mainly selected from the China Statistical Yearbook that span many years. In the process of data processing, all continuous variables are winsorized to 1%, so as to reduce the influence of abnormal values to estimate results. Table 1 is a statistical description of main variables. From the table, there are distinct differences among mean and standard deviation of each variable. In general, the local government debt per capita goes through the largest fluctuation, showing the range as high as 8.701 (the maximum is 8.701 and the minimum is 0). Financial development and investment demand present remarkable fluctuation. However, fiscal decentralization has lower fluctuation and FDI competition is the lowest. The preliminary guess is that compared with fiscal decentralization and FDI competition, financial development and investment demand exert more influences on the convergence of local government debt growth

Table 1 Statistical description of variables

Variables	Names of Variables	Samples	Mean	Standard Deviation	Minimum Value	Maximum Value
DEB	Local Government Debt Scale Per Capita	360	4.867	2.443	0.000	8.701
DEC	Fiscal Decentralization	360	0.155	0.084	0.017	0.502
FIN	Financial Development	360	1.141	0.406	0.537	2.585
COM	FDI Competition	360	0.033	0.047	0.001	0.199
INV	Investment Demand	360	0.674	0.226	0.240	1.372

5. Results and Discussion

5.1 Spatial autocorrelation test of debt growth in China’s local governments

Before examining the convergence of China’s local government debt growth by using the method of spatial econometric, it is necessary to find out whether there is spatial autocorrelation in China’s local government debt growth. If there is spatial autocorrelation, the measure of spatial econometric should be adopted; if not, the measure of standard econometric should be adopted. Generally speaking, spatial autocorrelation test can be divided into global spatial autocorrelation test and local spatial autocorrelation test. The main measures of global spatial autocorrelation test are Moran’s I and Geary’s C. Because the former is less influenced by deviation from normal distribution than the latter [37], this paper uses Moran’s I to find out whether there is spatial autocorrelation in China’s local government debt growth. The formula is shown as follows:

$$Moran's I = \frac{\sum_{i=1}^n \sum_{j=1}^n W_{ij} (X_i - \bar{X})(X_j - \bar{X})}{S^2 \sum_{i=1}^n \sum_{j=1}^n W_{ij}}, S^2 = \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n}, \bar{X} = \frac{\sum_{i=1}^n X_i}{n} \quad (10)$$

In the above formula, X_i and X_j represent the observed values of regions i and j respectively. n is the number of region and W stands for spatial weight matrix. The value range of Moran’s I is [-1, 1]. When Moran’s I equals to 0, it shows no spatial autocorrelation; when Moran’s I is greater than 0, it shows spatial positive correlation; when Moran’s I is less than 0, it shows spatial negative correlation. The larger the absolute value of Moran’s I is, the stronger the spatial autocorrelation is, and vice versa. As the value of Moran’s I is estimated, Z statistics is generally used to check whether the results are significant or not.

$$Z = \frac{[I - E(I)]}{\sqrt{VAR(I)}} \quad (11)$$

Table 2 Moran’s I results of China’s local government debt growth from 2005 to 2016

Year	2005	2006	2007	2008	2009	2010
Moran’s I	0.237***	0.372***	0.417***	0.267***	0.326***	0.339***
Z	2.890	3.706	4.006	3.065	3.321	3.442
Year	2011	2012	2013	2014	2015	2016
Moran’s I	0.302***	0.234**	0.221***	0.373***	0.248***	0.249***
Z	3.944	2.242	2.587	3.591	2.785	2.571

Description: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2 shows Moran’s I results of China’s local government’s debt growth from 2005 to 2016.

From Table 2, the Moran's I value of local government debt growth is significantly positive (the value fluctuates between 0.221 and 0.417 and, at least, passes the significant level test of 5%). the table tells that over the past 12 years, there is a strong spatial positive autocorrelation of China's local government debt growth, that is, the China's local government debt growth is not random, but is under the influence of neighboring local government debt growth. It shows a strong spatial correlation, which forms two increase groups, namely the higher-level local government debt growth group and the lower-level local government debt growth group. Therefore, it can be seen that whether geographical location is adjacent is an important factor affecting the growth of China's local government debt. It provides statistical logic supports for the spatial econometric method to study the convergence of China's local government debt growth.

