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The Effect of Local Government Debt on Regional Economic Growth in China: A Nonlinear Relationship Approach

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Abstract: By drawing on the concept of sustainable economic development, this study advances the research on debt sustainability in the economic literature. We explore the correlation between local government debt and regional economic growth in 30 provinces in China. Previous studies have established that the development of economic growth between regions is not independent and we, therefore, investigate the spatial effect of regional economic growth due to the existence of a spatial spillover effect or spatial expansion among regions. Using Moran's scatter plot, a Local Indicator of Spatial Association (LISA) map, and a semiparametric spatial model (SE-SDM), our results demonstrate the following: (1) the spatial agglomeration effect has a significant influence on regional economic growth; (2) the relationship between local government debt and regional economic growth presents nonlinear characteristics, rather than having an inverted U-shaped relationship; (3) the semiparametric spatial model more accurately characterizes in the nonlinear relationship between local government debt and regional economic growth compared to a basic regression model and the spatial Durbin model; and (4) when the scale of local government debt exceeds a certain level, economic growth will be suppressed by the crowding-out of private investment and the reduction of public expenditure.

Keywords: local government debt; regional economic growth; spatial effect; semiparametric spatial model

1. Introduction

Financing plays an important role in economic development. Scholars such as Levine [1] and Ziolo et al. [2] have regarded financing as the lifeblood of economic development and sustainability. Levine [1] posits that countries with more developed financial systems experience faster economic growth. Indeed, financing involving debt (e.g., bank loans, the issue of bonds, etc.) or equity (e.g., self-raised funds, stock financing, etc.) can be both beneficial to and hamper economic development [3]. Over the past decades, several local governments from both advanced and emerging economies have resorted to debt financing in one way or other in order to enhance economic development. In the literature, research on local government debt has increasingly demonstrated the important role and strategic position of such debt in promoting sustainable regional economic growth [1,2]. Scholars and economic practitioners have asserted that local government debt can kick-start economic growth with infrastructure spending [4–6]. Interestingly, a 2013 report by the Chinese National Audit Office indicated that in China, 88.77% of the total local government debt was invested in basic infrastructure projects such as municipal facilities [7]. The application of local government debt within the debt ceiling can promote the construction of urban and rural infrastructure and stimulate the regional economy [8]. Démurger's studies of the influence of transport infrastructure and telecommunications facilities on the growth performance of provinces in China reveal a positive significant relationship among the variables [9]. According to Shi and Huang [10], the development of local government infrastructure has a positive impact on economic growth. They believe that when the general infrastructure level increases by 1%, the gross domestic product (GDP) of a province can increase by around 0.25%. In fact, proper infrastructure development stimulates the efficiency of regional research and development (R&D) which, in turn, reduces the operating cost of enterprises, thereby accelerating the sustainable regional economic development [11]. Conversely, local government debt which is above the regional debt ceiling can inhibit economic development [12,13]. Research has shown that local government debt that exceeds a certain threshold crowds out private investment, increases the debt burden and slows down economic growth [14]. For instance, in China, local government debt has been growing rapidly for the past decade and records indicate that this has strongly threatened the country's economic and financial security [11].

The literature indicates that the relationship between local government debt and economic growth is a popular issue, having created much debate among scholars, economic practitioners, and policy-makers [15,16]. Some authors have used different theoretical and empirical models to analyze the relationship between local government debt and economic growth in different regions in different time periods [17,18]. However, the results continue to create controversy in the macroeconomic literature. For instance, empirical studies have indicated that local government debt has no significant impact on regional economic growth in the short-term or the long-term [12,19–23]. On the other hand, other researchers [24–31] have established that an inverted U-shaped nonlinear relationship exists between local government debt and regional economic growth. This paradoxical contrast necessitates further investigations to determine which empirical model can establish the correlation between these two variables. The authors of the present study are of the view that the selection of an appropriate empirical model will have an effect on the overall reliability of the empirical results. A review of previous empirical studies reveals that scholars have employed in linear models or introduced the quadratic term of local government debt variables to construct nonlinear models. It is obvious that there is presently no clear theoretical evidence that suggests a monotonic-linear or inverted U-shaped relationship between local government debt and regional economic growth [32].

Nevertheless, some authors [33–35] have attempted to combine a semiparametric approach with the usual parametric econometric models in order to accommodate nonlinearities in the relationship between local government debt and regional economic growth. In these models, scholars [33–35] mostly use an unknown function to depict the nonlinear relationship and do not make strict assumptions about relationship forms, which overcome possible setting errors and the so-called "curse of dimensionality". Indeed, there are defects associated with both parametric and non-parametric models. The former is linked with possible setting errors, while the latter is subject to the curse of dimensionality. To overcome these limitations, researchers have advocated the use of a semiparametric model to depict a nonlinear relationship [35,36]. In the past few years, there has been a rapid increase in the use of semiparametric models in many fields. Scholars [37,38] have attested the remarkable impact of such models, especially in the field of economics and finance. The outstanding advantage of semiparametric models compared to parametric models is that they can visually show nonlinear relationships between variables.

Additionally, researchers have used spatial econometric models to scrutinize regional economic issues across the globe [39]. Their findings have revealed a significant spatial correlation between the economic performance of adjacent regions [40,41]. This suggests that increasing cooperation and competition among local governments can strengthen the spatial relationship between regional economies. The failure to consider the spatial effect between regional economies certainly has a significant impact on the accuracy of empirical results [42–52].

Consequently, in this study, we build a spatial weight matrix for 30 provinces in China using the concepts of geographic distance and economic distance. Firstly, we use Moran's Index and Moran's scatter plot to analyze the overall and local spatial agglomeration characteristics of regional economic growth. Secondly, we construct a semiparametric spatial model (SE-SDM) to analyze the relationship between local government debt and regional economic growth. Specifically, this study intends to address the following research questions: RQ1: What kind of spatial effects exist in regional economic growth? RQ2: What are the characteristics of the nonlinear relationship between local government debt and regional economic growth? RQ3: What is the optimal level of local government debt to promote regional economic growth?

This study contributes to the literature in two ways: first, prior studies [26–31] analyzing the relationship between local government debt and regional economic growth have attempted to treat different regions as independent. Meanwhile, scholars [26–31] have ignored the importance of spatial correlation effects between the economic growth of different regions. In this study, we introduce a spatial econometric model to analyze the relationship between local government debt and regional economic growth. Prior to the analysis using the spatial measurement model, we adopt Moran's Index to conduct a rigorous statistical test of the spatial effects between regional economies. The results of our statistical test show that the spatial agglomeration effect has a significant influence on overall regional economic growth. This indicates that spatial effects have a significant impact on the relationship between local government debt and regional economic growth.

Subsequently, we combine the spatial econometric model with a semiparametric model to construct a new semiparametric spatial econometric Durbin model. Our empirical results demonstrate that there is a "wave-shaped" relationship between local government debt and regional economic growth. This relationship does not exactly coincide with the inverted U-shaped, however, it does conform to the nonlinear relationship between local government debt and regional economic growth described by the regional economic growth theory. Additionally, the results of the statistical test illustrate that the goodness of fit of the semiparametric spatial Durbin model (SDM) is higher than both the panel regression model and the SDM. Therefore, this study builds on existing research.

The remainder of this paper is structured as follows. Section 2 deals with the effect of local government debt on regional economic growth. Section 3 describes the methodology of the study. Section 4 discusses the spatial characteristics of regional economic growth and further describes the quantitative analysis performed in the study. Section 5 presents conclusions, implications, and limitations.

