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Impact of China's Provincial Government Debt on Economic Growth and Sustainable Development

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Abstract: Macroeconomic stability is the core concept of sustainable development. However, the coronavirus disease (COVID-19) pandemic has caused government debt problems worldwide. In this context, it is of practical significance to study the impact of government debt on economic growth and fluctuations. Based on panel data of 30 provinces in China from 2012 to 2019, we used the Mann–Kendall method and Kernel Density estimation to analyze the temporal and spatial evolution of China's provincial government debt ratio and adopted a panel model and HP filtering method to study the impact of provincial government debt on economic growth and fluctuation. Our findings indicate that, during the sample period, China's provincial government debt promoted economic growth and the regression coefficient (0.024) was significant. From different regional perspectives, the promotion effect of the central region (0.027) is higher than that of the eastern (0.020) and western regions (0.023). There is a nonlinear relationship between China's provincial government debt and economic growth, showing an inverted "U-shaped" curve. Fluctuations in government debt aggravate economic volatility, with a coefficient of 0.009; tax burden fluctuation and population growth rate aggravate economic changes. In contrast, the optimization of the province's industrial structure and the improvement of the opening level of provinces slow down economic fluctuations.

Keywords: local government debt; economic growth; economic fluctuation; sustainable debt management; COVID-19

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1. Introduction

The coronavirus disease (COVID-19) pandemic has extensively impacted the economy of countries worldwide, leading to prominent government debt problems [1]. According to estimates by the Congressional Budget Office (CBO) of the United States (US), because of the pandemic, the US federal government debt ratio rose to 126% in 2020 and continues to rapidly rise (Date sources: https://www.cbo.gov/publication/57635, Washington, DC, U.S. accessed on: 31 August 2021) [2]. Furthermore, the data released by China's National Bureau of Statistics suggest that China's government debt balance in 2020 was 46.55 trillion yuan, and that the government debt ratio was 45.82%. As of the end of December 2020, the national local government debt balance was 25.66 trillion yuan—a year-on-year increase of 20.44%—but the issue of sustainability of local government debt is very urgent (Date sources: http://www.gov.cn/xinwen/2021-01/26/content_5582612.htm Beijing, China. accessed on: 31 August 2021). In recent years, the scale of local government debt in China has shown a trend of continuous expansion, which has had a profound impact on macroeconomic stability and fiscal sustainability [3–5]. The local government debt has a positive impact on promoting investment and enhancing the vitality of the local economy [6–8]. Furthermore, China's economy has been seriously affected by COVID-19. In order to quickly restore the social and economic order, China implemented economic stimulus policies by issuing government bonds and other forms of financing. The phenomenon of rapid increase in government debt risks has begun to frequently occur throughout the

country, which has aroused panic among the people and caused widespread concern in society [9].

Since the post-Keynesian era, government debt and GDP, as well as the relationship and fluctuations between them, are important components of macroeconomic theories [10,11]. There have been endless debates among various schools of thought about whether government debt expansion can effectively promote economic growth in the long term [12,13]. Some scholars believe that government borrowing will weaken its ability to formulate relevant countercyclical policies in response to economic crises, which will cause the government to do nothing in the face of economic fluctuations, thereby affecting the stability of the entire economy and society [14,15]. Furthermore, scholars have proposed that, when government issues additional public bonds and implements fiscal deficit policies, it can effectively expand domestic demand and promote regional economic development [16–18]. In addition, others have demonstrated that the effects of raising debts and levying taxes on finance are the same, and that the behavior of local governments raising debt will not affect social resources, investment, labor supply, and other factors, which proves the neutrality of debt [19–22].

Evaluating relevant research conducted from an empirical perspective, we found that empirical results were very different owing to the different theories and data referred to in discussions concerning these matters. On the one hand, some scholars used the panel regression of a time series to draw the conclusion that government debt promotes economic growth. They mainly studied the debt and economic development of Southeast Asian countries and found that, in most Southeast Asian countries, government debt has an obvious positive effect on economic growth [23]. Others showed that government debt can promote economic development to a certain extent in both the short and long term [24]. On the other hand, some scholars have confirmed that the influence of government debt on economic growth is unfavorable. Cohen [25] proposed using the ratio of government debt to regional GDP to represent the degree of dependence of the local economy on government debt. His research showed a negative correlation between government debt and economic growth. Elmeskov and Sutherland [26] conducted research from a long-term perspective and suggested that excessive government debt would seriously affect public savings. Their research data showed that, for every 1% increase in the total government debt, the total gross domestic product (GDP) of the region under stable output will be reduced by 10%. At the same time, Woo and Kumar [27] pointed out that government debt led to a decrease in investment and labor. Slowdown in productivity growth is the root cause of this phenomenon.

With the enrichment of empirical tools and data sources, many scholars have found that there is a nonlinear relationship between government debt and economic development. Some scholars used empirical research to find that the relationship between government debt and economic growth is "U-shaped" [28]. However, other scholars have different views, such as Checherita-Westphal and Rother (2011) [29], who selected 12 Eurozone countries as their research sample. They found that there is a clear threshold effect between government debt and economic growth, and that the relationship between them is a typical inverted "U-shaped". Many scholars have conducted similar studies correspondingly [30–33], others believe that there is not only a threshold effect between debt and economic growth, but also a more complex relationship [34–36].

For China, China's government debt-to-GDP ratio is lower than that of most large, developed economies [37], and government debt scales have not reached their respective thresholds [38]. However, there is a lack of research on China's provincial government debt. In recent years, China's provincial government debt has risen every year, and the debt ratio of some relatively backward provinces has reached the risk warning point. Many scholars [39–41] used a panel data model to study the relationship between government debt and corporate leverage and found that there is a negative relationship between the two. Some of them [42] used a fixed effects model and panel data from 2006 to 2015 to study the impact of land hoarding and prices on the scale and risk of local government

debt. Subsequently, they found that both the scale and the price of land had a positive impact on the scale and risk of urban investment bonds (UIB). In terms of different regions, only the eastern region showed a significant correlation between land assets and the UIB. Other scholars [43] used economic fluctuations, local debt risks, and bank risk-taking variables to construct an econometric model and found that both economic changes and local government bond risks have a significant positive impact on bank risks and a negative correlation with regional economic growth. The authors of [44] researched China's local government financing platform (LGFV) and found that there is an inverted "U-shaped" relationship between the diversification of LGFV and local economic growth.

Based on sustainable development theory, we used the Mann–Kendall method and Kernel Density estimation to analyze the evolution of China's provincial government debt ratio and adopted a panel model to study the impact of provincial government debt on economic growth and fluctuations. Because of the opaqueness of local hidden debts before the "New Budget Law" was promulgated and implemented, related debts were difficult to obtain. The data of previous studies lacked timeliness and guidance for the implementation of current policies was limited. Therefore, compared with previous studies, our study mainly contributes to the existing literature in several ways. First, we considered provincial government debt as the research object, which could make the research on economically sustainable development more in-depth and specific. Our study explores the sustainability of China's provincial government debt and depicts the temporal and spatial evolution of the provincial government debt ratio from 2009 to 2020. Second, our research overcomes the limitations of the availability of local debt data, updates the research data to the latest, extends the perspective to the impact of local government debt on economic growth and volatility, builds an empirical model to verify them, and analyzes nonlinear relationships and regional differences. Third, we tested other influencing factors and proposed specific suggestions to improve the sustainable economic growth of different regions and provinces.

The remainder of this paper begins with Section 2, which introduces the research concept of this article and includes study ideas, methods, and data. Section 3 presents the trend analysis, provides empirical results and robustness tests, and provides an analysis. Section 4 discusses the empirical results and propose methods for sustainable development under COVID-19. Section 5 includes the conclusions, policy implication and limitations.

2. Study Idea, Method and Research Data

2.1. Study Idea

First, we determined the methods for studying the economically sustainable development of China's provinces, constructed econometric models, and analyzed the variables and data needed for the study.

Second, we used geographic information system (GIS) tools and kernel density estimation to show the dynamic distribution of China's provincial government debt ratio from 2009 to 2020. By using a Mann–Kendall test, we analyzed the trend of China's provincial government debt ratio from 2009 to 2020. In terms of empirical testing, we used econometric methods to determine the impact of provincial government debt on economic growth and fluctuations and analyzed nonlinear relationships and regional differences.

Finally, based on the results of the empirical analysis, we proposed specific policy recommendations for the eastern, central, and western provinces in China and explored research deficiencies and improvement methods.

2.2. Method

2.2.1. Kernel Density Estimation

We used kernel density estimation to describe the evolution trend of China's provincial government debt ratio and analyzed the status quo of sustainable development of government debt in various regions of China.

As a non-parametric method, kernel density estimation has weak model dependence and strong robustness (Mariani and Vaden, 2010) [45]. This has become a common method

for analyzing spatial imbalances. This method usually assumes that the density function of random variable X is:

$$f(x) = \frac{1}{Nh}\sum_{i=1}^{N} K(\frac{X_i - x}{h}) \quad (1)$$

The kernel density function, as a smooth transition function or weighting function, usually satisfies:

$$\begin{cases} \lim\limits_{x\to\infty} K(x) \times x = 0 & \\ K(x) \geq 0 & \int_{-\infty}^{+\infty} K(x)dx = 1 \\ \sup K(x) \prec +\infty & \int_{-\infty}^{+\infty} K^2(x)dx \prec +\infty \end{cases} \quad (2)$$

where N represents the number of observations, X_i represents the independent and identically distributed observations, x represents the average value, k represents the kernel density, and h represents the bandwidth. The larger the bandwidth, the smoother the estimated density function curve and the lower the accuracy of the estimation; in contrast, the smaller the bandwidth, the less smooth is the density function, but the estimation accuracy is higher.