5.2 Spatial econometric analysis of β convergence of debt growth in China's local government

On the basis of spatial autocorrelation tests, this paper is determined to use spatial econometric methods to carry out the β convergence analysis. Taking into account the differences economic bases, resource endowments, and national policies in various regions of China, the economic development among regions is extremely uneven and there are clear differences in the scale of government debt. For this reason, this paper divides all samples into the eastern coastal regions and the midwestern inland regions according to the geographical distribution to carry out the regression test. Because the data come from local government debt of China's provinces, the spatial fixed effect model is used to analyze β convergence. However, based on the spatial fixed effect model, LM test determines whether to choose the spatial lag model or to choose the spatial error model. According to suggestions given by Ansenlin et al. (1996) [38], spatial correlation tests of LM-lag, LM-error and relating robust forms can be viewed as standards to whether to choose the spatial lag model or to choose the spatial error model. If the statistical value of LM-lag is larger than that of LM-error, the spatial lag model can be chosen, and vice versa. If the statistical value of LM-lag and LM-error cannot pass the test of significance level, Robust LM-lag and Robust LM-error can be taken into consideration. Besides, the judgment criterion is similar to the above.

Table 3 Spatial correlation testing results of China's local government debt growth

Testing methods	Absolute β convergence			Conditional β convergence		
	Whole country	Eastern coastal regions	Midwestern inland regions	Whole country	Eastern coastal regions	Midwestern inland regions
LM-lag	0.842 (0.359)	21.416*** (0.000)	0.675 (0.411)	0.956 (0.328)	16.825*** (0.000)	0.229 (0.632)
Robust LM-lag	132.202*** (0.000)	0.049 (0.825)	218.977*** (0.000)	11.292*** (0.001)	32.826*** (0.000)	16.592*** (0.000)
LM-error	10.126*** (0.003)	22.693*** (0.000)	2.679 (0.102)	4.764** (0.029)	9.041*** (0.003)	1.017 (0.313)
Robust LM-error	141.485*** (0.000)	1.326 (0.249)	220.981*** (0.000)	15.101*** (0.000)	25.042*** (0.000)	17.380*** (0.000)
Model selection	SEM	SEM	SEM	SEM	SLM	SEM

Description: 1. p values in parentheses; 2. * p < 0.1, ** p < 0.05, *** p < 0.01

Table 3 shows the spatial correlation test results of the traditional convergence model. From Table 3, in absolute β convergence, LM-error of samples from the whole country is significant at the level of 1%, but LM-lag cannot meet the standard of test of significance. Therefore, the spatial error model is selected. LM-lag and LM-error of samples from eastern coastal regions are all significant at the 1% level, but the latter (22.693) is larger than the former (21.416) in terms of

statistical value. Therefore, the spatial error model is selected too. Robust LM-lag and Robust LM-error of samples from the midwestern inland regions are all significant at the 1% level, the statistical value of the latter (220.981) is larger than the former (218.977), and likewise, the spatial error model is selected. In the same way, in conditional β convergence, LM-lag of sample from the whole country cannot meet the standard of test of significance, but LM-error pass the 5% test of significance level. So the spatial error model is chosen. LM-lag and LM-error of samples from the eastern coastal regions are all significant at the level of 1%, whereas the former (16.825) is larger than the latter (9.041) in terms of statistical value. So the spatial lag model is chosen. Robust LM-lag and Robust LM-error of samples from the midwestern inland regions pass the significant tests at the level of 0.01, but the statistical value of Robust LM-lag (16.592) is smaller than that of Robust LM-error (17.380). Therefore, the spatial error model is better than the spatial lag model.