2. Analysis of the Effect of Local Government Debt on Regional Economic Growth

Local government debt is referred to as local government liabilities, which are broken down into local government bonds, municipal bonds, finance leases and loans. Local governments around the world borrow from commercial banks, trust companies, and the corporate bond market to finance projects (e.g., infrastructure investments, housing investments, and property market-related activities). Indeed, the local government is responsible for a large proportion of infrastructure investment, service delivery, and social spending. Additionally, they allocate social funds, compensate for fiscal deficits, and regulate economic operations. In the past decades, local governments had been keen to promote local economic growth. Proponents of economic growth believe that the proper application of local government debt can stimulate economic growth. However, if such debt continues to accumulate above the debt ceiling, there can be serious consequences for economic development. Unsustainable local government debt can crowd out development and social programs since huge portions of revenue are taken away from external services in order to repay debt. The increase of public debt and deficit has significantly reduced the economic development of many local governments across the globe through reductions in revenue and expenditure, along with limitations to the deficit and the use of debt. For instance, in China, local government debt is at a "boiling point" that is, it has grown to levels that threaten economic development. Figure 1 depicts the current situation regarding the effect of local government debt on regional economic growth in China.

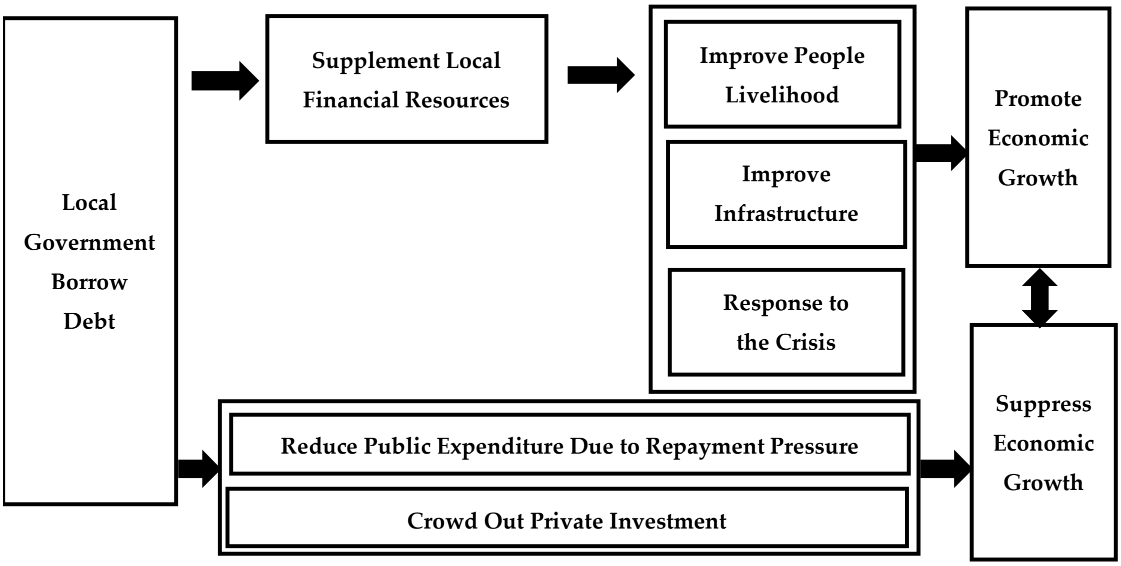

Figure 1. Mechanism of the effect of local government debt on regional economic growth in China.

From Figure 1, it is clear that local government debt has been having a momentous effect on China's economic growth and sustainability. First, local government debt can accelerate the pace of regional economic growth by boosting local financial resources, crowding in private investments, and increasing local government public expenditure [47]. Basically, the effect of local government debt on economic growth depends upon a range of factors, including the scale of debt investment, debt fund performance, and debt sustainability [53]. The net effect of the abovementioned factors depends on whether the debt level is within a reasonable range. Second, local government debt that remains within reasonable limits helps to tackle issues related to infrastructure construction and public welfare projects, which, in turn, correct market failures caused by externalities and public goods [54]. Chen and Wang [55] contend that when the local government debt to GDP ratio is less than 0.837, local government debt can promote economic growth, while, when the debt ratio is greater than 0.837, there can be negative consequences for economic growth. Their research indicates that when local government debt is above the debt ceiling, economic growth can be hindered. Chen and Wang [55] also state that the negative effect of high local government debt on economic growth comes from the crowding out of private investment and the reduction of public expenditure caused by fiscal repayment pressure.

Consequently, here we argue that local government debt can promote local economic growth. Once local government debt has exceeded a reasonable level, the debt performance will continue to decline due to an excessive government investment rate. The results of the present study show that once local government debt has exceeded a reasonable level, the ability of such debt to counter market failures will weaken and disappear, and, negative effects of such debt will begin to appear. Then, the effect of local government debt on economic growth will change from positive to negative. We expect the following hypotheses to hold true:

Hypothesis 1. *There is a nonlinear relationship between local government debt and regional economic growth.*

Hypothesis 2. *When local government debt is below a threshold, such debt can promote economic growth, while when it exceeds the threshold, it will inhibit economic growth.*

3. Methodology

3.1. Data Collection

The collection and estimation of local government debt data are cumbersome in empirical analyses. For instance, in China, local government debt data are not released below the provincial level. Additionally, access to local government debt data from the Tibet Municipality is restricted. In this paper, we use 30 provincial-level regions as our research objects. The study period is from 2010 to 2017. The study uses 2010 as a base year since China first audited local government debt data from the National Audit Office from that year. Data on local government debts were mainly collected from the Wind database, which is a popular and authoritative database in China. Data on other macroeconomic variables were mainly drawn from the China Statistical Yearbook.

In this study, data on foreign direct investments, imports, and exports are given in in RMB through exchange rate adjustment.

3.2. Variables and Measurement

3.2.1. Dependent Variables

We consider the per capita GDP growth rate as the dependent variable to measure the regional economic growth of 30 provinces in China. Previous studies on regional economic growth also use per capita GDP growth as a measure to analyze regional economic variables [56]. In order to eliminate the impact of inflation on the per capita GDP growth rate, we use the year 2010 as the base period to convert per capita GDP data after 2010. In this study, the per capita GDP growth rate is referred to as GDPGROWTH. In order to test the crowding-out effect of local government debt on private investment and the reduction of local government public expenditure in our theoretical analysis, we also choose private investment rate (PIR, private investment/GDP) and local government public expenditure (PE, local government public expenditure/GDP) as dependent variables.

3.2.2. Independent Variable

In China, local government debt mainly consists of provincial, municipal, and county-level debt. After the reform era, the central government only allowed provincial governments to conduct debt financing. In turn, provincial local governments allocated funds to the lower-level local governments. This means that the provincial local government debt balance can represent the province's debt situation. Consequently, we consider the logarithm of per capita provincial government debt, which represents the level of local government debt as our independent variable. In this study, LNDEBT denotes the logarithm of per capita provincial government debt.

3.2.3. Control Variables

In the previous studies, scholars have established that regional economic growth is significantly affected by the local government debt, the size of the region's economy, and the macroeconomic environment [16–18]. On the microeconomic level, other scholars have used the GDP of each Chinese province to represent the economic development of the provinces [12,20,21]. However, using GDP as a measurement index cannot exclude the impact of population size on economic development. Consequently, in this paper, we use the logarithm of per capita GDP (in Yuan) as a control variable to represent the economic growth of the regions. We denote this variable by LNPERGDP.

Additionally, due to the increasing openness of China's economy, foreign economic exchanges have a significant positive impact on regional economic development. In particular, trade (i.e., import and export) and foreign direct investments have a positive impact on regional economic growth. Accordingly, we use the ratio of the total volume of imports and exports to GDP, and the ratio of foreign direct investment to GDP as control variables to represent the economic openness of the regions; we denote these variables by TRADE and FDI, respectively.

