Research of Chinese Government debt sustainability and its effect on economic growth

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Abstract. This paper researches the appropriate scale of Chinese government debt from the perspective of debt sustainability and its effect on economic growth. First, we made a model based on fiscal response framework and introduced trade openness, savings ratio and so on as control variables. We use it to measure the upper limit of the sustainable debt ratio over the years. Then we did empirical research and found that government debt has a threshold effect on economic growth, with a turning point of about 33.3%. Besides, we also found that debt affects economy by affecting the formation of total society capital significantly, and excessive debt may inhibit the formation. According to our research, the government should release savings reasonably, improve its sensitivity to debt and use it more efficiently to enhance the turning point of debt impact. Government should also gradually reduce current debt ratio to optimize the relative scale of debt.

1. Introduction
After the financial crisis, many economies experienced adverse debt impacts. Economic recession, financial aid and expanded government spending have led to rapid increases in debt ratios in many countries. It has also aroused extensive discussions on the relationship between government debt sustainability, debt scale and economic growth in academic areas. There are two perspectives to study debt sustainability: theoretical model analysis and empirical indicator system. In the theoretical model, a mainstream thinking system was proposed by Bohn (2007). He put forward the idea that the current debt policy would respond to the previous period government debt ratio and constructed a framework of government debt ratio research. Later scholars such as Ostry (2010) and Ghosh (2013) made some compensation. They believed that when the debt scale is higher than the critical value, the government's ability to adjust fiscal surplus is limited (this situation is called fiscal fatigue), and the surplus is not enough to cover the actual interest expenditure of debt, which leads to the further expansion of the debt scale and eventually the outbreak of the crisis. On the other hand, the relationship between debt size and economic growth has many possibilities in theory. The mainstream view is that there exists a non-linear quadratic curve relationship. It was put forward by Checherita et al. (2012) firstly, which also accords with the theoretical analysis and empirical test. The phenomenon that the impact of government debt on economic growth has a turning point is called the threshold effect.

In China, since the financial crisis and the rapid accumulation of local government debt, the central government attached great importance to the debt problem. In 2011 and 2013, the official national debt audit result was published for the first time. Meanwhile, local debt limit management was also launched. Whether the debt of the Chinese government is in a sustainable stage and has a good role in promoting the economic growth ratio is a question worthy of study under the current situation. The
famous 60% debt ratio warning line given by the EU Treaty of Maastricht is roughly based on the average of its member level at that time, which does not necessarily have wide applicability, especially for developing countries. For example, in some Latin American countries, the debt ratio was less than 60% when the debt crisis broke out, while Japan did not break out under the debt ratio of 200%. And the scale of debt that most promotes economic growth is quite different because of the different economic environment and the use of debt. The main work of this paper is to study the upper limit of the relative sustainable scale of Chinese government debt in recent years and observe the debt space. The second is to study the relationship between debt scale and economic growth in the context of debt sustainability.

The new contributions of this paper are as follows: Firstly, this paper combine the two perspectives of debt sustainability and the threshold effect of debt on economic growth. Previous studies including Ostry (2010), Ghosh (2013) or Checherita (2012), are based on a single perspective of sustainability. In this paper, sustainability is included in the research framework. We further sought the scale that can satisfy both conditions of debt sustainability and economic growth. Secondly, in terms of debt sustainability, this paper solves the financial response function of China to explore the debt ceiling from the perspective rarely used in Chinese literature, which provides evidence for the phenomenon of financial fatigue in China. The data processing has been improved, and more accurate ratio data of China's fiscal surplus has been obtained compared with the predecessors. For the first time, China's inflation ratio and trade openness are included in the Chinese literature, which provides a new empirical study on the factors affecting China's debt ceiling. Thirdly, in terms of debt threshold effect, this paper takes into account the variables that have an important impact on China's economic growth (such as total savings ratio, real interest ratio, trade openness, etc.) and enriches the study of the turning point factors that affect debt threshold effect. Fourthly, the empirical study further finds that the impact of debt on social capital formation is a significant channel for debt to affect economic growth, which enriches the research on how debt affects economic growth. Fifthly, in view of the fact that the current situation of the developed and developing economies is the main object of study in a large number of literature. In this paper, the historical data of China as the research object, more targeted.