2.2.2. Econometric Methodology

Many scholars have adopted the most cutting-edge models and empirical methods to study the problem of government debt, such as the dynamic debt stabilization game model [46] and Python toolkit [47]. Based on the applicability of our study, following the classic research on government debt [9,11,48,49], we applied a panel data approach to examine the impact of local government debt on economic growth, namely, whether there was a threshold effect and the impact of local government debt on economic volatility, starting at the provincial government level. First, the impact of government debt on economic growth was examined by constructing a panel model, as follows:

$$lnGDP_{i,t} = \beta_0 + \beta_1 lnDebt_{i,t-1} + \Sigma\beta_i Controls_{i,t} + Province_i + Year_t + \varepsilon_{i,t} \quad (3)$$

Second, we used the quadratic curve analysis method to bring the quadratic term of government debt variables into the econometric Model (4), as follows:

$$lnGDP_{i,t} = \beta_0 + \beta_1 lnDebt_{i,t-1} + \beta_2 lnDebt^2{}_{i,t-1} + \Sigma\beta_i Controls_{i,t} + Province_i + Year_t + \varepsilon_{i,t} \quad (4)$$

Finally, the impact of local government debt on economic volatility was studied using the Hodrick–P rescott (HP) filter method to measure economic volatility; accordingly, a panel model was constructed as follows:

$$DGPFlu_{i,t} = \beta_0 + \beta_1 DebtFlu_{i,t-1} + \Sigma\beta_i Control_{i,t} + Province_i + Year_t + \varepsilon_{i,t} \quad (5)$$

where *lnGDP* is the dependent variable that represents the natural logarithm of provincial real GDP and *GDPFlu* is the dependent variable that represents the fluctuating term of the natural logarithm of provincial real GDP. As an independent variable, *lnDebt* is the natural logarithm of provincial government debt size, $lnDebt^2$ is the quadratic term of the natural logarithm of government debt size, and *DebtFlu* is the fluctuating term of the natural logarithm of provincial government size. *Controls* and *ControlsFlu* represent the set of control variables of Models (3) to (5), respectively. $Province_i$ and $Year_t$ are province and year fixed effects, respectively, which help mitigate issues from omitted variable bias. The symbol ε represents the estimated error item; the terms i and t denote the province and time, respectively. In the empirical process, the first-order lag term of the independent variable was used for the regression. The reasons are as follows: (1) The data selected to measure the level of government debt are the balance of government debt at the end of each year, and the balance at the end of the year will generally affect government spending in the second year and have an impact on provinces' GDP. Therefore, the impact of government

debt on economic growth generally has a time lag [50,51]. (2) Using the first-order lag term of the independent variables can alleviate the endogeneity problem to a certain extent.

2.3. Research Data

The specific calculation methods and data sources of the variables are listed in Table 1.

Table 1. Definitions of variables and data sources.

Variable	Definition	Source
lnGDP	Economic growth: ln(province's real GDP)	CSY
GDPFlu	Economic fluctuations: province's GDP fluctuations	Calculation
lnDebt	Government debt: ln(province's government debt)	Wide Database
DebtFlu	Government debt fluctuations: province's government debt fluctuations	Calculation
Urb	Urbanization level: number of province's urban population/total province's population	PSY
Indus	Industrial structure: province's tertiary sector value added/province's GDP	CSY
Pop	Population growth: province's (births-deaths)/total province's annual average	CSY
Open	Opening level of provinces: total imports and exports/province's GDP	PSY
Gov	Public budget expenditure levels: total local general public budget expenditure/province's GDP	PSY
Tax	Level of province's tax liability: total annual province's government tax revenue/province's GDP	Wide Database
Edu	Province's Human capital level: province's average years of education	PSY

Notes: Calculation: calculated by HP filtering method, CSY: China Statistical Yearbook, PSY: Provincial statistical yearbooks of 30 provinces in China. For the data used in this study, the time frame was 2009 to 2020.

(1) Dependent Variables:

Economic growth: *lnGDP*

To eliminate the effect of inflation, 2009 was used as the base period to measure economic growth by calculating the real GDP of each province by taking the natural logarithm of each province's nominal GDP collected for 2009 and the provincial GDP index for the period of 2010 to 2020 [52].

Economic fluctuations: *GDPFlu*

We chose the HP filtering method to deal with economic fluctuations. The HP filtering method approach can separate the trend items in the time series variables in a smooth sequence, so the time series data are divided into two parts: a smooth trend item and a periodic fluctuation item [53].

In data processing, HP filtering is performed on the natural logarithm of actual GDP. The trend item obtained after the HP filtering of the time series of the total output can be used to represent the potential output, the fluctuation item represents the output gap, and the time series of the output gaps can reflect economic changes. The decomposition process is the minimization process of solving Equation (6).

$$\Sigma_0^T (lnGDP_t - lnGDP_t^*) + \lambda \Sigma_0^{T-1} [(lnGDP_{t+1}^* - lnGDP_t^*) - (lnGDP_t^* - lnGDP_{t-1}^*)] \quad (6)$$

In Formula (6), *lnGDP* represents the total output level, and $lnGDP_t$* represents the actual potential output. The decomposed trend item is obtained by calculating the HP filter, which is the actual potential output $lnGDP_t$*. Next, the cyclical fluctuation part of economic growth is obtained by removing the trend item—that is, the output gap ($lnGDP_t$-$lnGDP_t$*). This result can be used to represent the cyclical fluctuation of the *GDPFlu* economy. The smoothing parameter λ in Formula (6) is set to 100, according to the value of regarding the annual data [54].

(2) Independent Variables

Provincial government debt: *lnDebt*

This study used the natural logarithm of the scale of local government debt to measure the level of provincial government debt.

Provincial government debt fluctuations: *DebtFlu*

This study calculated the natural logarithm of the scale of local government debt, performed HP filtering, set the smoothing parameter λ to 100, and considered the volatility term as an indicator to measure the volatility of government debt.

(3) Control Variables

Level of urbanization: *Urb* measures the level of urbanization using the urbanization rate of each province [55]. Industrial structure: *Indus*. This study used the share of the tertiary sector in the province's GDP to measure the degree the industrial sector's sophistication [56]. Population growth: *Pop*; represents a measure of the province's natural population growth rate. Opening level of provinces: *Open*, following [57], is the ratio of total provincial exports and imports to a province's GDP per year, used to measure the degree of a province's openness. Level of financial expenditure: *Gov*, this study used the ratio of province's general public budget expenditure to its GDP to measure the level of local general public budget expenditure [58]. Local general public budget expenditure includes general public services, public security expenditures, local overall social undertakings expenditures, and so on. Level of province's tax liability: *Tax*; in this study, the ratio of provincial government's annual tax revenue to nominal GDP was used to measure the tax burden level in each province. Province's human capital levels: *Edu*. We chose the years of formal education per capita in each province to measure this indicator [59].

The descriptive statistics of the variables are presented in Appendix A. We used Eviews 10.0® and Stata 16.0® for data calculation, statistical analysis, and regression analysis.

3. Empirical Results

We divided China's 30 provinces into three regions: East, Central, and West. Among them, there are 11 provinces in the eastern region: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. The eight provinces in the central region are Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan. Furthermore, the 11 provinces in the western region are Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. Because the sample data volume in Tibet was too small and it was difficult to obtain accurate data, it was not within the scope of the sample selection in this study. In the text, we abbreviated the provincial government debt ratio as the PDR (Provincial government debt ratio: The ratio of the provincial government debt balance at the end of the year to province's GDP of the year. It is an indicator that measures the carrying capacity of the province's economic scale on government debt or the dependence of province's economic growth on government debt. Internationally, the debt ratio of 60% stipulated in the Maastricht Treaty is usually used as the reference value of the government debt risk control standard), and the indicator would be used for robustness testing. We calculated the PDR of 30 provinces from 2009 to 2020, as shown as in Appendix B.

3.1. Dynamic Evolution

3.1.1. Temporal Evolution

We used ArcGIS 10.C S® to draw PDR distribution map. Figure 1A–D show the changing trend of China's PDR in 2009, 2012, 2016, and 2020. It divides the PDR in China's 30 provinces into four categories, from low to high. Notably, the darker the red color, the higher the PDR in that year. The data of the PDR originates from Wind database and manual calculation by authors.

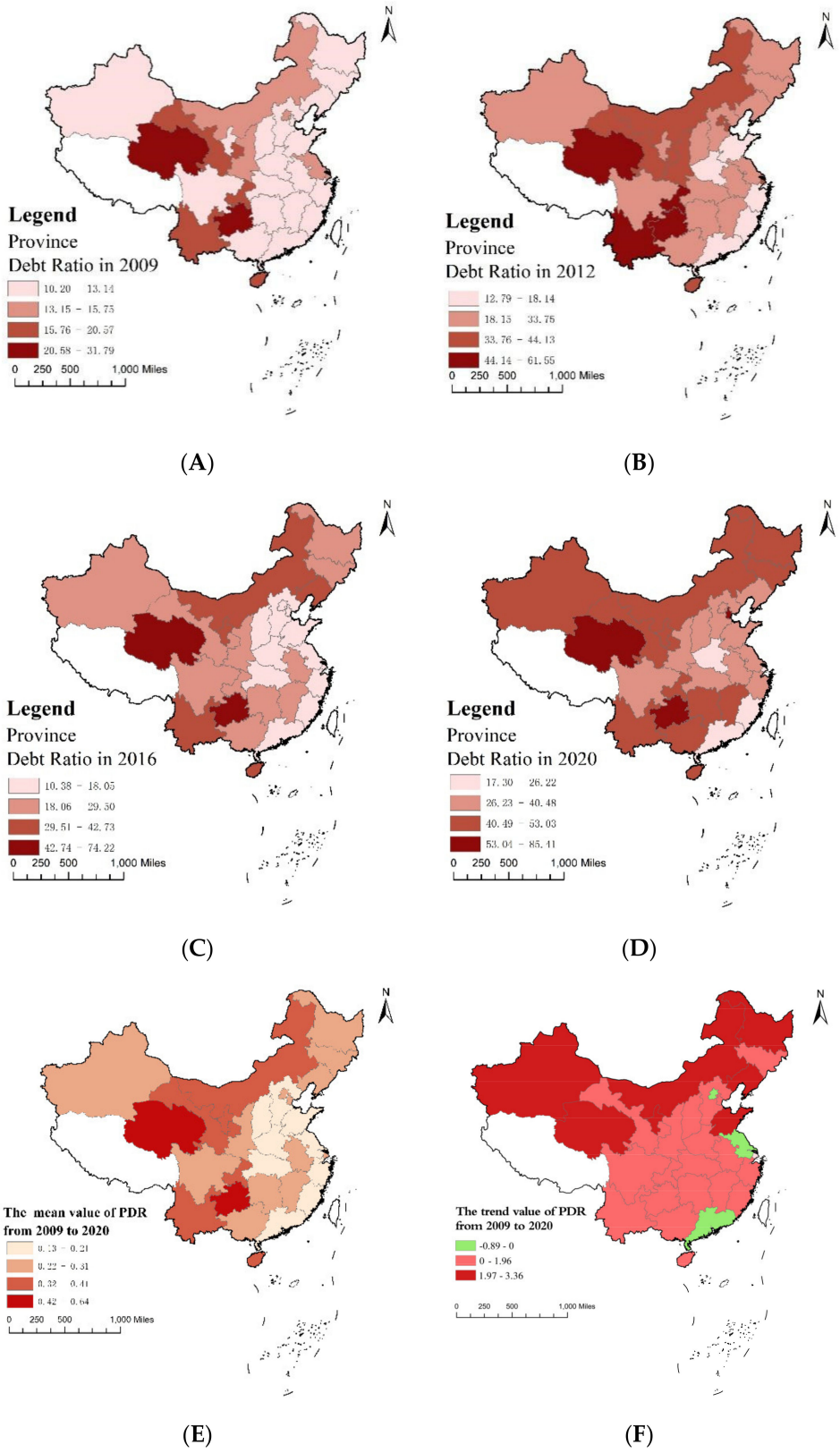

Figure 1. Temporal evolution maps of the debt ratio of the 30 provinces in China: (**A**) PDR distribution map 2009, (**B**) PDR distribution map 2012. (**C**) PDR distribution map 2016, (**D**) PDR distribution map 2020. (**E**) PDR mean value map 2009–2020, (**F**) PDR trend value map 2009–2020.