Local government fiscal expenditure is another vital driving force of regional economic growth. The appropriate allocation of local government funds can stimulate economic growth and development in provincial regions. However, excessive spending by local governments can undermine the long-term growth potential of the local economy. Therefore, in this paper, we use the logarithm of the per capita financial expenditure of the local governments to measure the local financial situation of the local governments. We denote this variable by LNGOVERNMENT.

3.3. Construction of the Spatial Econometric Model

(i). Basic Regression Model

The basic regression model is based on relevant research conducted by scholars using a nonlinear relationship hypothesis as the framework [24–31]. We construct a basic regression model using panel data from 30 provinces (municipalities and autonomous regions) in China from 2010 to 2017. The basic regression model is specified as

$$gdpgrowth_{it} = \gamma + \beta_1 lndebt + \beta_2 lnX_{it} + \varepsilon_{it} \tag{1}$$

where $gdpgrowth_{it}$ denotes the dependent variable, that is, the interpreted variable, γ denotes a constant, and β_1 and β_2 denote the regression coefficients, which reflect the impact of local government debt and other variables. If β_1 is statistically significant, it means that the local government debt impacts regional economic growth. X_{it} represents the control variables and ε_{it} denotes the random error.

To verify the nonlinear relationship between local government debt and economic growth, this paper introduces a quadratic term of local government debt in Equation (1). The nonlinear panel model is specified as

$$gdpgrowth_{it} = \beta_1 lndebt + \beta_2 ln^2 debt + \beta_3 lnX_{it} + \varepsilon_{it} \tag{2}$$

where $ln^2 debt$ denotes the square of the local government debt variable, which reflects the nonlinear relationship between local government debt and regional economic growth. If β_1 is statistically significant, it means that the relationship between local government debt and regional economic growth is linear. Conversely, if β_2 is statistically significant, this means that the relationship between local government debt and regional economic growth is nonlinear, therefore indicating that there is an inverted U-shaped relationship between local government debt and economic growth.

As indicated in Figure 2, there is a significant correlation between spatial location and regional economic growth [43,44]. We argue that spatial measurement models can more accurately characterize the relationship between local government debt and regional economic growth. In the spatial econometrics literature, scholars often use the spatial lag model (SLM), spatial error model (SEM), and SDM to investigate spatial correlation [57–59].

Figure 2. The overall Moran's Index of regional economic growth in 2010–2017.

Spatial effects may occur simultaneously in the spatial lag of the dependent variable and the variation of the error term caused by the random impact. However, the SLM and SEM can only describe a spatial conduction mechanism. Thus, scholars such as Le Sage and Pace [60] built the SDM, which considers the above two spatial conduction mechanisms. In this paper, we use the SDM to analyze the spatial relationship between local government debt and regional economic growth.

(ii). Spatial Durbin Model

The SDM is used to determine whether there exists a diffusion or spillover phenomenon is present in the spatial dimension of each province. This approach helps to determine whether the growth of the regional economy is affected not only by the relevant economic factors in the region but also by the growth of the regional economy in neighboring provinces. The model is defined as follows:

$$gdpgrowth_{it} = \rho Wgdpgrowth_{it} + \beta_1 lndebt_{it} + \beta_2 lnX_{it} + \theta_1 Wlndebt_{it} + \theta_2 WlnX_{it} + \delta_t + \mu_i + \varepsilon_{it} \tag{3}$$

where ρ denotes the spatial regression coefficient, which reflects the spatial dependence of sample observations. If ρ is statistically significant, it means that the growths of the regional economies do not depend on each other spatially. The value of ρ can effectively measure the spatial impact of the growth of the regional economies in neighboring provinces on the growth of the regional economy, and the direction of the impact. W denotes the spatial weight matrix. $Wgdpgrowth_{it}$ represents the spatial lag variable, which indicates the degree of influence of adjacent areas. In this paper, $Wgdpgrowth_{it}$ is used to illustrate the degree of spatial spillover of the growth of the regional economy to the neighboring provinces. θ_1 and θ_2 represent coefficients, μ_t represents the spatial fixed effect, and δ_t represents the temporal fixed effect. In order to analyze the nonlinear relationship between local government debt and regional economic growth, we introduce a quadratic term of local government debt into the SDM. The nonlinear SDM is specified as

$$\begin{aligned} gdpgrowth_{it} = {} & \rho Wgdpgrowth_{it} + \beta_1 lndebt_{it} + \beta_2 ln^2 debt_{it} + \beta_3 lnX_{it} + \theta_1 W\, lndebt_{it} + \theta_2\, Wln^2 debt_{it} + \\ & \theta_3 W\, lnX_{it} + \delta_t + \mu_i + \varepsilon_{it} \end{aligned} \tag{4}$$

(iii). Semiparametric Spatial Durbin Model

As explained in the introduction, parametric models adhere to a specific distribution with unknown parameters. It has the advantage of high efficiency and easy operation, which requires the model to meet strict assumptions, resulting in a large model setting error. For example, when the true distribution is not a normal distribution, inferences made under the premise of a normal distribution may be biased. Therefore, scholars [61–64] have proposed nonparametric models that do not make any assumptions about the relationship between economic variables. In practice, a non-parametric model converges slower than its parametric counterpart. In contrast to parametric and nonparametric models, semiparametric models retain the advantages of both models and also reduce the effects of disadvantages, such as the parametric setting error caused by the linear model hypothesis. Moreover, semiparametric models have a similar convergence speed as parametric models. Wu et al. [38] constructed a semiparametric spatial lag model to analyze the nonlinear relationship between economic development and air pollution. Their findings reveal that the semiparametric spatial model works better than a parametric model in terms of the goodness of fit, as it can effectively elaborate the nonlinear relationship. In view of this, we construct a semiparametric SDM, by combining a semiparametric model with the SDM, in order to further capture the nonlinear relationship between local government debt and economic growth. The semi-parametric SDM is defined as follows:

$$gdpgrowth_{it} = \alpha_i + \rho Wgdpgrowth_{it} + \beta_1 X_{it} + \theta_1 WX_{it} + G(lndebt_{it}) + \mu_{it} \tag{5}$$

where $G(\cdot)$ represents the unknown nonlinear function, representing the possible nonlinear relationship between local government debt and regional economic growth. μ_{it} denotes an independent random variable whose mean is 0 and variance is 1.

3.4. Parameter Estimation for the Semiparametric Spatial Durbin Model

In this study, we followed the parameter estimation method of a semiparametric spatial lag model constructed by Wu et al. [38]. The parameters of the semiparametric SDM ρ, β_1, θ_1, and the nonlinear function $G(\cdot)$, can be estimated as follows:

First, assume that the parameters are known, and are available from Equation (5):

First, assume that the parameters ρ, β_1, and θ_1 are known, computing the conditional expectation of each term under the nonparametric term, the function $G(\cdot)$ can be obtained from Equation (6):

$$\begin{aligned} G(lndebt_{it}) = {} & E(gdpgrowth_{it}|lndebt_{it}) - \alpha_i - \rho E(Wgdpgrowth_{it}|lndebt_{it}) - \beta_1 E(X_{it}|lndebt_{it}) \\ & - \beta_2 E(WX_{it}|lndebt_{it}) \end{aligned} \tag{6}$$

Then, obtain a preliminary estimate of the nonlinear function $G(\cdot)$:

$$\begin{aligned} \widehat{G}(lndebt_{it}) = {} & \widehat{E}(gdpgrowth_{it}|lndebt_{it}) - \alpha_i - \rho\widehat{E}(Wgdpgrowth_{it}|lndebt_{it}) - \beta_1\widehat{E}(X_{it}|lndebt_{it}) \\ & - \beta_2\widehat{E}(WX_{it}|lndebt_{it}) \end{aligned} \tag{7}$$