2. Literature review

Research on government debt risk and sustainability has the following perspectives:

Comparing the real economic growth ratio with the real debt interest ratio, comparing current assets and liabilities from the view of balance sheet, quantitatively calculating default risk or building an index evaluation system to measure. The existing analysis mainly analyzed the probability of debt default risk and relevant research were abundant. However, there are some blanks, such as little research on the relative scale of the sustainable debt ceiling. For fiscal policy reference, it is intuitive and meaningful to calculate the ceiling ratio of debt.

Academic research models on the relative scale of debt sustainability have been developed first in foreign countries. The current mainstream ideas and methods originated from Bohn (1998, 2007) who constructed a new framework to test the sustainability of government debt by using the idea that current debt policy would respond to the previous debt ratio. Follow-up scholars continue to improve it. Ostry et al. (2010) argued that when a country's debt level is too high, it is difficult for the government to adjust its basic fiscal surplus to deal with debt. So a non-linear model was introduced to simulate the fiscal response function. Ghosh (2013) put forward the idea of debt space, using the current debt ratio and debt ceiling gap to measure the sustainability of government debt. The estimated debt space can not only more intuitively reflect the sustainability, but also quantitatively reveal the degree.

On the other area about the relationship between debt and economic growth, under the framework of neoclassical economics, debt affects economic growth by influencing capital formation. It can not only squeezes out private investment, but increase public investment, therefore causing an uncertain impact on total investment and economic growth ratio. The specific empirical results depend on the relative size of the two impacts, which are related to the unique economic environment, the relative
scale of debt and even the efficiency of public investment. When the debt ratio is low, the effect of increasing public investment may be dominant, while when the debt ratio is high, the effect of crowding out private investment funds is significant. Therefore, we argue that the formation of social capital and the relationship between economic growth and debt ratio may be a quadratic curve, and there is a turning point in the effect of debt ratio on economic growth. At the empirical level, the literature on their relationship has been less. Up to recent years, Reinhart and Rogoff (2010) conducted descriptive studies using data from 44 countries and found that government debt has a threshold effect on economic growth, which aroused a sensation in the academic and political circles. Checherita et al. (2012) considered that there is a non-linear quadratic curve relationship between government debt and economic growth, which has become a widely accepted academic view.

These documents have the following characteristics. Literature on sustainability rarely directly showed the relative scale of debt from the perspective of fiscal response function. In the study of economic threshold effect, previous studies such as Checherita (2012) focused on developed countries and developing countries as a whole, rather than on a specific target like China. There are obvious differences between China and developed countries in capital formation, factor productivity and other important variables, so the group empirical conclusions are not necessarily suitable for China. In addition, more importantly, the connotation of moderatio scale in existing papers is almost only from the perspective of economic growth. This is not comprehensive. For example, Reinhart believes that the appropriate debt size of developing countries is about 90%, but the Treaty of Maastricht gives a reference value of 60% for the debt ratio ceiling. This shows that some countries are limited by sustainability and the debt scale can not reach the level that most promotes economic growth. This paper expands the connotation of moderatio scale in view of this problem.

3. Model and Data

3.1. Analysis Framework of Sustainable Government Debt

This paper mainly uses the analytical framework proposed by Ghosh et al. (2013) to establish the equation between the basic fiscal surplus (basic fiscal surplus = fiscal revenue - fiscal expenditure deducting debt expenditure) and the government debt ratio to solve the debt ceiling.