As shown in Figure 1 and Appendix B, the PDR of the whole country changes over time. From 2009 to 2014, the national PDR showed a continuous upward trend, from an average of 14.553% in 2009 to an average of 35.135% in 2014. After the promulgation of the New Budget Law from 2015 to 2019, the average PDR was in a dynamic range of 25.000% to 29.000%. In 2020, affected by coronavirus, the national PDR has risen to 43.250%, with an annual increase of 49.809%.

In the eastern region, from 2009 to 2012, the average PDR of the eastern provinces continued to increase, from 13.177% in 2009 to 27.602% in 2012. From 2013 to 2017, the average PDR of the eastern provinces gradually declined, and the lowest was 19.169% in 2017. From 2018 to 2020, the average PDR of the eastern provinces rapidly rebounded, especially in 2020, when it rose to 36.835%.

In the central region, from 2009 to 2013, the average PDR of the central provinces continued to increase, and the average in 2013 reached a high of 28.105%. From 2014 to 2017, the average PDR of the central provinces gradually declined; the lowest was 18.906% in 2017. From 2018 to 2020, the average PDR of the central provinces rapidly increased, rising to 38.479% in 2020, thus surpassing that of the eastern region.

In the western region, because of the relatively backward economic development, the average PDR of the western provinces from 2009 to 2020 was higher than that of the whole country as well as the eastern and central regions. From 2009 to 2014, the average PDR of the western provinces continued to increase, from 17.883% in 2009 to 52.106% in 2014. From 2015 to 2019, the average PDR of the western provinces fluctuated between 35.000% and 40.000%. In 2020, the average PDR of the western provinces increased to 53.134%, which is a year-on-year increase of 37.821%.

Figure 1E shows the mean value of the PDR from 2009 to 2020; the darker the red, the higher the mean value, where Guizhou Qinghai and Yunnan have the highest average value and a heavy debt burden; Guangdong Henan and Shandong have the lowest average value, and the debt pressure is relatively light. As shown in Figure 1F, the Mann–Kendall method was used to measure the trend value of the PDR in each province. The first interval is green, indicating that the PDR has a downward trend; the second range is light red, indicating that the PDR has an upward trend; and the third range is dark red, indicating that the PDR shows a significant upward trend. We found that the most developed regions in China—such as Beijing (−0.89), Shanghai (−0.89), Jiangsu (−0.75), and Guangdong (−0.48)—have the smallest and negative PDR trend values, while the PDR trend the values of the four provinces of Liaoning (3.63), Shandong (3.36), Ningxia (3.36), and Xinjiang (2.95).

3.1.2. Spatial Evolution

We used MATLAB R2021® to make the nuclear density distribution map of PDR of whole country, eastern region, central region, and western region from 2009 to 2020.

As shown in Figure 2, the main peak of China's overall PDR tended to shift to the right and the peak increased after the main peak became shorter. After 2013, the peak increased, the bandwidth increased to a certain extent, and there was a right tailing trend with greater ductility. Overall, China's overall PDR shows a continuous upward trend with obvious inter-provincial differences—but a downward trend, nonetheless, especially after 2013. The provinces with a higher index widen the domestic differences, but the provinces with a lower PDR have a catch-up effect, and the differences between regions begin to narrow.

The main peak of the PDR in the eastern region shifted to the right and the peak height increased after a certain decline. The decline was more obvious from 2009 to 2013. Specifically, the bandwidth showed a continuous shrinking trend; there was a right tailing phenomenon, and the ductility increased. It can be seen that the PDR level in the eastern region shows little difference and change. In recent years, the gap between provinces with a high PDR and provinces with a low PDR has gradually narrowed and the PDR level in the region is relatively stable.

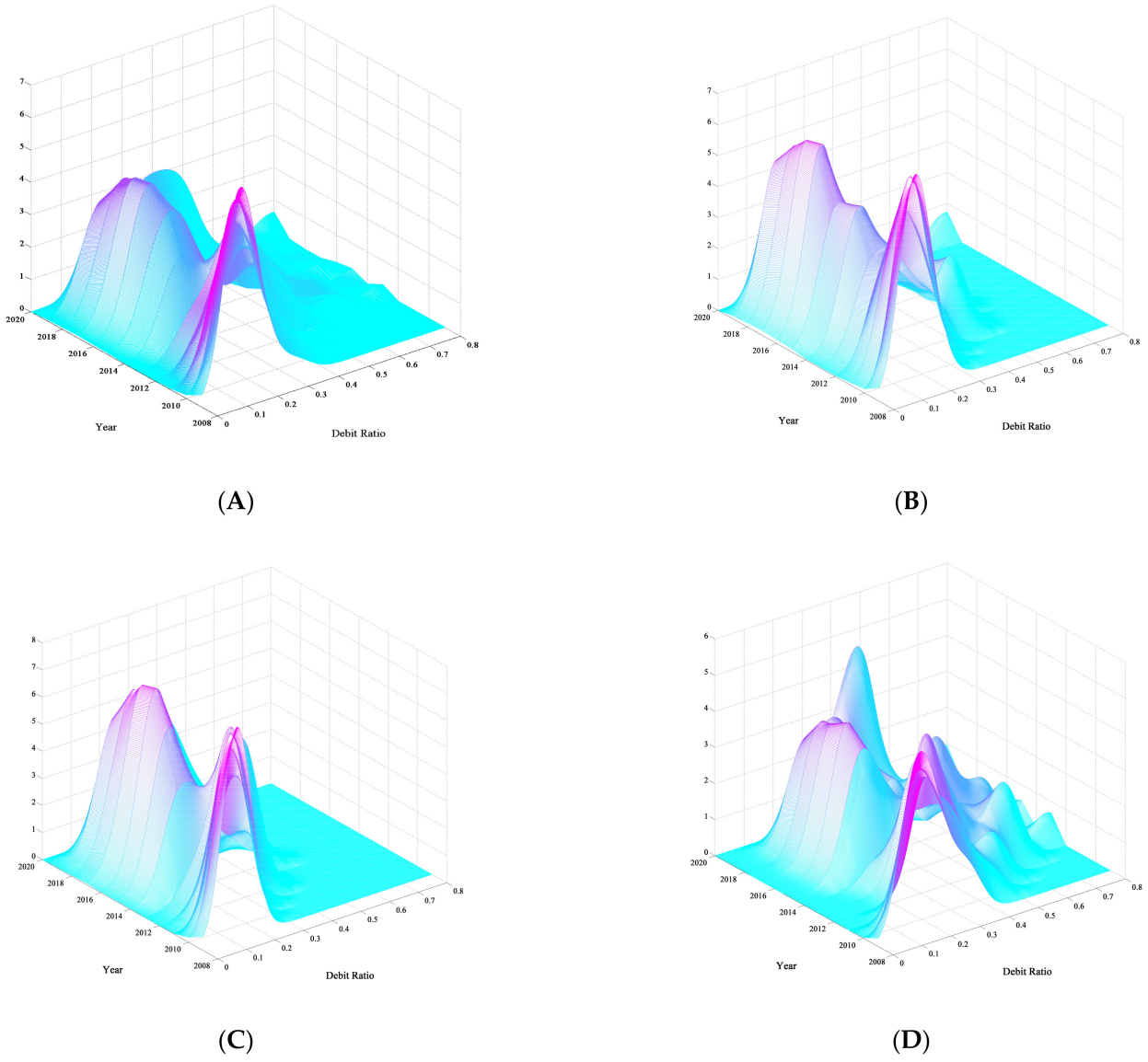

Figure 2. Spatial evolution maps of the debt ratio of the 30 provinces in China: (**A**) Whole Country, (**B**) East Region, (**C**) Central Region, (**D**) Western Region.

The main peak of the PDR in Central China tends to shift to the right after a small range, and the peak obviously fluctuates in stages. There is an obvious downward trend from 2009 to 2013 and an obvious upward trend from 2014 to 2020. The bandwidth shows a certain expansion trend as there is a right tailing phenomenon and the ductility decreases. The level of PDR in the central region shows an overall difference, the change is small, and there is an obvious polarization effect. The provinces with high levels of PDR continue to grow, while the provinces with low levels of PDR grow slowly.

The main peak of the PDR in the western region has a small and rapid increasing trend. Accordingly, the decline is stable and there is rapid growth, and the peak height has obvious fluctuations. This is mainly manifested in a slight decline from 2009 to 2013, a small increase from 2014 to 2018 as the bandwidth continued to shrink from a right tailing trend, and the ductility decreased. Therefore, it is still necessary to focus on the problem of high PDR in areas with backward economic development in order to further improve the sustainability of government debt in the region.

3.2. Primary Finding

3.2.1. The Influence of Government Debt on Economic Growth

(1) Benchmark regression

To test whether provincial government debt has an impact on economic growth, Model (3) needed to be regressed. Before the regression, there was an F test of the panel data. This showed that the *p* value of the F statistic is less than 0.01, which proves that the fixed effect of the sample data of the model is extremely obvious; Hausmann's test has a *p* value of 0.0000, strongly rejecting the null hypothesis, and confirms the use of fixed effects, and that provinces and years are fixed in the regression. As shown in Figure 3, the time trend lines of *lnGDP* in China's 30 provinces are relatively flat, and the time trend lines of *lnDebt* in China's 30 provinces show a fluctuating trend and gradually move closer to the *lnGDP* line.

