The Nonlinear Relationship between Inflation and Economic Growth--Empirical Analysis Based on Panel Threshold Model

Jiahui Wu and Rong Chen*

College of Economics, Sichuan Agricultural University, Chengdu, 611130, China

Keywords: Inflation; Economic Growth; Panel Threshold Model; Non-linear Relationship

Abstract: Based on the provincial panel data from 30 provinces in China from 1997 to 2018, the article empirically tests the impact of inflation on economic growth by using the panel threshold regression method, taking China's inflation rate as the threshold variable and the core explanatory variable. The results show that China's inflation rate has a "single threshold effect" on economic growth, with a threshold value of 2.9%, there is a non-linear relationship between China's inflation rate and economic growth. There is a negative correlation between economic growth and inflation when inflation is below the threshold, and there is a significant positive correlation between growth and inflation when the inflation rate is above the threshold.

1. Introduction

To maintain sustained and stable economic growth and control of inflation are among the main objectives of macroeconomic policy choices. However, the " mysterious" relationship between inflation and economic growth complicates the issue of economic policy choices. Although the research on the influence of inflation on economic growth is one of the key issues in economic theory, it is still inconclusive. Looking back at the first 10 years of the "financial crisis" (1998-2007), China's GDP growth rate and CPI growth rate data show that in the first five years of deflation or low inflation (mean -0.38%), the average economic growth rate of China was 8.24%. In the next five years of moderate inflation (mean 2.64%), the average economic growth rate is 11.02%. The average economic growth rate in 2008-2012 is 9.32%, however, the average inflation rate is 3.3%. Therefore, people can't help thinking, what is the real relationship between inflation and economic growth?

2. Literature Review

For a long time, there are three main findings in theoretical analysis and empirical testing of inflation and economic growth: (1) Neutral theory: the view holds that there is no link between inflation and steady economic growth, i.e. there is no significant correlation between the two (Bullard et al., 1995); (2) Tobin effect theory: under the assumption that money and capital can be completely replaced, it is found that inflation plays a positive role in the process of economic development (Tobin, 1965); (3) Anti-Tobin effect theory: under the assumption that money is a complement to capital, Stockman found that inflation plays a negative role in the process of economic development, i.e. "anti-Tobin effect"(Alexander, 1997). Obviously, it is unreasonable to attribute the connection of the two simply to the theory of " Neutral theory", "Tobin effect" and "Anti-Tobin effect". The most popular view at the moment is that the influence of inflation has a threshold value, which helps economic development when it is below the threshold, and which suppresses growth when it exceeds that threshold (Dunaev, 2007； Kremer et al., 2011). Therefore, in the relationship of the two, most economists in recent years agree that moderate inflation is conducive to economic development, and high inflation plays a negative role. That is, the role of inflation plays in the process of economic development has an optimal target range, in which there is a "Tobin effect"; otherwise, there is an "Anti-Tobin effect".

Domestic scholars have also carried out a lot of research on the connection between them from different perspectives. Liu Jinquan et al. (2003) pointed out that there is a significant positive

correlation, moderate inflation helps the economy maintain rapid development. Wang Shuangzheng (2009) based on the VAR model research on the connection of them, the results show that there is a two-way granger causality connection, moderate inflation is conducive to economic development, and excessive or worsening inflation will adversely affect economic development. At the same time, rapid economic growth will also lead to follow-up inflation. The research of Zhou Wen et al. (2012) points out that the two variables have a similar change relationship, and there is a stable equilibrium between the two in the long run, which has the potential synchronization. Zeng Zhi et al. (2014) used the threshold auto-regression model to demonstrate this question. The results showed that inflation has a significant threshold effect on economic development, which plays a promoting role below the threshold limit, and hinders economic growth above the threshold limit.

3. Methodology and Variables

3.1. Panel Threshold Model

The value to be estimated in the traditional linear model is stable, assuming that the effect of the explanatory variable on the interpreted variable is steady state. While this setting explains the relationship between the two to some extent, it may overlook the nonlinear connection between the variables, the effect of X on Y may change with X (or other factors). This kind of economic phenomenon is more common in real life, such as the back bend of the labor supply curve, the labor supply will not be increased with the wage increase. In the empirical study of nonlinear relationship, some literatures solve nonlinear problems by adding squares, but there are great problems in this method. First of all, a single item and square diffraction will cause the model to have multiple collinearity problems; Secondly, the introduction of squares represents the nonlinear relationship between the left and right sides is symmetrical, but no theory suggests that this must be established. Therefore, for purpose of test the possible structural change interaction between the subjects, this paper will use Hansen (1996) panel threshold model to study the nonlinear connection between inflation and economic development. The general function of the panel threshold model is as follows:

$$y_{it} = \mu_i + \beta_1 x_{it} \cdot 1(q_{it} \le \gamma) + \beta_2 x_{it} \cdot 1(q_{it} > \gamma) + \varepsilon_{it} \tag{1}$$

y_{it} is the interpreted variable, x_{it} is the explanatory variable, β_1、β_2 is the parameter to be estimated; q_{it} represents the threshold variable, γ is the threshold value; $1(\cdot)$ represents an indicative function, if the expression is true in parentheses, the value is 1; ε_{it} is a random perturbation. According to the value of the indicative function, equation (1) can also be written as follows:

$$y_{it} = \mu_i + \beta_1 x_{it} + \varepsilon_{it}\ ,\ \ if\ q_{it} \le \gamma \tag{2}$$

$$y_{it} = \mu_i + \beta_2 x_{it} + \varepsilon_{it}\ ,\ \ if\ q_{it} > \gamma \tag{3}$$