The nonlinear function in Equation (7) is replaced with the above preliminary estimate to obtain a model where the α_i term is eliminated:

$$\begin{aligned} gdpgrowth_{it} - \widehat{E}(gdpgrowth_{it}|lndebt_{it}) = {} & \rho\Big[Wgdpgrowth_{it} - \widehat{E}(Wgdpgrowth_{it}|lndebt_{it})\Big] + \\ & \beta_1\Big[X_{it} - \widehat{E}(X_{it}|lndebt_{it})\Big] - \beta_2\Big[WX_{it} - \widehat{E}(WX_{it}|lndebt_{it})\Big] + \mu_{it} \end{aligned} \tag{8}$$

By reusing tool variable estimation to obtain the estimated values $\widehat{\rho}$, $\widehat{\beta}_1$, and $\widehat{\theta}_1$ of the parameters ρ, β_1, and θ_1, known by $E[G(lndebt_{it})] = 0$, obtain the estimated result of α_i:

$$\alpha_i = E(gdpgrowth_{it}) - \widehat{\rho}E(Wgdpgrowth_{it}) - \widehat{\beta}_1 E(X_{it}) - \widehat{\beta}_2 E(X_{it}) \tag{9}$$

Then, using the local linear estimation method to estimate $\widehat{E}(gdpgrowth_{it}|lndebt_{it})$, $\widehat{E}(Wgdpgrowth_{it}|lndebt_{it})$, $\widehat{E}(X_{it}|lndebt_{it})$, and $\widehat{E}(WX_{it}|lndebt_{it})$, the function $\widehat{G}(lndebt_{it})$ and first-order partial derivative function $\frac{\partial\widehat{G}(\cdot)}{\partial lndebt_{it}}$ are also available.

We can use the first-order partial derivative function $\frac{\partial\widehat{G}(\cdot)}{\partial lndebt_{it}}$ of the semiparametric SDM to draw a partial-derivative relationship diagram, which can reflect the nonlinear effects of local government debt on regional economic growth.

In order to compare the goodness of fit between the parametric and nonparametric models, we select R^2 as our rating indicator for the model goodness of fit. After estimating the parameters $\widehat{\rho}$, $\widehat{\beta}_1$, and $\widehat{\theta}_1$, the random variable μ_{it} can be obtained from Equation (10). Then, finally, R^2 can be obtained from Equation (11):

$$\mu_{it} = gdpgrowth_{it} - \widehat{\alpha}_i - \widehat{\rho}Wgdpgrowth_{it} - \widehat{\beta}_1 X_{it} - \widehat{\theta}_1 WX_{it} - \widehat{G}(lndebt_{it}) \tag{10}$$

$$R^2 = 1 - \mu_{it}^2/(gdpgrowth - mean(gdpgrowth))^2 \tag{11}$$

where *mean* (*gdpgrowth*) represents the mean of gdpgrowth.

Currently, scholars and practitioners do not have access to generalized software packages for the implementation of the semiparametric spatial econometric model. Consequently, in this study, we use the MATLAB (R2016a) and R (3.5.3) software programming languages to develop the semiparametric model.

3.5. Construction of Spatial Weight Matrices

Whether or not the spatial weight matrix can be correctly set will significantly affect the reliability of the spatial econometric model. In previous research, scholars [42–47] often used the spatial distance or the spatial neighbor relationship to construct the spatial weight matrix. However, in fact, economic linkages between regions also have a significant impact on the spatial effect. Consequently, in this paper, we construct two kinds of spatial weight matrices to analyze the spatial effect, namely, a geographic distance and an economic distance matrix.

We use the inverse of the square of the geographic distance between two regions to construct the geographic distance spatial weight matrix. The matrix is defined as follows:

$$W_G = \begin{cases} \frac{1}{d_{ij}^2} & i \neq j \\ 0 & i = j \end{cases} \tag{12}$$

where d_{ij}^2 represents the geographic distance between province i and province j.

We use the difference in per capita GDP between two provinces to construct the economic distance spatial weight matrix. The matrix is defined as follows:

$$\omega_{ij} = \begin{cases} \frac{1}{\left|\overline{Y}_i - \overline{Y}_j\right|} & i \neq j \\ 0 & i = j \end{cases} \tag{13}$$

where $\overline{Y}_i$ and $\overline{Y}_j$ represent the per capita GDP in province i and province j.

4. Empirical Results

4.1. Descriptive Statistics

Prior to analyzing the nonlinear relationship between local government debt and regional economic growth, we carried out a descriptive statistical analysis of variables. The results are shown in Table 1.

Table 1. The descriptive statistics for the dependent variable and all control of variables.

Variables	Mean	S.D.	Maxim	Minim
GDPGROWTH	0.112	0.069	0.270	−0.230
LNDEBT	−0.098	0.286	1.210	−1.587
LNPERGDP	1.087	0.583	2.073	−1.578
TRADE	0.295	0.337	1.520	0.030
FDI	0.021	0.018	0.090	0.001
LNGOVERNMENT	−0.018	0.277	2.096	−2.071

4.2. Spatial Agglomeration Characteristics of Regional Economic Growth

Exploratory spatial data analysis (ESDA) is a crucial step in spatial modeling. It basically focuses on the spatial features of data [64]. There are two main types of ESDA, namely global statistics and local statistics. The former is mainly used to explore the distribution characteristics of the data in a region, while the latter is mainly used to independently analyze information in the sub-areas to investigate whether the change of regional information is smooth or if there is a mutation [65]. To identify spatial regimes of regional economic growth, we use global statistics (Moran's Index, Getis-Ord General G) and local statistics (Moran scatterplot, Local Indicator of Spatial Association (LISA) map) to detect the spatial properties of the data. We also use the GeoDa (1.47) spatial measurement software to perform an overall spatial autocorrelation analysis of 30 provinces in China. The overall Moran's Index value, probability *p*-value, and Z-value reflecting the level of the spatial relationship of regional economic growth from 2010 to 2017 are calculated (see Table 2 and Figure 2).

Table 2. The overall Moran's Index of regional economic growth.

	2010	2011	2012	2013	2014	2015	2016	2017
Moran's I	0.1389	0.1757	0.1223	0.1637	0.2504	0.2341	0.2828	0.2401
Z	1.9458	2.9438	1.9883	1.8809	2.7041	2.5495	1.6130	2.6478
P	0.012	0.005	0.015	0.025	0.006	0.003	0.045	0.008

From Table 2, it can be seen that there is a significant upward trend for the overall Moran's Index test during the study period (i.e., 2010 to 2017). The peak value (0.2828) is recorded in 2016, while the minimum value (0.1223) is recorded in 2012. As can be seen from Table 2, the Z-value, which reflects the degree of significance, is greater than 1.6130 and reaches the maximum value of 2.9438 in 2011. The *p*-value is less than 0.05, and the data, therefore, pass the spatial significance test, falling within the 5% significance level.

This shows that the level of regional economic growth in the 30 studied Chinese provinces can produce spatial agglomeration effects, indicating a significant positive correlation between adjacent areas. The results suggest that areas with the same level of regional economic development are more likely to be located close to one another due to the existence of a spatial spillover effect or spatial expansion among regions.

The overall Moran's Index shows an upward trend from 2010 to 2017. This indicates that the spatial correlation of regional economic development increased gradually over the period (i.e., the spatial agglomeration effect gradually increased) due to the differences in development around regional economies. Importantly, these differences in development create difference supply and demand, which in turn affect the intensity of agglomeration of the development level of the regional economies.

At this stage, we employed Global G statistics (Getis-Ord General G) to analyze the distribution of high and low levels of regional economic growth. The hypothesis of the Global G statistic is that there is no spatial agglomeration of high or low regional economic growth in 30 provinces in China (including autonomous regions and municipalities). Here, the Global G statistic only processes positive value data, which is suitable for calculation using the spatial weight matrix defined by a fixed distance. We use the ArcGIS (10.2) software to calculate the Global G statistic by selecting a fixed distance and making the number of adjacent neighborhoods not less than 3. The results are as follows.