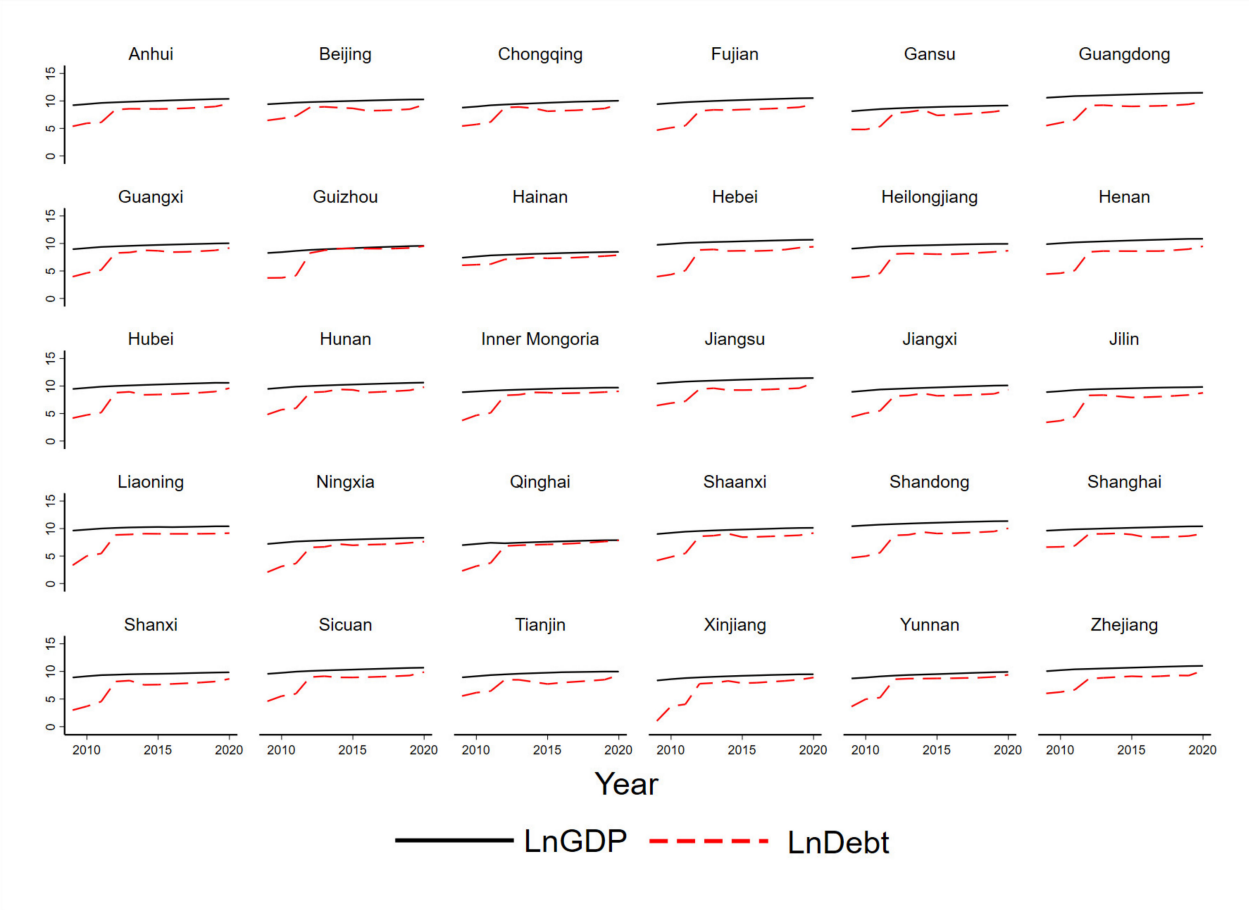

Figure 3. The influence of government debt on economic growth at temporal scale and province scale.

As shown in Table 2, according to Model (3), Column (1) describes fixed effect regression of 30 provinces, the dependent variable is *L1-lnDebt*, and *L1-lnDebt* has a positive impact on *lnGDP* and passes the 1% significance test. That is, provincial government debt can significantly promote economic growth. The coefficient is 0.024, which means that, when the provincial government debt increases by 1% point, the real GDP will increase by 0.024% points. Among the control variables, *Urb*, *Indus*, and *Edu* significantly increased *lnGDP* and passed at least 1% significance level test. *Open* and *Tax* have a negative impact on *lnGDP* and passed the 1% significance test. The impact of *Pop* on *lnGDP* is negative and passed at least a 10% significance level test.

Table 2. Sub-sample regression for Models (1) and (2).

	(1)	(2)	(3)	(4)	(5)
	lnGDP	***lnGDP***	***lnGDP***	***lnGDP***	***lnGDP***
L1-lnDebt	0.024 ***	0.020 ***	0.027 ***	0.023 ***	0.016 ***
	(6.910)	(2.640)	(4.310)	(5.500)	(4.030)
L1-lnDebt^2	/	/	/	/	−0.001 ***
	/	/	/	/	(−3.560)
Urb	0.040 ***	0.032 ***	0.050 ***	0.051 ***	0.039 ***
	(20.020)	(8.220)	(13.470)	(19.810)	(19.550)
Indus	0.005 ***	0.011 ***	−0.003	0.001	0.005 ***
	(3.890)	(4.320)	(−1.340)	(0.430)	(4.010)
Pop	−0.007 *	−0.006	−0.011	−0.006	−0.006 *
	(−1.790)	(−0.930)	(−1.550)	(−1.300)	(−1.670)
Open	−0.003 ***	−0.002 ***	−0.012 ***	0.001	−0.003 ***
	(−8.270)	(−4.410)	(−3.840)	(0.390)	(−8.440)
Gov	0.002	0.002	0.007 ***	−0.001	0.002
	(1.030)	(0.370)	(2.770)	(−0.240)	(1.020)
Tax	−0.015 ***	−0.016 *	−0.029 **	−0.002	−0.017***
	(−3.080)	(−1.780)	(−2.470)	(−0.280)	(−3.520)
Edu	0.164 ***	0.208 ***	0.104 ***	0.095 ***	0.151 ***
	(10.920)	(7.330)	(3.340)	(5.440)	(10.010)
Cons	5.783 ***	5.562 ***	6.480 ***	5.687 ***	5.954 ***
	(43.700)	(17.180)	(28.110)	(39.310)	(43.050)
Province fixed effet	Yes	Yes	Yes	Yes	Yes
Year fixed effet	Yes	Yes	Yes	Yes	Yes
r^2	0.955	0.935	0.961	0.972	0.957
N	330.000	121.000	88.000	121.000	330.000

Notes: L1-lnDebt and L1-lnDebt2 are first-order lag term of the independent variables, in order to alleviate the endogenous problem of the model, the independent variables are processed by lag first-order, t-statistics are in parentheses. *** $p < 0.01$ and * $p < 0.1$.

(2) Regional variability analysis

Columns (2), (3), and (4) of Table 2 describe fixed effect regression of the eastern provinces, central provinces, and western provinces, respectively.

In the three major regions, *L1-lnDebt* is positively significant for *lnGDP* and passes at least a 1% significance level test. The eastern region has the lowest impact coefficient of 0.020, and the central region has the highest impact coefficient, reaching 0.027. The influence coefficient of the western region is 0.023, which is slightly lower than the overall level of 0.024. From the perspective of control variables, in the eastern region, *Urb*, *Indus*, and *Edu* all significantly promote *lnGDP* and pass the 1% significance level test. On the contrary, *Open* and *Tax* have an inhibitory effect on *lnGDP*; specifically, *Open* passes the 1% significance test, and *Tax* passes the 10% significance test. In the central region, *Urb*, *Gov*, and *Edu* have a significant positive impact on *lnGDP* as they all pass the 1% significance test. Notably, *Indus*, *Open*, and *Tax* hinder the growth of *lnGDP*; among them, *Indus* fails the significance test, *Open* passes the 1% significance test, and *Tax* passes the 5% significance test. In the western region, *Urb* and *Edu* have a significant promoting effect on *lnGDP* and they all pass the 1% significance test. Finally, *Pop*, *Gov*, and *Tax* inhibit the growth of *lnGDP*, but they all fail the significance test.

(3) Further study

To examine the nonlinear relationship between the debt scale and economic growth, we conducted an empirical regression on Model (4). As shown in Table 2, according to Model (4), Column (5) describes the fixed effect regression of 30 provinces. The corresponding dependent variables are *L1-lnDebt* and *L1-lnDebt*^{2}, and they are both significant at the 1% level. This shows that there is a nonlinear relationship between China's provincial government debt and economic growth, showing an inverted "U-shaped" curve. This is

similar to the findings of others, such as Bailey et al. (2021) [39] and Wei et al. (2021) [60]. Based on the quadratic axis of symmetry, the axis of symmetry of the government debt *L1-lnDebt* can be calculated as 6.684. From descriptive statistics, because 6.684 is within the value range of *L1-lnDebt*, and the provincial data year corresponding to the value is 2010, we say that, when the value of *L1-lnDebt* is 6.684, the threshold is reached; at this time, local government debt has the greatest positive impact on local economic growth. It can be seen from Figure 4 that the growth rate of China's GDP in 2010 reached 10.640%, the highest point from 2009 to 2020, which simultaneously confirmed the threshold effect.