Since the gap in the basic fiscal surplus is compensated by debt financing, it can be concluded that:

\[ D_t - (1 + r_t)D_{t-1} = E_t - R_t \]  \hspace{1cm} (1)

Among them, \( D_t \) represents the balance of the debt at the end of the t period, \( R_t \) and \( E_t \) refers to the fiscal revenue and fiscal expenditure deducting debt expenditure respectively. After simplification, the equation is as follow:

\[ D_t = (1 + r_t)D_{t-1} - S_t \]  \hspace{1cm} (2)

\( S_t \) represents the basic fiscal surplus at t period. Because we care about the relative scale of these variables, the following equation is obtained by introducing GDP and simple calculation.

\[ d_t - d_{t-1} = (r_t - g_t)d_{t-1} - s_t \]  \hspace{1cm} (3)

Among them, \( d_t \) represents the government debt ratio (government debt/GDP) at the end of the t period. \( S_t \) represents the basic fiscal surplus ratio (basic fiscal surplus/GDP). \( r_t \) is the debt interest ratio and \( g_t \) is the economic growth ratio. \( (r_t - g_t)d_{t-1} \) represents the ratio of actual interest expenditure in the t period.

To further study the upper limit of debt ratio through this equation, we need to estimate the fiscal response function, that is, the relationship between basic fiscal surplus ratio and debt ratio. In this paper, we adopt the conclusion that the relationship is non-linear put forward by Ostry (2010) and Ghosh (2013). They believe when the debt ratio starts to rise from a lower level, the government will increase the basic fiscal surplus to tackle it. But when the debt ratio exceeds a certain level, the basic
fiscal surplus ratio will decrease with the increase of the debt ratio because of the limited ability. This paper constructs the following fiscal response function:

\[ s_t = a_0 + f(d_{t-1}) + X_t + \varepsilon_t \]  

(4)

\( f(d_{t-1}) \) is the cubic function of debt ratio. \( X_t \) represents other control variables that may affect the basic fiscal surplus. The significant ones from previous research results are inflation ratio, trade openness, output gap, government expenditure gap (Ghosh, etc.), economic growth ratio (proposed by Tang Wenjin), and savings level (proposed by Hoshi).

In the fiscal response function, the government debt ratio data comes from the IMF. As for the calculation of the basic fiscal surplus ratio, this paper calculates the accurate basic fiscal surplus ratio on the basis of China Fiscal Yearbook. Inflation ratio, nominal GDP comes from the National Bureau of Statistics. The degree of trade openness comes from China's Foreign Trade Statistics Yearbook. Referring to the research of Tang Wenjin (2014), the non-stationary economic growth ratio is used to replace the output gap and fiscal expenditure gap as explanatory variables. The data of economic growth ratio comes from the National Bureau of Statistics. The data of residents' savings deposit balance come from the National Bureau of Statistics and the People's Bank of China.

After calculating the fiscal response function, the debt ceiling can be obtained by substituting it into equation (3).

Analysis Framework of Government Debt and Economy Growth

Referring to Checherita’s (2012) idea, this paper sets the government debt ratio as the main explanatory variable. The equation is as follows:

\[ g_{t+5} = a_0 + h(d_t) + a \ln gdp_t + X_t + \varepsilon_t \]  

(5)

In the regression equation, the response variable is the medium-term economic growth ratio. We use the real average per capita GDP growth ratio in the next five years as an agent, which can eliminate the impact of economic fluctuations and endogenous problems.

\( d_t \) refers to government debt ratio. In economic theory, government debt has both positive and negative effects on economic growth. Government debt is represented by the government debt ratio. The data comes from IMF.

\( h(d_t) \) is a function of debt ratio. We adopt the quadratic function form proposed by Checherita (2012) of it. In China, the specific form of this function can be further judged according to the image. \( \ln gdp_t \) is the logarithm of per capita real GDP. \( X_t \) represents the control variables. This paper chooses Martin (2004) and Checherita (2012) theory and empirical results as reference to select the total savings ratio (sav), real interest ratio (rir), trade openness (tra), dependency ratio of the elderly population (old), population growth ratio (pop), as control variables. Data comes from National Bureau of Statistics, People's Bank of China, World Bank, China Foreign Trade Statistics Yearbook.