From Table 3, it can be seen that the difference between the observed value of the Global G statistic and the expected value of Global G statistic is small, and the *p*-value is less than 0.05. Therefore, we cannot reject the hypothesis. This empirical finding is consistent with Moran's I statistical results. In terms of change over time, the Global G statistic shows an upward trend from 2010 to 2017, indicating that the spatial agglomeration of regional economic development increased gradually over this period.

Table 3. The Global G statistical results.

	2010	2011	2012	2013	2014	2015	2016	2017
Observed Value	0.15	0.22	0.21	0.25	0.30	0.33	0.39	0.41
Expected Value	0.12	0.18	0.19	0.21	0.23	0.25	0.29	0.35
Z	2.42	2.35	2.75	3.01	2.25	2.85	3.05	3.10
p	0.02	0.03	0	0	0.04	0	0	0

In this paper, we use both the overall Moran's Index and Getis-Ord General G to calculate the spatial dependence and agglomeration effect of regional economic growth in the 30 provinces. However, these methods cannot determine the degree of spatial correlation between each province and its surrounding provinces. It is clear from the empirical analysis that considerable differences exist between adjacent provinces. Therefore, it is prudent to examine the spatial correlation among provinces. To do this, we select three years (2010, 2013, and 2017) to analyze on the basis of the principle of the average distribution of the regional economic development level. We use the local Moran's Index to analyze the spatial correlation of the economic growth of the 30 provinces in 2010, 2013, and 2017, and estimate the heterogeneity and homogeneity of the provinces' economic growth in space (see Figures 3–5).

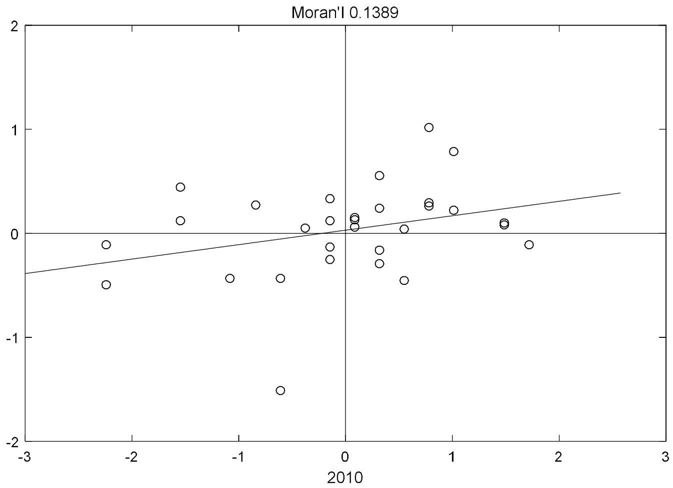

Figure 3. Local Moran's I scatter plot in 2010.

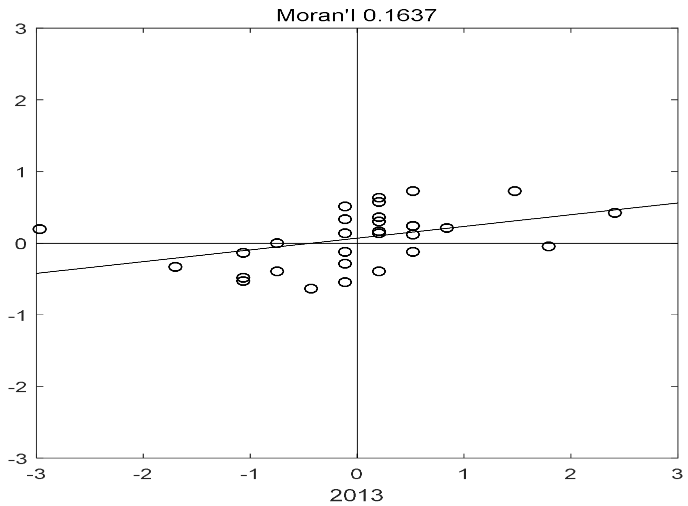

Figure 4. Local Moran's I scatter plot in 2013.

As can be seen in Figures 3–5, most points fall in the first quadrant, followed by the third, fourth and second quadrants, in order of abundance. The points present three kinds of agglomeration: high economic growth-high economic growth, low economic growth-high economic growth, and low economic growth-low economic growth. From the figures, it can be seen that the data for only a few provinces fall in the fourth quadrant, which represents high-low agglomeration. A large number of points fall in the first and third quadrants, which indicates that there is a significant positive spatial correlation in regional economic growth. This is mainly due to the fact that the different levels of regional economic growth have a negative impact on neighboring provinces. From 2010 to 2013, both the spatial patterns of regional economic growth and the intensity of the spatial correlation of some provinces changed. Indeed, the number of provinces in the high-high agglomeration mode and the low-low agglomeration mode both increased by 1, while the number of provinces in the low-high agglomeration mode and the high-low agglomeration mode both decreased by 1. Additionally, from 2013 to 2017, the number of provinces in the high-high and high-low agglomeration modes decreased by 2, the number of provinces in the low-high agglomeration mode increased by 2, and the number of provinces in the low-low agglomeration mode remained unchanged.

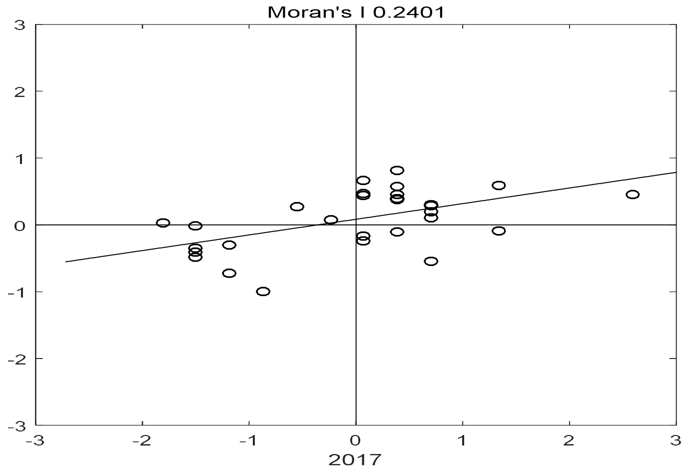

Figure 5. Local Moran's I scatter plot in 2017.

A cursory examination of the scatter plots in Figures 3–5 reveals that there are four correlative models among the 30 provinces. However, the spatial correlation analysis cannot explain spatial heterogeneity. Previous studies have shown that economic growth often presents spatial heterogeneity, which affects the definition and identification of spatial regimes [65]. Consequently, in this study, we employ the GeoDa software and draw LISA agglomeration maps for 2010, 2013, and 2017 to display the spatial heterogeneity of the economic development of the 30 provinces (see Figures 6–8).

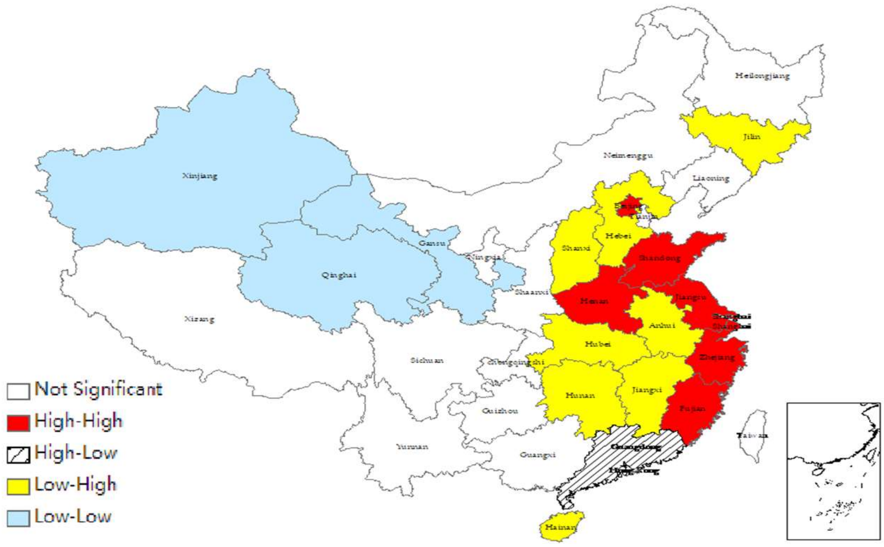

Figure 6. The aggregation graph in 2010 of the regional economic growth.