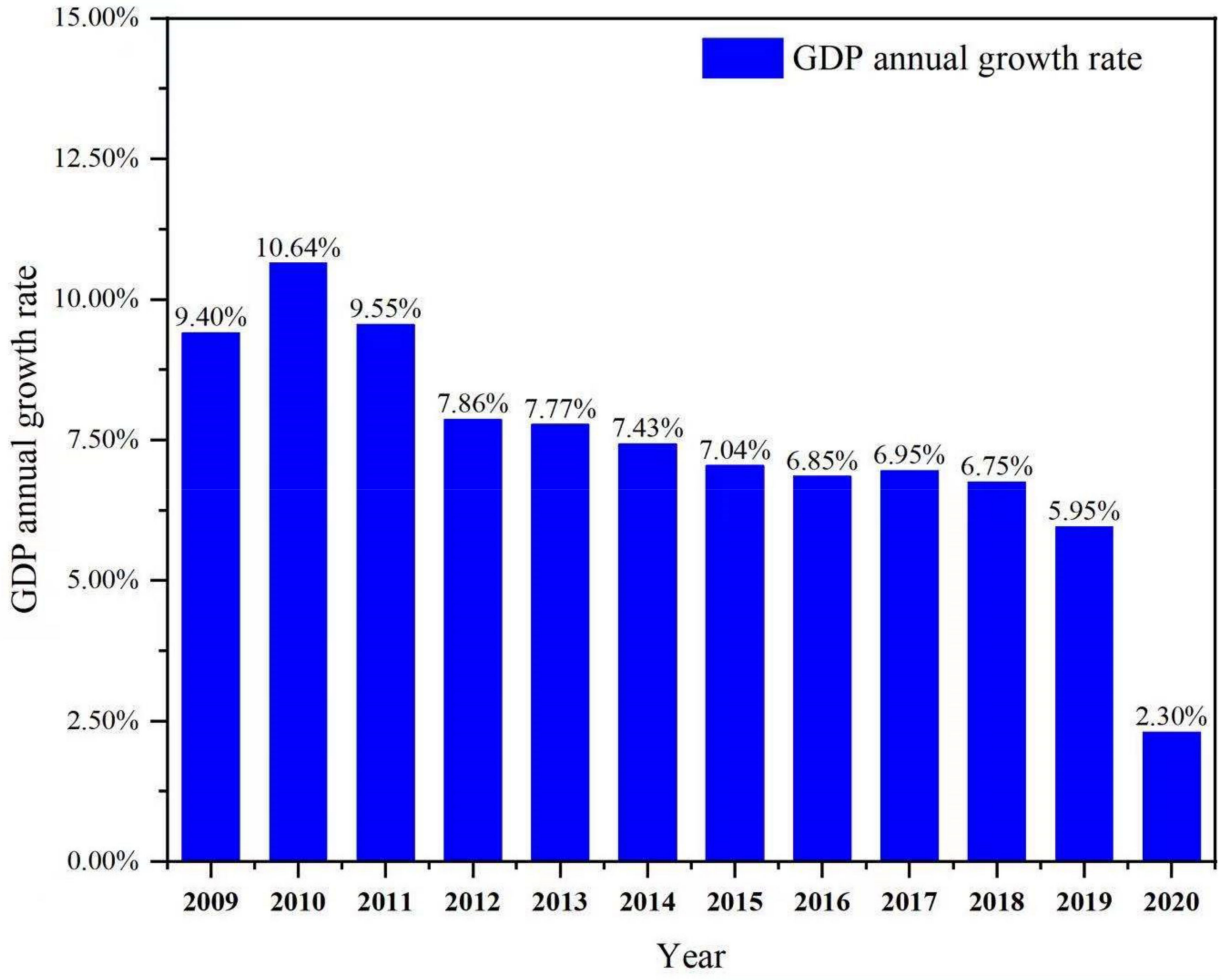

Figure 4. China's annual GDP growth rate from 2009 to 2020.

3.2.2. The Influence of Government Debt on Economic Growth Fluctuations

(1) Benchmark regression

To test whether provincial government debt has an impact on economic fluctuations, Model (5) was regressed. Before regression, the F test of the panel data was performed, and the result showed that the F statistic *p* value was 1, which confirmed that the model was not suitable for fixed effects. The LM test was performed, and the result showed that the *p* value was 1, which confirmed that the model was not suitable for random effects. After the F test and LM test, we used mixed regression to conduct an empirical analysis on Model (5). Figure 5 shows the time trend charts for *GDPFlu* and *DebtFlu*. It can be seen that the time trend line of *GDPFlu* is very flat; from an overall point of view, the time trend line of *DebtFlu* presents a trend of upward fluctuations around the time trend line of *GDPFlu*.

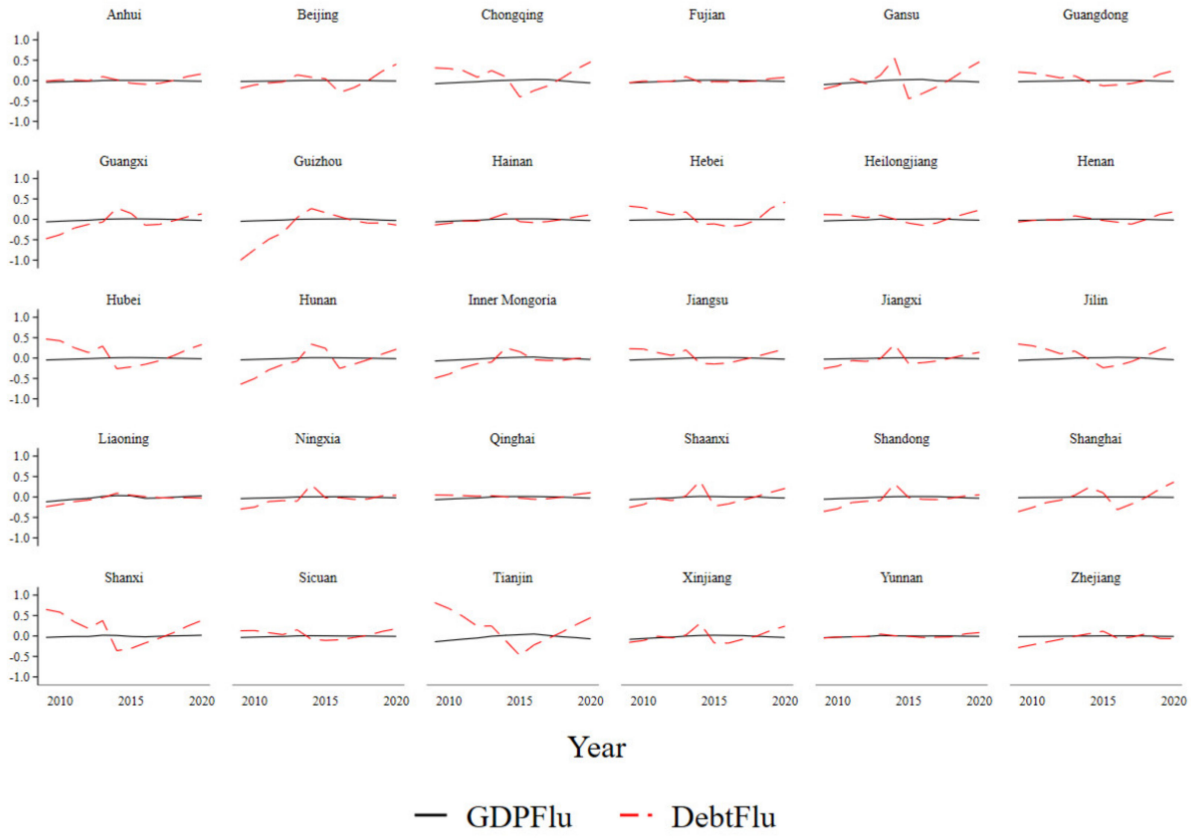

Figure 5. The influence of government debt on economic fluctuations at temporal scale and province scale.

As shown in Table 3, according to Model (5), Column (1) describes fixed effect regression of 30 provinces. The dependent variable corresponding to Column (1) is *L1-DebtFlu*. Accordingly, it can be seen that *L1-DebtFlu* has a positive impact on *GDPFlu* and passes the 10% significance test. That is, provincial government debt volatility can significantly promote economic growth volatility. The coefficient is 0.009, which means that, when the provincial government debt volatility increases by 1% point, the real GDP volatility will increase by 0.009% points. Among the control variables, *UrbFlu*, *PopFlu*, *GovFlu*, *TaxFlu*, and *EduFlu* have positive impacts on *GDPFlu*; among them, *PopFlu* passes the 5% significance test, and *TaxFlu* passes the 1% significance test, but the remaining variables fail to pass the significance test. In contrast, *IndusFlu* and *OpenFlu* have a significant inhibitory effect on *GDPFlu*, and they all pass the 1% significance test.

(2) Regional Fluctuations analysis

As shown in Table 3, Columns (2), (3), and (4) of Table 2 describe mixed effect regression of the eastern provinces, central provinces, and western provinces, respectively. The independent variable corresponding to Columns (2) through (4) is *L1-DebtFlu*. Based on Columns (2) and (3), in the eastern and central regions, *L1-DebtFlu* in provincial government debt has no significant impact on *GDPFlu*. Among them, the coefficient in the eastern region is positive, the coefficient in the central region is negative, and the absolute values are both small. This shows that the eastern and central regions have done a relatively good job in controlling government debt risks and the influence of government debt fluctuations on economic changes can be eliminated. Column (4) shows that, in the western region, the influence coefficient of *L1-DebtFlu* is significantly positive and passes the 5% significance test; moreover, the coefficient is 0.016, and the absolute value of the western region is higher than the overall national level. This shows that the volatility of provincial government

debt in the western region has greatly aggravated economic volatility and caused unstable economic operations.

Table 3. Sub-sample regression for Model (3).

	(1)	(2)	(3)	(4)
	GDPFlu	***GDPFlu***	***GDPFlu***	***GDPFlu***
L1-DebtFlu	0.009 *	0.001	−0.003	0.016 **
	(1.700)	(0.050)	(−0.320)	(2.120)
UrbFlu	0.004	0.011 **	−0.024 ***	0.002
	(1.290)	(2.460)	(−3.970)	(0.007)
IndusFlu	−0.002 ***	−0.004 ***	−0.001	−0.0002
	(−4.090)	(−3.680)	(−1.450)	(−0.200)
PopFlu	0.002 **	−0.002	0.006 ***	0.007 ***
	(1.990)	(−1.270)	(4.070)	(3.380)
OpenFlu	−0.002 ***	−0.003 ***	−0.005 ***	−0.002 **
	(−7.300)	(−6.480)	(−6.200)	(−2.340)
GovFlu	0.001	0.001	−0.002 *	−0.001
	(0.910)	(1.040)	(−1.960)	(−0.890)
TaxFlu	0.003 ***	0.001	0.016 ***	0.015 ***
	(3.340)	(1.280)	(6.280)	(5.500)
EduFlu	0.0001	−0.0001	−0.003	0.006
	(0.120)	(−0.020)	(−0.410)	(0.780)
$Adj.r^2$	0.445	0.516	0.734	0.461
N	330.000	121.000	88.000	121.000

Notes: L1-DebtFlu is first-order lag term of the independent variable; in order to alleviate the endogenous problem of the model, the independent variable is processed by lag first-order, t-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

(3) Robustness test

To ensure the reliability of the regression results, this study adopted the independent variable substitution method and used the government debt ratio to replace the natural logarithm of the government debt scale to measure the government debt level. The province's government debt ratio in the current year was attained by calculating the ratio of government debt this year to the province's GDP. Amplify 100 times and perform HP filter processing and retain its fluctuation term as a new explanatory variable. The results of the robustness tests are presented in Table 4.