4. Empirical Analysis

4.1 Calculating the upper limit of Chinese government debt ratio

4.1.1 Estimating Fiscal Response Function

Fiscal response function is the basis of solving the dynamic equation of government debt. According to the latest research, this function is a non-linear (cubic) function because of financial fatigue. From the figure, this phenomenon does exist in China. Therefore, the financial response function is constructed as follows:

\[ s_t = a_0 + f(d_{t-1}) + X_t + \varepsilon_t \]  

(6)
The unit root test of all variables shows that the first order difference of all variables passes the stationarity test at 1% significance level. This paper estimates the fiscal response function in four forms of the $f(d - i)$, uses stepwise regression method to determine the proper specific form of the cubic function, and excludes the economic growth ratio in the explanatory variables. The regression results of the equation are shown in Table 1.

### Table 1. Estimated results of fiscal response function

| Variable               | Correlation coefficient | Standard error | P-value |
|------------------------|-------------------------|----------------|---------|
| Constant term          | 0.0330                  | 0.010          | 0.009   |
| Debt Ratio             | 1.5366                  | 0.382          | 0.0008  |
| Squared Term           | -1.5380                 | 0.405          | 0.001   |
| Cubic Term             | -0.4491                 | 0.121          | 0.001   |
| Resident savings ratio | -0.0655                 | 0.016          | 0.0005  |
| Trade openness         | 0.0827                  | 0.015          | 0.0000  |
| Inflation ratio        | -0.0690                 | 0.020          | 0.008   |

| R²                     | 0.846                   |                |         |
| Adj R²                 | 0.797                   |                |         |
| DW stat                | 1.970                   |                |         |
| Prob(F)                | 0.000                   |                |         |

The explanatory power and significance of the equation are good, and the coefficients of variables are significant at 0.01 level. Residual items pass the EG co-integration test to exclude the possibility of "pseudo-regression". DW statistic shows that there is no autocorrelation in random error terms. From the result, we can see high inflation will have a negative impact on the adjustment of China's basic fiscal surplus. Increasing trade openness helps to reduce debt risk. It is worth mentioning that the saving ratio coefficient is significantly negative, proving our theory assumption that in China, excessive savings ratio will weaken the government's response and regulatory capacity to debt.
cubic-term coefficient of government debt ratio is significantly negative, which confirms the phenomenon of "fiscal fatigue" in China.

4.1.2 Calculating the upper limit of government debt ratio

The expression of fiscal response function is obtained and therefore we can solve equation (3). It means:

\[ (r_t - g_t) d_{t-1} - s_t = 0 \]  

(7)

Using equation (7) and data, we can get the upper limit of government debt ratio over the years, as shown in Figure 2. It can be seen that the upper limit of the debt ratio of the Chinese government varies from 53.8% (2016) to 70.3% (2007), which is also close to the "Maastricht Treaty". From 2003 to 2007, with the increase of trade openness, high economic growth and the release of savings ratio, the debt ceiling increased. After 2008, due to the impact of the financial crisis, economic growth slowed down gradually, while trade openness began to decline from the peak in 2006, and the savings ratio also maintained a high upward trend, which had a negative impact on the debt ceiling.

![Figure 2. Chinese debt ceiling between 2003-2016](image)

Measuring Turning Point of Government Debt Economic Effect

Referring to the analytical framework of Checherita et al. (2012), the model is set as follows:

\[ g_{t+1, t+5} = a_0 + h(d_t) + a_1 \ln gdp_t + X_t + \varepsilon_t \]  

(8)

Considering the scale of government debt ratio was very small before 1994, the sample period of this paper is 1995-2016. The specific form is judged by observing scatter plots. As can be seen from Figure 3, quadratic function is more suitable for simulation.
First, we did ADF test, and the first-order difference of all variables passed the stationarity test at 1% significance level. In this paper, we use the stepwise regression method and eliminate the control variable of population growth ratio. The regression results of the final equation are shown in Table 2.