Figure 6 shows that the spatial correlation model of regional economic growth in 2010 mainly involves high-high, low-high, and low-low modes, and the provinces with high-high agglomeration are mainly located in Central and Eastern China. The Central region includes Henan Province, and the Eastern region includes the Beijing, Shandong, Jiangsu, Shanghai, Zhejiang, and Fujian provinces. The provinces with low-high concentration are located in Central China, such as the Jilin, Hebei, and Shanxi provinces. The low-low agglomeration pattern is located in Western China, which mainly includes the Xinjiang, Qinghai, and Gansu provinces. In 2013, Hebei Province, in Eastern China, joined the high-high agglomeration area, and the Heilongjiang and Jilin provinces in Northeast China, joined the low-low agglomeration area. This shows that the economic growth of Hebei provinces is higher than that of neighboring provinces, and the gap is gradually decreasing, while the economic growth of the Heilongjiang and Jilin provinces are lower than that of neighboring provinces, and the gap is gradually increasing. In 2016, the Anhui, Jiangxi, Hubei, Guizhou, and Hainan provinces joined the high-high agglomeration area, since their economic growth was higher than that of the surrounding provinces, while Inner Mongolia entered the low-low agglomeration area, and the Sichuan, Yunnan, Jilin, and Heilongjiang provinces joined the low-high agglomeration area. In 2016, the spatial correlation between the economic growth of the Chongqing municipality and that of the surrounding provinces was negative, which reflects the spatial heterogeneity of economic growth.

Figure 7. The aggregation graph in 2013 of the regional economic growth.

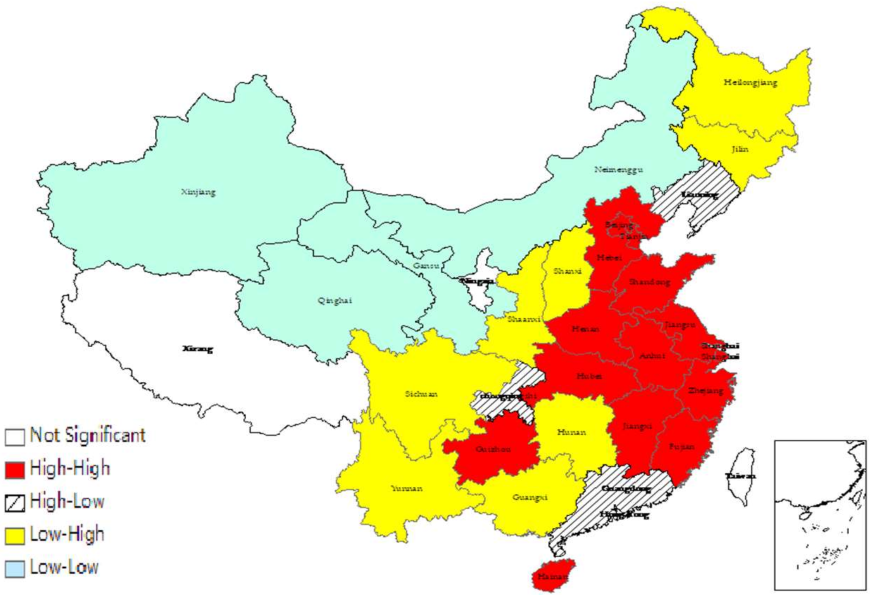

Figure 8. The aggregation graph in 2017 of the regional economic growth.

4.3. Estimation Results of the Linear Spatial Durbin Model

In this study, we use the Moran's I test to test the spatial effect of the panel data, which illustrates the rationality of using the spatial econometric model for empirical analysis. Additionally, we use spatial econometric models to analyze the economic data, including an SDM, an SLM and an SEM. In order to select an appropriate spatial econometric model, we use the Wald and likelihood ratio (LR) tests to select a model. The test results show that the Wald and LR statistics (Wald = 38.9656, $p < 0.01$; LR = 36.4871, $p < 0.01$) are significant at the 1% significance level. This result suggests that the SDM is more suitable than the SLM and SEM. The results of the Hausman test show that the p-value of the SDM is less than 0.01 (Hausman = 49.3001; $p < 0.01$), that is, the null hypothesis of random effect is rejected. Consequently, we report only the empirical result of the fixed effect model. We use the MATLAB software to explore the relationship between local government debt and regional economic growth from 2010 to 2017. Tables 4 and 5 present the results of the parameter estimation of the SDM for the two kinds of spatial weight matrices.

Table 4 presents the results of the parameter estimation. For the spatial dimension, the spatial lag coefficient passes the 10% significance level. This demonstrates that research on regional economic growth cannot ignore the spatial effect. However, the important influence of the spatial effect on regional economic growth is often neglected in the existing literature. For the local government debt variable, our empirical result shows that the local government debt has a positive coefficient, but is not statistically significant (*LNDEBT* = 0.0279, $p > 0.1$; *LNDEBT* = 0.0281, $p > 0.1$). This finding indicates that the relationship between local government debt and regional economic growth is not linear. Therefore, the linear relationship cannot be verified. To further analyze and verify the hypothesis of the nonlinear relationship between local government debt and regional economic growth proposed in the previous theoretical analysis, it is necessary to add a quadratic term of the local government debt variable to the SDM (see Table 5).

Table 4. The estimation results of the linear Spatial Durbin Model.

	Geographic Distance Matrix W_G		**Economic Distance Matrix W_E**	
	β	W_x	β	W_x
LNDEBT	0.0279 (1.1506)	−0.0345 (−0.6031)	0.0281 (1.1437)	−0.0501 (−0.8674)
LNPERGDP	−0.0573 *** (6.6449)	0.0496 ** (1.9989)	−0.0541 *** (6.2150)	0.036 (1.4571)
TRADE	0.0237 ** (2.0171)	−0.0893 * (−1.8880)	0.0163 (0.6873)	−0.0883 (−1.8358)
FDI	0.4026 (1.0935)	1.7028 ** (2.3806)	0.2339 *** (2.6329)	1.4609 ** (2.0227)
LNGOVERNMENT	0.3984 *** (4.6614)	0.6235 *** (2.9104)	0.3674 *** (4.2523)	0.5519 *** (2.5407)
ρ		0.2744 *** (3.0025)		0.1520 ** (2.4774)
R^2	0.3827		0.3754	
N	240		240	

Note: *, **, *** significant at the 10%, 5%, 1% levels, respectively. Data in parentheses are t statistics.

From the above parameter estimation result (see Table 5), it can be seen that the primary term coefficient of local government debt is significant (*LNDEBT* = 0.2034, $0.05 < p < 0.1$; *LNDEBT* = 0.2117, $0.05 < p < 0.1$), while the quadratic coefficient of local government debt is not statistically significant (*LNDEBT2* = −0.1489, $p > 0.1$; *LNDEBT 2* = −0.1539, $p > 0.1$). This demonstrates that there is no quadratic relationship between local government debt and economic growth. The empirical results show that the relationship between local government debt and regional economic growth does not conform to the inverted U-shaped relationship. This finding is significantly different from the prevailing research conclusions [28–33,66,67]. Therefore, it is necessary to use a semiparametric model to analyze the nonlinear relationship, or the wave-shaped relationship between local government debt and regional economic growth. Table 6 presents the estimation results of the three models.