Table 4 Spatial econometric regression of absolute β convergence of China's local government debt growth

	Whole country		Eastern coastal regions		Midwestern inland regions	
	OLS	SEM	OLS	SEM	OLS	SEM
β	-0.286*** (-8.961)	-0.382*** (-7.523)	-0.215*** (-5.165)	-0.225*** (-5.015)	-0.324*** (-7.484)	-0.444*** (-5.236)
λ		0.350*** (3.966)		0.317*** (4.421)		0.297** (2.263)
Convergence rate	0.031	0.044	0.022	0.023	0.036	0.053
R-squared	0.216	0.217	0.216	0.216	0.219	0.219
Observations	330	330	110	110	220	220

Description: 1. OLS means the estimation results of traditional convergence model; 2. z statistics in parentheses; 3. * p < 0.1, ** p < 0.05, *** p < 0.01

Table 4 lists the spatial econometric regression results of absolute β convergence of China's local government debt growth. From Table 4, the spatial error coefficients λ in the spatial error model (SEM) are all greater than 0 and pass the test of significance level of 1%, which shows that there is an obvious spatial correlation in China's local government debt growth. The convergence coefficients β of the whole country, the eastern coastal regions and the midwestern inland regions are all less than 0 and pass the test of significance level of 1%, indicating that there is absolute β convergence in China's local government debt growth. Based on the convergence formula for the neo-classical economic growth model, we calculate the absolute convergence rate

($|\beta| = 1 - e^{-\phi T}$, ϕ is the convergence rate, T is the length of sample data survey period, then $\phi = -\frac{1}{T} \ln(1 - |\beta|)$) of local government debt growth in China. As shown by the calculated results, compared with the traditional convergence models, the convergence models that the spatial effect are added have the obvious improvement in the convergence rate. Meanwhile, there is a significant difference in the convergence rate between the eastern coastal regions and the midwestern inland regions in China. The convergence rate of local government debt growth in the midwestern inland regions is significantly faster than that in the eastern coastal regions, which means the implementation of debt regulatory policies is hard to reach agreements among different regions. In addition, according to the Moran scatter plot and LISA cluster chart, the growth of local government debt in China also shows the features of high value agglomeration in the eastern coastal regions and low value agglomeration in the midwestern inland regions. To sum up, there is absolute β convergence in the growth of local government debt in China, that is, China's local government debt growth tends to converge among provinces with similar levels of economic development. Next, conditional β convergence can be taken into consideration in terms of China's local government

debt growth.

Table 5 Spatial econometric regression of conditional β convergence of China's local government debt growth

Variables	Whole country		Eastern coastal regions		Midwestern inland regions	
	OLS	SEM	OLS	SLM	OLS	SLM
β	-0.524*** (-11.726)	-0.687*** (-9.878)	-0.420*** (-7.036)	-0.529*** (-6.115)	-0.715*** (-11.430)	-0.785*** (-8.862)
DEC	5.783*** (4.372)	8.363*** (3.778)	0.660 (0.599)	5.475*** (2.991)	9.702*** (4.568)	11.455*** (3.194)
FIN	1.129*** (5.058)	1.562*** (4.684)	1.173*** (4.521)	1.360*** (2.834)	0.014 (0.029)	0.153 (0.268)
COM	1.421 (0.553)	1.385 (0.377)	3.819* (1.732)	-3.076 (-0.401)	-10.124 (-0.615)	-16.939 (-0.818)
INV	1.982*** (4.441)	2.800*** (4.780)	2.378*** (3.716)	2.438*** (3.363)	4.878*** (5.480)	5.180*** (5.312)
λ/ρ		0.198* (2.368)		0.395*** (3.075)		0.116 (1.164)
Convergence rate	0.068	0.106	0.050	0.068	0.114	0.140
R-squared	0.424	0.435	0.411	0.494	0.464	0.470
Observations	330	330	110	110	220	220