Table 2. Estimation results of equation

| Variable | correlation coefficient | Standard error | P-value |
|----------|------------------------|----------------|---------|
| $d_t$    | 3.6960                 | 0.69           | 0.0010  |
| $d_t^2$  | -5.5500                | 1.28           | 0.0017  |
| $\ln gdp_t$ | -0.0474          | 0.02           | 0.0403  |
| $rir_t$  | 0.1340                 | 0.05           | 0.0179  |
| $tra_t$  | 0.0970                 | 0.10           | 0.0143  |
| $old_t$  | 1.6178                 | 0.83           | 0.0818  |
| $sav_t$  | -0.1430                | 0.07           | 0.0403  |
| Constant term | -2.086              | 0.10           | 0.0503  |

$R^2$  0.9485
Adj $R^2$ 0.9085
DW stat 2.3400
Prob(F) 0.0000

The model is significant and has good explanatory power. The P value of cointegration test is less than 0.01, which excludes pseudo-regression. The DW value indicates that there is no autocorrelation. Heteroscedasticity White test shows that the model has no heteroscedasticity.

As per capita GDP rises, Chinese economic growth slowed down. Opening trade and rising real interest ratios could help stimulate economic growth. The coefficient of dependency ratio of the elderly population is positive, it is very interesting. Obviously, it is not because the increase of the proportion can directly promote economic growth, but because of China's "demographic dividend" period in the process of population aging in the past two decades. "Demographic dividend" means that there has been an increase in the proportion of working-age population and a period of abundant labor resources. The explanation is consistent with the fact that the proportion of working-age population (15-64 years old) in China rose in the past two decades (data from the National Bureau of Statistics).
The total savings ratio coefficient is negative. A reasonable explanation is that excessive savings may inhibit household consumption, thus inhibiting the enthusiasm of social investment in production, which makes the savings funds unable to effectively transform into productive capital.

From the estimation results, we can estimate that the turning point of government debt in China is about 33.3%. That is to say, when the relative scale of government debt exceeds this value, the marginal effect of increasing debt on economy will be negative. The critical value obtained in this paper is close to that in some famous literature. For example, Kumar's famous paper (2010) also found that when the government debt ratio was less than 30%, the impact of government debt on economic growth was positive. When the government debt ratio was between 30% and 90%, the overall impact of the increase of government debt ratio on economic growth was negative.

4.2 Exploring how government debt affects economic growth

Under the neoclassical framework, capital accumulation is most closely related to debt among the driving forces of economic growth ratio. Therefore, government debt affect economic growth through affecting total social investment or capital formation is an obvious theoretical channel. This paper will explore the assumption.

We use total capital formation ratios to measure the variable of capital accumulation (total capital formation ratio = total capital formation / GDP). Data comes from the World Bank web. The government debt ratio is taken as the main explanatory variable, and the sample period is 1994-2016. We refers to Fan Xiaoyun(Chinese NanKai University Finance Prof.)'s research(2014), and chose the lagging total capital formation ratio, lagging per capita GDP growth ratio, lag savings ratio and current real interest ratio as the control variables. The econometric model is constructed as follows:

$$\text{Cap}_t = a_0 + h(d_{t-1}) + \text{Cap}_{t-1} + X_t + \epsilon_t \tag{9}$$

We did unit root test. It was found that the first-order difference of total capital formation ratio and its lag term passed the test at the 5% significant level, while the first-order difference of other variables passed the stationarity test at the 1% significant level. Using stepwise regression method, the measurement results are shown in Table 3.