The independent variables corresponding to Columns (1) through (4) in Table 4 are *L1-DRFlu*. The dependent variables in Table 4 are the same as those listed in Table 3. The regression results in Column (1) of Table 4 show that the independent variables are significant and that the regression coefficient is 0.008 and is significant at the 10% level. This supports the regression results in Table 4 that provincial government debt volatility can significantly promote economic growth volatility. However, compared with the regression results in Column (1) of Table 3, the regression coefficient is lower, indicating that government debt ratio volatility is less sensitive to economic growth volatility. Columns (2) to (4) of Table 4 describe the eastern, central, and western regions, respectively. After adjusting for the independent variables, the sign and significance of the regression coefficients of the independent variables did not change. This shows that the influence of government debt on economic fluctuations is not affected by the form of the independent variable and the model is robust.

Table 4. Robustness test: replacing independent variables.

	(1)	(2)	(3)	(4)
	GDPFlu	***GDPFlu***	***GDPFlu***	***GDPFlu***
L1-DRFlu	0.008 *	0.005	−0.002	0.014 *
	(1.940)	(0.830)	(−0.210)	(1.680)
UrbFlu	0.006	0.010 ***	−0.019 ***	0.005
	(1.550)	(2.880)	(−3.910)	(0.830)
IndusFlu	−0.002 **	−0.004 *	−0.0001	−0.0001
	(−2.220)	(−1.700)	(−1.430)	(−0.120)
PopFlu	0.002	−0.002	0.006 ***	0.007 ***
	(1.460)	(−1.080)	(3.130)	(2.920)
OpenFlu	−0.002 ***	−0.002 ***	−0.005 ***	−0.002 ***
	(−4.140)	(−3.710)	(−6.160)	(−4.170)
GovFlu	0.0001	0.0001	−0.001	−0.0004
	(0.110)	(0.630)	(−1.330)	(−0.510)
TaxFlu	0.003 **	0.002 ***	0.013 **	0.009 ***
	(2.480)	(2.840)	(2.280)	(2.590)
EduFlu	0.0003 ***	−0.001	−0.010	0.003
	(5.620)	(−0.880)	(−0.880)	(0.360)
$Adj.r^2$	0.408	0.526	0.605	0.462
N	330.000	121.000	88.000	121.000

Notes: L1-DRFlu is first-order lag term of the independent variable; in order to alleviate the endogenous problem of the model, the independent variable is processed by lag first-order, t-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

4. Discussion

Based on sustainable development theory, we adopted the fixed effect model to analyze the impact of China's provincial government debt on economic growth and conducted regional heterogeneity analysis. Then, we introduced the square term of government debt into the model to verify the "nonlinear relationship" of the impact of China's government debt on economic growth and judged whether there is a threshold effect showing "U" or inverted "U" relationship between them. Finally, we conducted HP Filtering on all variables to further test the impact of China's provincial government debt on economic fluctuations and completed the robustness test.

We can see from the above empirical results that, on the one hand, China's provincial government debt promoted economic growth, Dey et al. [61] had the same view, and the regression coefficient (0.024) was significant. From different regional perspectives, the promotion effect of the central region (0.027) is higher than that of the eastern (0.020) and western (0.023) regions. This is consistent with the conclusion of [62]. Theoretically, there is a nonlinear relationship between China's provincial government debt and economic growth, showing an inverted "U-shaped" curve; however, ref. [63] presented nonlinear characteristics, rather than an inverted "U-shaped" relationship.

On the other hand, the variation in government debt aggravates economic fluctuations, and the regression coefficient (0.009) is significant. The regression coefficients of the eastern and central provinces are not significant; however, the regression coefficient of the western provinces (0.016) is larger and more significant than that of other regions. Tax burden fluctuations and population growth rates aggravate economic changes. In contrast, the optimization of provincial industrial structure and improving provincial opening level can slow economic fluctuations. This is similar to the viewpoint of [64].

We discovered that China's provincial government debt has a significant positive impact on economic growth. Moreover, debt volatility contributes to regional economic volatility. For example, owing to the effect of COVID-19, Hubei's GDP in 2019 was 4582.831 billion yuan, with an annual growth rate of 7.5%. However, by 2020, the provincial GDP was 4344.346 billion yuan, representing a year-on-year decrease of 5.0%—its economy has significantly declined. To speed up recovery and stabilize employment, the Hubei Provin-

cial Government has increased its borrowing efforts. In 2020, the debt balance of Hubei Province was 1494.933 billion yuan, an increase of 85.934% year-on-year, and the provincial government debt ratio increased by 96.141% year-on-year. If the government does not borrow to increase investment and stabilize economic growth, Hubei's economy will experience more severe fluctuations and decline.

In short, China's provincial government debt has increased significantly under COVID-19. Owing to the slow economic recovery, the debt ratios of certain provinces such as Qinghai and Guizhou remain high, and there is even the possibility of debt crises. Therefore, we need to further explore how the economy can sustainably develop if the new coronavirus epidemic becomes a normal facet of the economy. First, the government must maintain macroeconomic stability and a stable level of government debt, and ensure that no debt crisis occurs. Second, the developed provinces in the east should assist the backward provinces in the west by providing horizontal fiscal expenditures to ensure that all provinces can overcome these difficulties. Third, the coronavirus highlights the ecological environment's importance. To maintain sustainable economic development, the government must increase investment in environmental protection; guide government debt to invest in green environmental protection industries and the green economy; and achieve sustainable economic development through green innovation. Finally, China in 2020 GDP growth rate has dropped by half because of the impact of COVID-19. The influence of COVID-19 has greatly restricted international trade and personnel movement; in order to revive the China's provincial economies, the government should increase the stimulation of domestic demand and simultaneously develop a combination of online and offline methods to promote product sales.

5. Conclusions, Policy Implication and Limitations

5.1. Conclusions

This study examines the impact of local government debt on economic growth and fluctuation, which has important research value. In the context of COVID-19's impact, local governments have increased borrowing, which has stimulated the economy; but local government debt also impacts local economic fluctuations. For example, when the government debt ratio is too high to repay debt, it will cause a debt crisis and have a disastrous impact on sustainable economic development. The data used here are more complete than those of previous studies and have been updated to 2020, which tests the impact of China's provincial government debt on economic growth and sustainable development with COVID-19. We build an empirical model to test the different impacts and regional differences in the scale of provincial government debt on economic growth and fluctuations. In addition, we verify the non-linear relationship between provincial government debt and economic growth.

From a national perspective, analyzing local government debt's impact on economic growth shows that such debt promotes economic growth, with a coefficient of 0.024. From the perspective of regional heterogeneity, the coefficients for the eastern and western regions are 0.020 and 0.023, respectively, and the role of government debt in promoting economic growth is significantly lower than the national level. The coefficient in the central region is 0.027, and the contribution of provincial government debt to economic growth is higher than the national level.

We empirically conclude that there is a nonlinear relationship between China's provincial government debt and economic growth, which shows an inverted "U-shaped" curve. There may be a theoretical threshold effect between local government debt and economic growth. When the threshold is reached, local government debt has the greatest positive impact on local economic growth. During the sample period, the maximum value of China's economic growth rate corresponds to the threshold point, confirming the above conclusion.

Regarding the impact of local government debt on economic fluctuations, from a national perspective, government debt volatility aggravates economic volatility with a coefficient of 0.008; however, in the eastern and central regions, its impact on economic

shifts is not significant. In China's western region, the fluctuation of provincial government debt significantly aggravates changes in the local economy and causes unstable economic operations.

Thus, this study results are important. We propose a new perspective for China's local debt research; that is, China's regions should use government debt to manage the impact of the coronavirus pandemic, prevent risks in debt expansion, alleviate economic fluctuations, and ensure economic and social stability throughout China. This operation has a certain reference significance.

5.2. Policy Implication

This study reveals relevant policy implication.

The economic development level in the eastern region is leading the country in this category. With strong debt management capabilities and relatively complete market systems, under normal circumstances, the market's self-adjustment mechanism should be relied upon, and it is not appropriate to extensively intervene [65]. The central region's economic endowment is insufficient, its economic foundation is weak, and the industrial structure remains imperfect. This requires actively promoting the reform of the government debt management system as well as rendering scientific and reasonable debt investment decisions. We recommend promoting the upgrading of the industrial structure in general and the entire market through the development of the characteristic economy in order to drive the regional economy's sustainable and coordinated development.

The degree of marketization, industrial structure, and economic development efficiency in the western region are far from those of the country's other two regions. The backward development concept for GDP should be abandoned, and a sound mechanism for evaluating government debt should be established. Government debt's role in promoting the economy and encouraging social capital within public investment should be emphasized. There should also be an appropriate increase in social capital's participation in areas of people's livelihoods, such as science, education, culture, and health.

5.3. Limitations

Several important limitations of this study warrant discussion. On the one hand, the sample data volume of this study is not rich enough, because only 30 provincial governments were studied, resulting in an insufficient sample size. In the future, we expect public disclosure of government debt data at the municipal and county levels; alternatively, we can use quarterly data from provincial units to expand the sample size. On the other hand, this study examined the impact of the scale of government debt on economic growth and fluctuation. However, in practice, the influence of different flows of government debt funds on economic growth is obviously different. In future research, we can consider subdividing government debt variables, studying the different effects of government debt flowing into different fields or industries on economic growth, analyzing the corresponding mechanism, and exploring specific ways to improve government debt's sustainable development.

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Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have influenced the results reported in this paper.

Appendix A

Table A1. Variables Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
lnGDP	360.000	9.715	0.897	6.986	11.483
lnDebt	360.000	7.680	1.770	1.030	10.567
Urb	360.000	56.886	12.642	29.890	89.600
Indus	360.000	46.443	9.872	28.615	84.880
Pop	360.000	5.038	2.710	−1.050	11.470
Open	360.000	26.386	29.291	0.758	154.816
Gov	360.000	24.816	11.053	9.640	77.728
Tax	360.000	8.189	2.956	4.217	19.962
Edu	360.000	9.060	0.955	6.764	9.913
GDPFlu	360.000	1.5×10^{-10}	0.013	−0.048	0.049
DebtFlu	360.000	1.1×10^{-10}	0.151	−0.478	0.546
UrbFlu	360.000	-1.7×10^{-10}	0.220	−1.002	0.861
IndusFlu	360.000	1.7×10^{-9}	1.512	−6.264	6.292
PopFlu	360.000	-6.1×10^{-10}	0.673	−2.930	3.783
OpenFlu	360.000	-4.8×10^{-9}	2.494	−10.558	14.479
GovFlu	360.000	3.1×10^{-9}	1.254	−4.109	5.331
TaxFlu	360.000	-9.0×10^{-10}	0.865	−7.613	3.923
EduFlu	360.000	0.357	1.932	−0.520	11.036

Notes: shows the statistical information of the variables adopted in this paper. When calculating the control variables involving the ratio, we take the value before the percentage sign, that is, enlarge the ratio by 100 times before regression.