Description: 1. OLS means the estimation results of traditional convergence model; 2. z statistics in parentheses; 3. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5 lists the spatial econometric regression results of conditional β convergence of local government debt growth. The results in Table 5 show that compared with absolute β convergence model, conditional β convergence that adds control variables witnesses an increase of R-squared. The R-squared of the spatial error model and the spatial lag model are superior to that of the traditional convergence model, which indicating that there are eloquent explanations of conditional β convergence taken the spatial econometric method. In terms of the spatial error model and the spatial lag model, when other variables are under controlled, the convergence coefficients β of the whole country, the eastern coastal regions and the midwestern inland regions are all negative and significant at the level of 1%. That is to say that there are conditional β convergence of local government debt growth in the whole country, the eastern coastal regions and midwestern inland regions. As the adjustment of the financial expenditure structure, the improvement of financial development, the strengthening of FDI competition and the expansion of investment demand, China's local government debt growth will reach stable levels for a long time. From the perspective of the convergence rate in each region, China's local government debt growth presents the faster in the inland regions of Midwest China and the slower in the coastal regions of East China. The local government debt growth of the midwestern inland regions will converge to a stable level first.

From the estimation result of the control variables in the conditional β convergence, the fiscal decentralization, financial development and investment demand of whole country samples all meet the standard of 1% tests of significance, which shows that the expansion of fiscal expenditure scale, the improvement of financial development level and the expansion of investment demand all promote the convergence of China's local government debt growth. From the perspective of regions, the financial development in the coastal regions of East China is significant at the 1% level; the FDI competition also passes the significant test at the level of 0.01. While the financial development and the FDI competition don not pass the tests of significance level in the midwestern inland regions, in addition, the fiscal decentralization and the investment demand are all significant at the 1% level in the eastern coastal regions and the midwestern inland regions.

These mean that there are differences in driving factors of local government debt growth. Therefore, in the regulation of local government debt growth, it is necessary to formulate governance policies according to the actual situations of different regions. However, generally speaking, regulating the scale of fiscal expenditure, stabilizing the level of financial development, rationalizing investment demands are still the focuses of local government debt growth prevention and governance in the future.

6. Research Conclusions and the Enlightenment of Policies

This paper has studied the dynamic changes, inter-provincial differences and convergences of China's local government debt growth in 30 provinces from 2005 to 2016. Some conclusions have been reached as follows: First, from the fluctuation trend of urban investment bonds data, the China's local government debt scale increases dramatically from 2005 to 2016, but there are differences in increase among provinces. Second, during the sample period, the Gini coefficient (GINI), logarithmic dispersion mean (GE0) and Theil index (GE1) of local government debt growth all show roughly the same downward trend. The variations of the three difference indexes are becoming smaller and smaller. These indicate that provincial differences of China's local government debt growth have somewhat decrease, initially confirming China's local government debt growth has the feature of convergence. Third, according to the Moran scatter plot and LISA cluster chart, there are remarkable spatial autocorrelation in local government debt growth, which indicates obvious spatial spillover effects and diffusion effects in terms of the borrowing behavior of China's local government. When taking spatial effects into consideration, China's local government debt growth not only shows the feature of absolute β convergence, but the feature of conditional β convergence as well. The fiscal expenditure level, financial development level and investment demands are important factors of local government debt growth convergence; meanwhile, the convergence speed of China's local government debt growth features the midwestern inland regions in faster speed, but the eastern coastal regions in lower speed.

Based on the above conclusions, we can get the following enlightenment: First, in macro control over provincial local government debt scales differentiate policies should be taken in different regions. It is necessary to focus on controlling the expansion of local government debt growth in the eastern coastal regions, particularly in debt congregating provinces such as Shanghai, Jiangsu and Zhejiang, so as to prevent it from spreading further into other provinces. It is reasonable to borrow money for the midwestern inland regions to stimulate economic development, but local government debt levels should be controlled below the warning line based on the economic strength and comprehensive financial resources of each province. Second, because of the obvious spatial dependence and spatial clustering features in provincial governments' debt growth, it is necessary to take the spatial spillover effects of local government borrowing behavior into account and strengthen the linkage governance and risk prevention among local governments. In the co-governance of regional debts problems, each province should share dynamic information and jointly seek technical supports. Third, in order to prevent excessive borrowing, the central government should form the budgetary hard constraint mechanism, and design the responsibility tracking mechanism for local governments borrowing from the legal level; The government should improve the loan management system of financial institutions and standardize the borrowing behaviors of local governments; It should rationally reduce local financial expenditure and reach the fiscal balance of local governments; In addition, local fixed asset investments should be improved so as to effectively prevent the expansion of local government debt.