| Variable     | Correlation coefficient | Standard error | P-value |
|--------------|-------------------------|----------------|---------|
| Constant term| -0.198                  | 0.061          | 0.007   |
| $d_{t-1}$    | 2.557                   | 0.502          | 0.000   |
| $d_{t-1}^2$  | -3.613                  | 0.808          | 0.000   |
| $g_{t-1}$    | 0.316                   | 0.179          | 0.097   |
| $\text{Cap}_{t-1}$ | 0.417              | 0.151          | 0.015   |
| R2           | 0.965                   |                |         |
| Adj R2       | 0.955                   |                |         |
| DW stat      | 2.160                   |                |         |
| Prob(F)      | 0.000                   |                |         |

The model is very significant and the explanatory is good. It also passed the EG cointegration test and we excluded the pseudo-regression. According to the empirical test results, we reasonably infer that in China, the impact of government debt on the formation of total capital is also a quadratic curve, with a turning point of about 35.4%. When the debt ratio exceeds 35.4%, the marginal effect of government debt on total capital is negative. This means that the crowding-out effect of government debt ratio on capital formation exceeds the effect of increase of public investment. This data is very similar to the turning point of government debt on economic growth ratio above. It can be reasonably
inferred that government debt affects economic growth by affecting total social investment is reasonable and significant.

5. Conclusions and recommendations
This paper combines debt sustainability and debt threshold effect to study the Chinese government debt problem for the first time. In terms of debt sustainability, based on the analysis framework of Ghosh (2013), this paper introduces the savings ratio, trade openness and inflation ratio as control variables for the first time to study the situation of Chinese government debt, and calculates the upper limit of China's government sustainable debt ratio for consecutive years.

The conclusions are as follows. Firstly, there is indeed a phenomenon of "fiscal fatigue" in China. The adjustment ability of basic fiscal surplus is limited, and it will gradually fail when the debt ratio exceeds a point. Secondly, in China, high inflation will increase debt risk, while the improvement of trade openness will enhance fiscal adjustment ability and high savings ratio has a negative effect on fiscal surplus adjustment. Finally, at this stage, there is still a little room for Chinese government debt, which has gradually approached the upper limit. In the future, debt prevention and control needs to be monitored dynamically.

About the threshold effect of government debt on economic growth. For the first time, based on the idea of Checherita (2012), this paper conducts empirical research on China and finds that: firstly, the government debt ratio has a quadratic function effect on economic growth with a turning point of about 33.3%, so the marginal benefit is negative when the government debt ratio exceeds this point. Secondly, trade openness promotes economic growth, while high savings does not directly promote economic growth. It may be because high savings has inhibited the normal consumption of residents and the production investment of enterprises. In addition, we should use saving funds for more efficient investments, so as to transform saving into real productive capital.

In addition, this paper further analyses the mechanism of government debt's effect on economic growth, and concludes that the channel which government debt affects economic growth by affecting the formation of social total capital is reasonable and obvious. It is also find that previous research believe government debt can promote capital formation and society investment, but if it exceeds a certain limit, it will also inhibit the formation of total social capital. The turning point of government debt ratio on society capital formation is about 35.4%. After exceeding this scale, the crowding-out effect of government debt ratio on capital formation exceeds the effect of increase of public investment and finally reduces the formation of total social capital.

This paper holds that the appropriate scale of Chinese government debt should be around 33.3% and puts forward following opinions. Firstly, Chinese government should take measures to help to release the savings ratio reasonably to form social consumption and investment, improve its sensitivity to debt and monitor the debt ceiling and real scale dynamically to ensure that it does not exceed the ceiling. Secondly, Chinese government should gradually reduce relative proportion of debt to GDP in order to optimize government debt ratio. In addition, increasing the efficiency of public investment or transfer more government debt to useful public investment can not only increase the turning point (proper size) of debt, but also help to promote economic growth.

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