Appendix B

Table A2. Government Debt Ratio of 30 Provinces, Whole Country, Eastern Region, Central Region, and Western Region from 2009 to 2020.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beijing	15.749	19.088	26.030	38.989	38.151	30.554	24.893	15.034	13.846	14.013	14.034	30.600
Tianjin	10.318	15.341	16.415	38.093	33.470	23.550	13.630	16.286	18.413	21.682	35.162	79.201
Hebei	10.923	15.147	19.964	25.703	26.420	19.214	19.754	17.881	17.103	20.212	29.079	33.603
Shanxi	12.815	18.304	20.496	29.258	32.992	15.294	15.863	17.720	17.221	17.622	20.626	32.462
Inner Mongoria	14.294	20.776	27.447	38.946	39.869	56.828	52.003	42.675	41.317	40.613	42.454	48.861
Liaoning	11.552	17.487	23.158	27.969	27.894	30.456	29.740	38.367	35.316	33.957	35.669	38.532
Jilin	10.236	11.384	20.356	33.753	32.563	26.067	19.571	19.455	20.886	24.610	37.050	51.776
Heilongjiang	11.537	13.562	18.337	23.689	24.667	22.762	20.857	20.280	21.325	25.160	34.884	43.196
Shanghai	15.103	18.955	24.917	40.195	37.980	38.793	29.031	15.915	15.323	15.407	14.997	22.343
Jiangsu	15.542	17.148	18.448	23.801	24.716	16.352	15.055	14.346	14.000	14.348	14.933	37.809
Zhejiang	11.402	14.714	17.309	17.064	18.350	19.887	21.425	18.051	17.847	19.208	16.660	39.773
Anhui	11.559	13.297	18.647	26.075	27.548	25.378	23.209	22.057	21.162	22.344	21.384	34.675
Fujian	12.655	13.446	14.170	18.139	20.037	17.293	17.678	17.452	16.913	16.916	16.591	26.225
Jiangxi	13.135	14.983	16.229	27.429	27.290	36.871	22.353	21.546	20.506	21.740	21.614	43.928
Shandong	10.967	11.117	11.814	12.789	12.869	19.706	14.379	14.094	14.030	14.954	18.472	31.653
Henan	11.294	13.286	15.793	16.059	17.216	15.992	14.769	13.757	12.333	13.616	14.578	24.028
Hubei	11.505	15.142	22.682	29.311	31.136	16.208	15.897	15.624	15.649	16.958	17.544	34.411
Hunan	12.867	18.645	25.863	31.482	31.425	44.403	38.140	21.853	22.166	23.907	25.595	43.355
Guangdong	10.884	12.725	13.997	16.754	16.264	12.921	10.956	10.383	9.846	10.237	11.098	17.302
Guangxi	12.030	17.245	24.569	30.089	29.960	40.791	34.872	25.029	23.714	26.992	29.799	43.679
Hainan	19.848	26.063	31.784	44.128	45.279	49.211	39.936	38.140	38.227	40.184	42.012	48.142

Table A2. *Cont.*

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Chongqing	20.567	29.621	34.204	58.676	57.577	41.434	21.500	21.283	20.607	23.035	23.739	46.792
Sicuan	12.099	19.399	25.473	33.523	34.971	26.229	24.836	23.904	22.993	22.860	22.690	40.480
Guizhou	31.793	42.803	50.315	57.238	78.171	94.689	83.359	74.224	63.565	59.770	57.685	76.438
Yunnan	19.848	28.063	36.443	51.747	50.327	46.892	45.734	42.725	40.752	39.929	34.912	48.986
Shaanxi	15.442	19.749	25.814	38.623	38.313	50.057	26.154	25.820	25.126	24.089	25.325	37.315
Gansu	19.893	28.955	32.429	43.581	46.780	64.050	23.386	24.876	26.945	30.222	35.748	51.419
Qinghai	28.775	35.332	47.543	61.553	61.731	61.606	61.481	59.300	61.359	64.156	70.870	85.413
Ningxia	11.773	14.084	25.423	30.891	30.687	47.962	36.348	37.313	36.145	37.473	44.248	52.060
Xinjiang	10.196	16.196	22.601	31.631	32.523	42.624	28.241	29.499	30.932	32.627	36.570	53.034
Whole Country	14.553	19.069	24.289	33.239	34.239	35.136	28.168	25.830	25.186	26.295	28.867	43.250
Eastern Region	12.677	16.088	20.401	28.082	28.386	27.549	23.524	20.759	20.340	21.651	24.487	38.360
Central Region	12.431	15.483	19.711	26.397	27.103	26.819	23.331	20.879	20.400	21.424	23.537	36.869
Western Region	14.877	19.391	24.837	33.274	34.467	37.133	29.650	27.230	26.499	27.512	29.505	43.139

Notes: The data of the provincial government debt ratio originates from Wind database and manual calculation. Unit (%).

References

1. Yang, H.C.; Syarifuddin, F.; Chang, C.P.; Wang, H.J. The Impact of Exchange Rate Futures Fluctuations on Macroeconomy: Evidence from Ten Trading Market. *Emerg. Mark. Financ. Trade* **2021**, *57*, 1–14. [CrossRef]
2. Elenev, V.; Landvoigt, T.; Shultz, P.J.; Nieuwerburgh, S.V. *Can Monetary Policy Create Fiscal Capacity*; National Bureau of Economic Research: Cambridge, MA, USA, 2021. [CrossRef]
3. Kozera, A.; Standar, A.; Satoła, Ł. Managing Rural Areas in the Context of the Growing Debt of Polish Local Government Units. *Agriculture* **2020**, *10*, 376. [CrossRef]
4. Wei, X.; Wang, N.; Luo, P.; Yang, J.; Zhang, J.; Lin, K. Spatiotemporal Assessment of Land Marketization and Its Driving Forces for Sustainable Urban-Rural Development in Shaanxi Province in China. *Sustainability* **2021**, *13*, 7755. [CrossRef]
5. Duan, W.; Zou, S.; Chen, Y.; Nover, D.; Fang, G.; Wang, Y. Sustainable water management for cross-border resources: The Balkhash Lake Basin of Central Asia. *J. Clean. Prod.* **2020**, *263*, 1931–2015. [CrossRef]
6. Guo, B.; Wang, X.; Pei, L.; Su, Y.; Zhang, D.; Wang, Y. Identifying the spatiotemporal dynamic of PM 2.5 concentrations at multiple scales using geographically and temporally weighted regression model across China during 2015–2018. *Sci. Total Env.* **2021**, *751*, 141765. [CrossRef]
7. Zha, X.; Luo, P.; Zhu, W.; Wang, S.; Lyu, J.; Zhou, M.; Huo, A.; Wang, Z. A bibliometric analysis of the research on Sponge City: Current situation and future development direction. *Ecohydrology* **2021**, *14*, 2328. [CrossRef]
8. Huang, W.; Duan, W.; Chen, Y. Rapidly declining surface and terrestrial water resources in Central Asia driven by socio-economic and climatic changes. *Sci. Total Env.* **2021**, *784*, 147193. [CrossRef]
9. Naumov, I.V.; Nikulina, N.L. Scenario modelling of the impact of the dynamics of public debt on the gross regional product of Russian regions. *Financ. Theory Pract.* **2021**, *6*, 68–84. [CrossRef]
10. Yared, P. Rising Government Debt: Causes and Solutions for a Decades-Old Trend. *J. Econ. Perspect.* **2019**, *33*, 115–140. [CrossRef]
11. Nguyen, T.A.; Luong, T.T. Fiscal Policy, Institutional Quality, and Public Debt: Evidence from Transition Countries. *Sustainability* **2021**, *13*, 10706. [CrossRef]
12. Xie, D.; Duan, L.; Si, G.; Liu, W.; Zhang, T.; Mulder, J. Long-Term 15N Balance After Single-Dose Input of 15N-Labeled NH4+ and NO3− in a Subtropical Forest Under Reducing N Deposition. *Glob. Biogeochem. Cycles* **2021**, *35*, 6959. [CrossRef]
13. Lucas, R.E. On the mechanics of economic development. *J. Monet. Econ.* **1988**, *22*, 3–42. [CrossRef]
14. Carmen, M.R.; Kenneth, S.R. The EIB Project Bond Credit Enhancement Initiative to Promote Transport Investments in the European Union. *Suvrem. Promet-Mod. Traffic* **2015**, *35*, 17–20. Available online: http://worldcat.org/issn/03511898 (accessed on 31 August 2021).
15. Minea, A.; Parent, A. Is High Public Debt Always Harmful to Economic Growth? Reinhart and Rogoff and some complex nonlinearities. *Work. Pap.* 2012, 18, pp. 1–23. Available online: https://halshs.archives-ouvertes.fr/halshs-00700471/document (accessed on 31 August 2021).
16. Wu, Y. Local Government Debt and Economic Growth in China. *J. Chin. Econ. Bus. Stud.* **2020**, *18*, 229–242. [CrossRef]
17. Hildreth, W.B.; Miller, G.J. Debt and the Local Economy: Problems in Benchmarking Local Government Debt Affordability. *Public Budg. Financ.* **2002**, *22*, 99–113. [CrossRef]
18. Zhang, Y.; Luo, P.; Zhao, S.; Kang, S.; Wang, P.; Zhou, M.; Lyu, J. Control and remediation methods for eutrophic lakes in the past 30 years. *Water Sci. Technol.* **2020**, *81*, 1099–1113. [CrossRef] [PubMed]
19. Jiang, Z.; Lustig, H.; Nieuwerburgh, S.V.; Xiaolan, M.Z. What Drives Variation in the U.S. Debt/Output Ratio? The Dogs that Didn't Bark. In *NBER Working Paper Series*; National Bureau Of Economic Research: Cambridge, MA, USA, 2021; Available online: https://www.nber.org/system/files/working_papers/w29351/w29351.pdf (accessed on 31 August 2021).