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References

- [1] Luo Dangling and She Guoman. Official's Turnover and Issuance of Local Government Debt. *Economic Research Journal*, 2015, 6: 131-146.
- [2] Niu Linlin, Hong Zhiwu and Chen Guojin. Local Government Debt Risk and Its Transmission in China: An Analysis Based on Treasury Yields and Urban investment Bond Spreads. *Economic Research Journal*, 2016, 11: 83-95.
- [3] Wu Xun, Yu Qiao. Risk Premium Determinants of Local Government Debt. *Public Finance Research*, 2017, 1: 89-102.
- [4] Fu Runmin, Miao Xiaolin. Spatial and Time Separation of Local Government Debt Accrual: Theory and Practice—On the Bottleneck and Solutions of Preventing the Debt Risk of Local Government in China. *Economic Perspectives*, 2014, 12: 72-78.
- [5] Zhang Jun, Fan Ziyang, Fang Hongsheng. *Race to the Top: Understanding the Institutional Mechanism of China's Economic Development*. Beijing: Peking University Press, 2015.
- [6] Guo Jie, Li Tao. Research on Tax Competition among Local Governments in China: Based on Experiences from China's Provincial Panel Data. *Management World*, 2009, 11: 54-64.
- [7] Long Xiaoning, Zhu Yanli, Cai Weixian. An Empirical Analysis of Spatial Tax Competition among Chinese Counties Based on Spatial Econometric Models. *Economic Research Journal*, 2014, 8: 41-53.
- [8] Tang Feipeng. Local Fiscal Competition, Governance Capability and Enterprise Migration. *The Journal of World Economy*, 2016, 10: 53-77.
- [9] Trehan B, Walsh C E. Common Trends, the Government's Budget Constraint, and Revenue Smoothing. *Journal of Economic Dynamics & Control*, 1988, 12(2): 425-444.
- [10] Bravo, A. B. S., & Silvestre, A. L. Intertemporal Sustainability of Fiscal Policies: Some Tests for European Countries. *European Journal of Political Economy*, 2002, 18(3): 517-528.
- [11] Greiner A, Köller U, Semmler W. Debt Sustainability in the European Monetary Union: Theory and Empirical Evidence for Selected Countries. *Oxford Economic Papers*, 2007, 59(2): 194-218.
- [12] Domar E D. The "Burden of the Debt" and the National Income. *American Economic Review*, 1944, 34(4): 798-827.
- [13] Zhang Xian. The Moderate Scale of National Debt and the Feasibility of Implementing Tax Reduction Policy in China. *Taxation Research*, 2003, 3: 24-27.
- [14] Bohn, Henning. Who Bears What Risk? An Intergenerational Perspective. *Social Science Electronic Publishing*, 2005, 10-37.
- [15] He Daixin. The Theory of Appropriate Size of National Debt: Model Characteristics and Non-linear Simulation. *Finance & Trade Economics*, 2015, 5: 5-19.
- [16] Peng Qinghui, Zeng Linghua. The Financing Sustainability of the Investment and Financing Platform of Local Government's Infrastructure. *Systems Engineering*, 2010, 8: 117-120.
- [17] Jia Junxue, Guo Qingwang. Financial Rules, Economic Growth and Government Debt Scales. *The Journal of World Economy*, 2011, 1: 73-92.
- [18] Panizza U, Presbitero A F. (2014) Public Debt and Economic Growth: Is There a Causal Effect? *Mo.fi.r. Working Papers*, 2014, 41(C): 21-41.
- [19] Pang Xiaobo, Li Dan. The Economic Climates and Government Debt Risk in China. *Economic Research Journal*, 2015, 10: 18-33.
- [20] Zhang Xiaodi, Shi Lei. Sustainability of Pension System and Public Debt in an Overlapping

Generation Model. *Nankai Economic Studies*, 2014, 2: 136-152.