Table 5. The estimation results of the nonlinear Spatial Durbin Model.

	Geographic Distance Matrix W_G		**Economic Distance Matrix W_E**	
	β	W_x	β	W_x
LNDEBT	0.2034 *	−0.0892	0.2117 *	−0.1028
	(1.6944)	(−0.2980)	(1.7590)	(−0.3417)
LNDEBT2	−0.1489	0.0451	−0.1539	0.0946
	(−1.1144)	(0.2538)	(−1.1797)	(0.8555)
LNPERGDP	−0.0554 ***	0.0743 *** (3.0608)	−0.0558 ***	0.0762 ***
	(−6.1946)		(−6.2032)	(3.0926)
TRADE	0.0031	−0.0503	0.0009	−0.0448
	(0.1299)	(−1.1797)	(0.0385)	(−1.0501)
FDI	0.6022 *	1.6573 *	0.5946 *	1.7687 **
	(1.6206)	(1.8854)	(1.5883)	(1.9938)
LNGOVERNMENT	0.2854 ***	0.2683	0.2838 ***	0.2874
	(3.2860)	(1.3393)	(3.2546)	(1.4137)
ρ		0.1399 **		0.0946 *
		(2.4532)		(1.8555)
R^2	0.3636		0.3605	
N	240		240	

Note: *, **, *** significant at the 10%, 5%, 1% levels, respectively. Data in parentheses are *t* statistics.

Table 6. The estimation results of the three kinds of model.

	Basic Regression Model	**SE-SDM (W_G)**		**SE-SDM (W_E)**	
		β	W_x	β	W_x
α	0.7224 ***				
	(7.4528)				
LNDEBT	−0.0689 ***				
	(−3.2573)				
LNPERGDP	−0.0475 ***	−0.0639 ***	0.0551 ***	−0.0619 ***	0.0748 **
	(−5.6975)	(−6.1327)	(11.9609)	(−6.4057)	(−14.0406)
TRADE	0.0329 **	0.023565	−0.0831 **	0.0104	−0.0481 ***
	(2.2975)	(0.8807)	(−8.8687)		
FDI	0.9700 ***	−0.4891	1.9324 **	−0.2967	1.5236 *** (2.0568)
	(3.3495)	(−0.6420)	(2.1249)		
LNGOVERNMENT	0.1721 ***	0.3969 ***	0.5878 ***	0.2944 ***	0.2874 ***
	(3.2825)	(4.4124)	(2.7049)		
ρ			0.4715 ***		0.0417 ***
			(2.7393)		(2.9138)
R^2	0.1878	0.9628		0.9686	
N	240	240		240	

Note: *, **, *** significant at the 10%, 5%, 1% levels, respectively. Data in parentheses are *t* statistics.

The results in Table 6 demonstrate that the R^2 values of the semiparametric SDM are significantly higher than that of the basic regression model. This suggests that the semiparametric SDM can give an accurate estimation of the variables. We now focus on the results of the semiparametric SDM. From the spatial effect coefficient ρ, under the influence of social and economic activities, the regional economic growth is closely related to the regional economic growth of the adjacent regions, which is consistent with the results of the Moran's I test (I > 0.1223, $p < 0.05$). The current research focuses on the nonlinear effect of local government debt on regional economic growth. One of the advantages of the semiparametric model is its ability to compute the partial derivatives of a non-parametric function

$G(\cdot)$, which can more intuitively reflect the nonlinear relationship between local government debt and regional economic growth.

In order to improve the robustness of the results, we also examine the nonlinear relationship between local government debt and regional economic growth using the two spatial weight matrices. Figures 9 and 10 present the results of the examination. The abscissa values are the per capita local government debt (*lndebt*) and the ordinate values are the marginal utility of local government debt on regional economic growth($\partial\widehat{G}(\cdot)/\partial lndebt_{it}$).

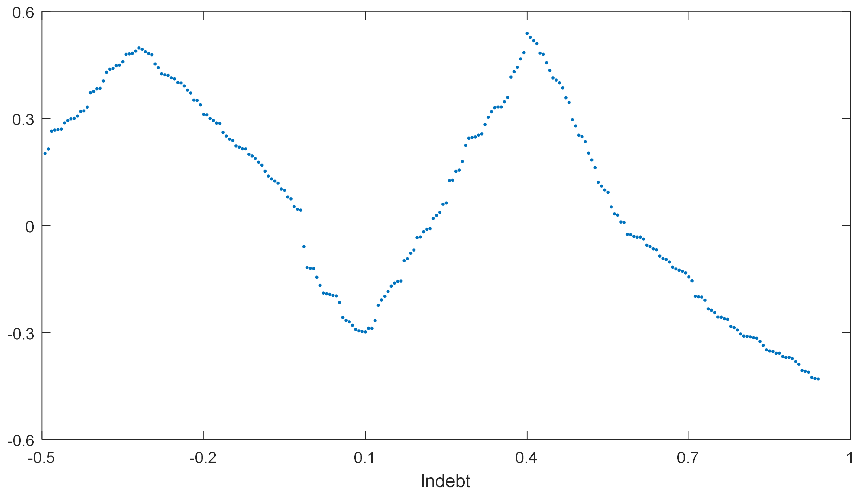

Figure 9. The derivative map of per capita local government debt to economic growth under the W_G spatial weight matrix.

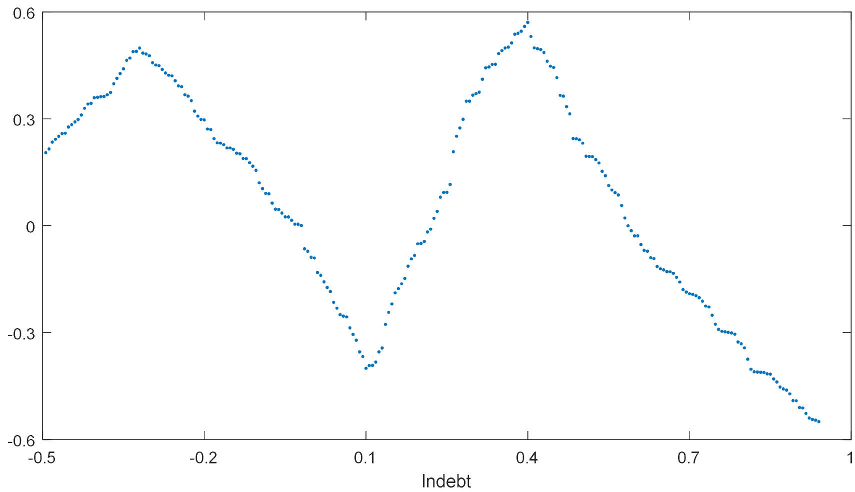

Figure 10. The derivative map of per capita local government debt to economic growth under the W_E spatial weight matrix.

Figures 9 and 10 highlight the trend of a derivative map of per capita local government debt to economic growth under the W_E spatial weight matrix. The results clearly demonstrate that the derivative maps remain basically the same between Figures 9 and 10. In Figure 9, the marginal impact of per capita local government debt on regional economic growth presents a shock-wave shape, which does not fully comply with the inverted U-shape found in previous studies; thus, this provides support for hypothesis 1. It is likely that the inverted U-shaped relationship is part of the wave-shaped relationship. However, the limitations of the model selection mean that it was not possible to fully verify the characteristics of the wave-shaped relationship in the existing literature. The wave-shaped relationship may be attributed to a dual effect of local government debt on regional economic growth. First, when local government debt is relatively low, local authorities invest borrowed funds in long-term development projects such as urban infrastructure, education, and health care, as well as short-term economic development projects which, in turn, stimulate regional economic growth in the short-term. On the other hand, when local government debt exceeds the optimal level, the cost of local government debt becomes relatively high, which in turn increases the financial pressure on the local government and forces them to reduce public investment. Thus, when the debt reaches a certain level, it has tremendous negative economic repercussions on the respective province.