20. Barro, R.J. Economic Growth in a Cross Section of Countries. *Q. J. Econ.* **1991**, *106*, 407–443. [CrossRef]
21. Zhu, Y.; Luo, P.; Zhang, S.; Sun, B. Spatiotemporal Analysis of Hydrological Variations and Their Impacts on Vegetation in Semiarid Areas from Multiple Satellite Data. *Remote Sens.* **2020**, *12*, 4177. [CrossRef]
22. Coibion, O.; Gorodnichenko, Y.; Weber, M. Fiscal Policy and Households' Inflation Expectations: Evidence from a Randomized Control Trial. In *NBER Working Paper Series*; National Bureau Of Economic Research: Cambridge, MA, USA, 2021; Available online: https://www.nber.org/system/files/working_papers/w28485/w28485.pdf (accessed on 31 August 2021).
23. Smets, F.; Wouters, R. An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area. *J. Eur. Econ. Assoc.* **2003**, *1*, 1123–1175. [CrossRef]
24. Panizza, U.; Presbitero, A.F. Public debt and economic growth: Is there a causal effect? *J. Macroecon.* **2014**, *41*, 21–41. [CrossRef]
25. Cohen, D. Low investment and large LDC debt in the 1980's. *Am. Econ. Rev.* **1993**, *83*, 437–449. Available online: https://ideas.repec.org/a/aea/aecrev/v83y1993i3p437-449.html (accessed on 31 August 2021).
26. Elmeskov, J.; Sutherland, D. Post-crisis Debt Overhang: Growth Implications Across Countries. In Proceedings of the Second International Research Conference 2012: "Monetary Policy, Sovereign Debt and Financial Stability: The New Trilemma", Mumbai, India, 1–2 February 2012; Reserve Bank of India: Kolkata, India, 2012. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1997093 (accessed on 31 August 2012).
27. Woo, J.; Kumar, M.S. Public Debt and Growth. *Economica* **2015**, *82*, 705–739. [CrossRef]
28. Pattillo, C.; Poirson, H.; Ricci, L.A. External Debt and Growth. *Rev. Econ. Inst.* **2011**, *2*, 30. [CrossRef]
29. Westphal, C.; Rother, P. The impact of Government Debt on Growth An Empirical Investigation for the Euro Area. *Rev. Econ.* **2011**, *62*, 1015–1029. [CrossRef]
30. Caner, M.; Grennes, T.; Koehler-Geib, F. Finding the Tipping Point—When Sovereign Debt Turns Bad. In *Policy Research Working Papers*; World Bank Group: Bretton Woods, NH, USA, 2010; Available online: https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-5391 (accessed on 31 August 2010).
31. Reinhart, C.; Kenneth, M.; Rogoff, S. Growth in a Time of Debt. *Am. Econ. Rev.* **2010**, *100*, 573–578. [CrossRef]
32. Mo, J. Land financing and economic growth: Evidence from Chinese counties. *China Econ. Rev.* **2018**, *50*, 218–239. [CrossRef]
33. Luo, P.; Xu, C.; Kang, S.; Huo, A.; Lyu, J.; Zhou, M.; Nover, D. Heavy Metals in Water and Surface Sediments of the Fenghe River Basin, China: Assessment and Source Analysis. *Water Sci. Technol.* **2021**, *84*, 3072–3090. [CrossRef]
34. Afonso, A.; Jalles, J.T. Growth and Productivity: The role of Government Debt. *International Review of Economics & Finance* **2013**, *25*, 384–407. [CrossRef]
35. Luo, P.; Mu, D.; Xue, H.; Ngo-Duc, T.; Dang-Dinh, K.; Takara, K.; Schladow, G. Flood inundation assessment for the Hanoi Central Area, Vietnam under historical and extreme rainfall conditions. *Sci. Rep.* **2018**, *8*, 12623. [CrossRef]
36. Ma, G.; Chen, J. The Role of Internally Financed Capex in Rising Chinese Corporate Debts. *Comp. Econ. Stud.* **2019**, *61*, 413–442. [CrossRef]
37. Xu, J.; Zhang, X. China's Sovereign Debt: A Balance-Sheet Perspective. *China Econ. Rev.* **2013**, *31*, 55–73. [CrossRef]
38. Chen, C.; Yao, S.; Hu, P.; Lin, Y. Optimal government investment and public debt in an economic growth model. *China Econ. Rev.* **2017**, *45*, 257–278. [CrossRef]
39. Bailey, W.; Fan, J.; Liu, J.; Zhou, Y. *Investing Like Conglomerates? When Local Governments Diversify Beyond Public Services*; BIS Working Papers No 920; Bank for International Settlements: Basel, Switzerland, 2021; Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3862686 (accessed on 31 January 2021).
40. Luo, P.; Mu, Y.; Wang, S.; Zhu, W.; Mishra, B.K.; Huo, A.; Zhou, M.; Lyu, J.; Hu, M.; Duan, W.; et al. Exploring sustainable solutions for the water environment in Chinese and Southeast Asian cities. *Ambio A J. Hum. Environ.* **2021**, *9*, 1–20. [CrossRef] [PubMed]
41. Zhao, B.; Yang, W. Does financial development influence CO_2 emissions? A Chinese province-level study. *Energy* **2020**, *200*, 117523. [CrossRef]
42. Zhang, J.; Li, L.; Yu, T.; Gu, J.; Wen, H. Land assets, urban investment bonds, and local governments' debt risk, China. *Int. J. Strateg. Prop. Manag.* **2020**, *25*, 65–75. [CrossRef]
43. Zheng, C.; Chen, S.; Dong, Z. Economic Fluctuation, Local Government Bond Risk and Risk-Taking of City Commercial Banks. *Sustainability* **2021**, *13*, 9871. [CrossRef]
44. Huang, Z.; Du, X. Holding the market under the stimulus plan: Local government financing vehicles' land purchasing behavior in China. *China Econ. Rev.* **2018**, *50*, 85–100. [CrossRef]
45. Mariani, R.D.; Vaden, D. Modeled salt density for nuclear material estimation in the treatment of spent nuclear fuel. *J. Nucl. Mater.* **2010**, *404*, 25–32. [CrossRef]
46. Engwerda, J.; van Aarle, B.; Anevlavis, T. Debt stabilization games in a monetary union: What are the effects of introducing eurobonds? *J. Macroecon.* **2019**, *59*, 78–102. [CrossRef]
47. De-Córdoba, G.F.; Molinari, B.; Torres, J.L. Public Debt Frontier: A Python Toolkit for Analyzing Public Debt Sustainability. *Sustainability* **2021**, *13*, 13260. [CrossRef]
48. Chen, Y.; Wu, Y. Regional Economic Growth and Spillover Effects: An Analysis of China's Pan Pearl River Delta Area. *China World Econ.* **2012**, *20*, 80–97. [CrossRef]

49. Hilscher, J.; Raviv, A.; Reis, R. Inflating Away the Public Debt? An Empirical Assessment. In *NBER Working Paper Series*; National Bureau of Economic Research: Cambridge, MA, USA, 2021; Available online: https://www.nber.org/system/files/working_papers/w20339/w20339.pdf (accessed on 31 January 2021).
50. Yang, W.; Zhao, J. Study on China's Economic Development from the Perspective of Strong Sustainability. *Singap. Econ. Rev.* **2020**, *65*, 161–192. [CrossRef]
51. Hodrick, R.J.; Prescott, E.C.; Postwar, U.S. Business Cycles: An Empirical Investigation. *J. Money Credit Bank.* **1997**, *29*, 1–16. [CrossRef]
52. Yuan, X.; Li, H.; Zhao, J. Impact of Environmental Pollution on Health-Evidence from Cities in China. *Soc. Work Public Health* **2020**, *35*, 413–430. [CrossRef] [PubMed]
53. Zhang, Y.; Huang, C.C.; Tan, Z.; Chen, Y.; Qiu, H.; Huang, C.; Li, Y.; Zhang, Y.; Li, X.; Shulmeister, J.; et al. Prehistoric and historic overbank floods in the Luoyang Basin along the Luohe River, middle Yellow River basin, China. *Quat. Int.* **2019**, *521*, 118–128. [CrossRef]
54. Backus, D.K.; Kehoe, P.J. International Evidence on the Historical Properties of Business Cycles. *Am. Econ. Rev.* **1992**, *82*, 864–888.
55. Ye, Z.; Zhang, F.; Coffman, D.M.; Xia, S.; Wang, Z.; Zhu, Z. China's Urban Construction Investment Bond: Contextualising a Financial Tool for Local Government. *Land Use Policy* **2020**, *112*, 105153. [CrossRef]
56. Yang, W.; Ban, L. The Green Sustainable Economic Development Model under Sustainable Use of Energy and Pollution Control. *Theor. Econ. Lett.* **2013**, *3*, 19–27. [CrossRef]
57. Wen, J.; Deng, P.; Zhang, Q.; Chang, C.P. Is Higher Government Efficiency Bringing about Higher Innovation. *Technol. Econ. Dev. Econ.* **2021**, *27*, 626–655. [CrossRef]
58. Duan, W.; Maskey, S.; Chaffe, P.L.B.; Luo, P.; He, B.; Wu, Y.; Hou, J. Recent Advancement in Remote Sensing Technology for Hydrology Analysis and Water Resources Management. *Remote. Sens* **2021**, *13*, 1097. [CrossRef]
59. Li, Z.; Li, D.; Yang, W.; Qi, X. The spatial-temporal evolution and spatial convergence of ecological total factor productivity in china. *Energy Environ.* **2020**, *14*, 1141. [CrossRef]
60. Zhao, B.; Yang, W. Short-run forecast and reduction mechanism of CO_2 emissions: A Chinese province-level study. *Environ. Sci. Pollut. Res.* **2020**, *9*, 1–20. [CrossRef] [PubMed]
61. Dey, S.; Saha, S.; Bhowmik, D. The Causal Nexus between Public Debt and Economic Growth, A Multivariate Time Series Analysis: Experience from a SAARC Nation. *Glob. J. Hum.-Soc. Sci. Res.* **2020**, *20*, 45–52. [CrossRef]
62. Chen, S.; Li, W. Local government debt and regional economic growth in China. *China Political Econ.* **2019**, *2*, 330–353. [CrossRef]
63. Zhao, R.; Tian, Y.; Lei, A.; Boadu, F.; Ren, Z. The Effect of Local Government Debt on Regional Economic Growth in China: A Nonlinear Relationship Approach. *Sustainability* **2019**, *11*, 3065. [CrossRef]
64. Leeper, E.M.; Leith, C.; Liu, D. Optimal Time-Consistent Monetary, Fiscal and Debt Maturity Policy. *J. Monet. Econ.* **2021**, *117*, 600–617. [CrossRef]
65. Yang, W.; Zhao, B.; Zhao, J.; Li, Z. An Empirical Study on the Impact of Foreign Strategic Investment on Banking Sustainability in China. *Sustainability* **2019**, *11*, 181. [CrossRef]