[21] Hong Yuan, Yang Sijian, Qin Yuqi. Is Finance of People's Livelihood Able to Reduce the Urban-rural Income Gap Effectively? *The Journal of Quantitative & Technical Economics*, 2014, 7: 3-20.

[22] Li Meng. Fiscal Cost of Urbanization of Population and the Mechanism—Experience from Major-country since 1960. *China Industrial Economics*, 2016, 10: 40-56.

[23] Huang Chunyuan, Mao Jie. Fiscal Condition and Local Debt Scale: New Findings Based on the Perspective of Transfer Payments. *Finance & Trade Economics*, 2015, 36 (6):18-31.

[24] Zhang Bo. Cause Analysis and Risk Management of Local Government Debt in China. *Seeker*, 2013, 5: 190-192.

[25] Liu Heng, Chen Zhiyong. Research on the Causes of Local Government Debt in the Process of Urbanization in China. *Statistics & Decision*, 2016, 19: 114-118.

[26] Gong Qiang, Wang Jun, Jia Shen. A Survey of Research on Local Government Debts and Fiscal Decentralization. *Economic Research Journal*, 2011, 7: 144-156.

[27] Zheng Wei, Lu Yuanquan, Li Xiaolong. Does Local Government Competition Promote Local Government Debt Growth? —Based on Empirical Evidences from China's Provincial Urban Investment Bonds and Spatial Spillover Effects. *Journal of Southwest Minzu University (Humanities and Social Science)*, 2017, 2: 135-141.

[28] Wang Yongqin, Chen Yinghui, Du Junlan. Soft Budget Constraint and the Default Risk of Chinese Local Government Debts: Evidence from the Financial Markets. *Economic Research Journal*, 2016, 11: 96-109.

[29] Xian Guoming, Leng Yanli. Local Government Debt, Financial Development and FDI: An Empirical Research Based on Spatial Econometrics. *Nankai Economic Studies*, 2016, 3: 52-74.

[30] Barro R J, Blanchard O J, Hall R E. Convergence Across States and Regions. *Brookings Papers on Economic Activity*, 1991, 1: 107-182.

[31] Lu Yuanquan, Zheng Wei, Li Xiaolong. Decentralization with Chinese Characteristics, Investment Competitions and Local Government Debt Scale: Based on Spatial Correlation Perspective. *Journal of Southwest Minzu University (Humanities and Social Science)*, 2016, 6: 98-106.

[32] Anselin L. Spatial Econometrics: Methods and Models. *Economic Geography*, 1987, 65(2): 160.

[33] Elhorst J P. Unconditional Maximum Likelihood Estimation of Dynamic Models for Spatial Panels. *Research Report*, 2003, 37(1): 85-106.

[34] Lee L F. Asymptotic Distribution of Quasi-Maximum Likelihood Estimators for Spatial Autoregressive Models. *Econometrical*, 2004, 72(6): 1899-1925.

[35] Elhorst J P. Spatial Panel Data Models, Spatial Econometrics. Springer Berlin Heidelberg, 2010.

[36] Arellano M, Bond S R. Arellano, B. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, 1991, 58(2): 277-297.

[37] Liu Yulin, Zheng Xiaochen, Wang Peng et al. The Spatial Panel Model Analysis of FDI and Industrial Pollution Emissions. *Journal of Industrial Engineering and Engineering Management*, 2015, 29(2): 142-148.

[38] Anselin L, Bera A K, Florax R, et al. Simple Diagnostic Tests for Spatial Dependence. *Regional Science & Urban Economics*, 1996, 26(1): 77-104.