As shown in Figures 9 and 10, this study shows that when the scale of local government debt increases, there are many extreme and inflection points in the regional economic growth increments, thus providing support for Hypothesis 2. The presence of these points indicates that there may be multiple thresholds for local government debt to promote regional economic growth in China. The optimization of local government debt can achieve regional economic growth.

According to Figures 9 and 10, there are two optimal levels of per capita local government debt in China, namely 10,190 and 19,410 Yuan. For example, the provinces in Southwest China (such as Guizhou and Qinghai) have already reached the second optimal level. However, the provinces in Eastern China (such as Jiangsu and Guangdong) have not yet reached the second optimal level. Additionally, some provinces in Southwest China are experiencing a downward trend in debt-promoting effects. However, in the vast majority of provinces, debt-promoting effects are becoming stronger. This means that local government debt can still be optimized to promote economic growth.

Concerning the control variables in our models, the established relationships are consistent with the literature. In the three models, the coefficient of the per capita GDP is negatively significant, which indicates that there is economic convergence in China. The per capita local government fiscal expenditure variables are also significantly positive, which is similar to the findings of Chen and Wang [55]. Conversely, other variables such as trade openness (TRADE) and foreign direct investment (FDI) are found to have no significant impact on regional economic growth.

4.4. The Level of Local Governmental Debts Suppresses Economic Growth

In the theoretical analysis, we propose that when local government debt exceeds a certain level, local government debt may crowd out private investment and reduce public expenditure. In order to verify the above theoretical hypothesis, we conducted an empirical analysis. Table 7 presents the empirical results.

Table 7. The results of local government debt on private investment and public expenditure.

Variables	Private Investment Rate (PIR)	Public Expenditure (PE)
LNDEBT	0.2727 * (1.76)	0.5848 * (1.98)
LNDEBT2	−0.0144 ** (−2.08)	−0.0304 ** (−2.35)
LNPERGDP	1.2601 (0.89)	0.5705 (0.12)
TRADE	0.3120 (0.47)	0.0322 (1.05)
FDI	0.0070 (0.01)	0.0270 (0.79)
CONSTANT	1.2914 ** (2.65)	2.8561 * (2.10)
R^2	0.4428	0.5142
N	240	240

Note: *, **, *** significant at the 10%, 5%, 1% levels, respectively. Data in parentheses are *t* statistics.

Table 7 presents the empirical results of the analysis of the effect of local government debt on private investment and public expenditure. From the table, it can be seen that the local government debt term is positive and significant for both private investments and public expenditure. In the two models, the quadratic term coefficient of local government debt is negative and significant. Therefore, the impact of government debt on private investments and public expenditure has an inverted U-shape, which means that when local government debt exceeds optimal sizes ($LNDEBT = 9.47$, $LNDEBT = 9.77$), it will crowd out private investments and reduce local government public expenditure.

5. Conclusions and Implications

The management of local government debt is regarded as a key driver of economic growth and sustainability. Most economies have benefited from debt, which is one of the sources of financing capital formation to advance infrastructure development, education, and health-care, among other sectors. However, the poor management of local government debt can be an inhibiting factor for economic growth. Few studies have investigated the nonlinear relationship between local government debt and regional economic growth using a semiparametric spatial model. In this study, we constructed a semiparametric spatial model to analyze the relationship between local government debt and regional economic growth in 30 provinces of China. Specifically, we first explored the kinds of spatial effects that exist in regional economic growth. Second, we examined the characteristics of the nonlinear relationship between local government debt and regional economic growth. Third, we investigated the optimal level of local government debt to promote regional economic growth. Finally, we examined the level of local government debt that suppresses regional economic growth. Our findings extend the literature on the relationship between government debt and economic growth in several ways: First, the study finds that the spatial agglomeration effect has a significant overall influence on regional economic growth. Our empirical results demonstrate that the level of regional economic growth of 30 provinces in China can produce a spatial agglomeration effect, indicating a significant positive correlation. The study suggests that areas with the same level of regional economic development are more likely to be agglomerated (i.e., to be spatially close to one another) due to the existence of a spatial spillover effect or spatial expansion among regions. Additionally, regarding temporal trends, the overall Moran's Index shows an upward trend from 2010 to 2017. This indicates that the spatial correlation of regional economic development increased gradually over the study period (i.e., the spatial agglomeration effect gradually increased) due to differences in the development of regional economies. Notably, this created differences in supply and demand which affect the agglomeration intensity of the development level of the regional economies.

Second, we combined a spatial econometric model and a semiparametric model to construct a new semiparametric spatial Durbin model in order to examine the characteristics of the nonlinear relationship between local government debt and regional economic growth. Our empirical results demonstrate that there is a "wave-shaped" relationship between local government debt and regional economic growth. This finding differs from the inverted U-shaped relationship that is documented in the literature [26–31,66,67]. However, the wave-shaped relationship is also in line with the existence of a nonlinear relationship between local government debt and regional economic growth, and the inverted U-shaped relationship is part of the wave-shaped relationship. Furthermore, the results of the statistical tests illustrate that the goodness of fit of the semiparametric spatial Durbin model is higher than that of both the panel regression model and the spatial Durbin model. The nonlinear relationship between the key variables obtained from the semiparametric spatial Durbin model supports the existence of a nonlinear relationship between local government debt and economic growth that is suggested in the literature. Therefore, this study expands on the existing literature.

Third, based on the empirical results of the semiparametric spatial Durbin model, we determined two optimal levels of local government debt for the 30 provinces in China, namely 10,190 and 19,410 Yuan. In the eastern and central provinces, the current per capita local government debt has not yet reached the second optimal level (19,410 Yuan). This suggests that there is room for continuous investment, which will, in turn, promote economic growth. However, in some western provinces, such as the Guizhou Province, the per capita local government debt has already reached the second optimal level; it is therefore not suitable to continue large-scale borrowing and investing in these provinces, as this could negatively affect economic growth.

Finally, based on the empirical results, it was found that the relationship between local government debt and private investment and public expenditure has an inverted U-shape, which means that when local government debt is low, private investments and public expenditure are facilitated. Conversely, when local government debt is relatively high, private investments will be crowded out and public expenditure will be reduced.

The results of this paper allow the following advice to be offered to local government authorities and policymakers: (1) the spatial correlation of regional economic growth makes it necessary to strengthen economic cooperation among regions, which means that the development of inter-regional collaborative economic activities should be encouraged. From a macroscopic perspective, we encourage the government to treat the spatial linkage of regional economic development as an important decision variable in policy formulation; (2) due to the wave-shaped relationship between local government debt and regional economic growth, multiple optimal values of local government debt can promote regional economic growth. The central government should appropriately allocate local government debt resources to maximize the overall economic growth; (3) with the increase in economic competition among local governments, sustainable economic development will become more challenging. For example, in order to attain a political promotion, some local government officials may invest in infrastructure and other projects regardless of local financial constraints. Although such investments can develop the economy rapidly in the short-term, they can damage the economic development process in the long-run. Therefore, the central government should assess local government officials using multiple criteria (e.g., economic development, debt sustainability, and public service).

There are several limitations to this study. First, our results are based on provincial data from China. However, the resolution of provincial data is slightly coarse compared with municipal or county-level data. We encourage future researchers to expand the scope of this research by concentrating on local government debt data at the municipal or county level. Another limitation of this study is that it assumes the per capita local government debt to be the only factor affecting regional economic growth. The study fails to consider other debt indicators that may have an impact on regional economic growth. In future studies, other variables should be considered more comprehensively in order to further elucidate the nonlinear relationship between local government debt and regional economic growth.

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