Since the exact threshold quantity and value have yet to be tested by the subsequent threshold effect, we first assume that there are N threshold values, and the model is set as follows:

$$\begin{aligned} GR_{it} = \mu_i + \beta_{11} infla_{it} \cdot 1(infla_{it} \le \gamma_1) + \beta_{12} infla_{it} \cdot 1(\gamma_1 < infla_{it} \le \gamma_2) + \cdots \\ \cdot + \beta_{1n} infla_{it} \cdot 1(\gamma_{n-1} < infla_{it} \le \gamma_n) + \beta_2 Z_{it} + \varepsilon_{it} \end{aligned} \tag{4}$$

GR_{it} is the economic growth rate, $infla_{it}$ is the inflation rate, which is the core explanatory variable and threshold variable of this paper; Z_{it} is a series of control variables, including the natural growth rate of population($popu_{it}$), the proportion of investment in GDP(inv_{it}), openness($open_{it}$), foreign trade level($ftrade_{it}$) and the proportion of government expenditure in GDP(gov_{it}).

3.2. Variables and Data

This paper uses the real GDP growth rate to represent the economic development level,

and $infla_{it}$ is the inflation rate calculated according to the CPI growth rate, the calculation formula is $infla_{it} = (CPI_{it} - 100)/100$.

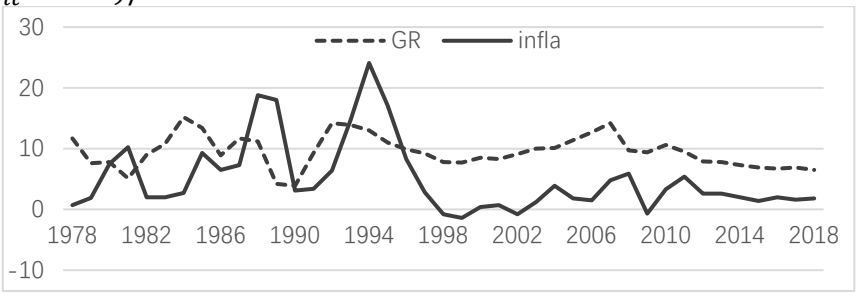

Figure 1 1978-2018 China's Economic Growth Rate and Inflation Rate

For purpose of study the direct link between inflation and economic growth, the indirect effects between them need to be controlled. There are many factors affecting economic development, and be built on summarizing the research conclusions of previous people, the following control variables are introduced: (1) The natural growth rate of population ($popu_{it}$): Since the founding of China, our country has been enjoying a huge demographic dividend. But in recent years, with the growth of the economy, and the increase in the cost of living and the improvement of education, China's natural population growth rate shows a downward trend, so the natural growth rate of population has an important influence on the economic development of a country. (2) The proportion of investment in GDP (inv_{it}): As one of the "troika" to promote economic growth, investment has contributed to economic growth. Therefore, the proportion of fixed investment in GDP is selected as one of the control variables. (3) Openness ($open_{it}$): In an open economy, the degree of openness will be related to the risk of economic growth. The greater openness of a region, the greater impact of domestic economic growth by foreign economic fluctuations. The calculation formula for $open_{it}$ is the share of total imports and exports to GDP. (4) Foreign trade level ($ftrade_{it}$): The continuous expansion of the trade surplus will lead to the excessive growth of currency issuance, which induces the inflation of demand labor, and China has always had a large trade surplus. The calculating formula for $ftrade_{it}$ is the proportion of exports in total imports and exports. (5) The proportion of government expenditure in GDP (gov_{it}): The socialist market economy has both visible and invisible hands, so government expenditure has a very important influence on economic development.

Based on the availability of macroeconomic data, this paper uses panel data from 30 provinces in China from 1997 to 2018 (excluding Tibet, Hong Kong, Macao and Taiwan) for empirical analysis, from the Yearbook of China Statistics and the Statistical Yearbook of various provinces, as well as CSMAR Database. Table 1 is the descriptive statistic of the variable. From 1997 to 2018, China's economic growth rate and inflation rate averaged about 9% and 1.9%. Although economic growth has slowed in recent years, it is still above 6%, and inflation remains in a moderate region, with greater volatility before 1997 and less volatility after 1997.

4. Results and Discussion

4.1. Threshold Effect Test and Determination of Threshold Value

For purpose of checking whether there is a nonlinear conversion relationship between inflation and economic growth, this paper uses stata16 software to carry out the threshold effect test with the original assumption that there is no single, double and triple threshold. Table 2 reports the results of the test for the model threshold effect at 300 bootstraps.

Based on the model (4) estimated threshold limits, $\hat{\gamma}_1$=2.9% and the confidence interval at the 5% significance level is [0.5%， 2.96%]. According to the bootstrap method mentioned above, significance test was conducted for the threshold effect of the model, and the results are shown in table 2.

Table 1 Summary statistics

Variable Type	Variable Name	Obs	Mean	Std. Dev.	Max	Min
Explained Variable	GR	660	0.1055	0.0284	-0.025	0.238
Explanatory Variable	infla	660	0.0200	0. 0212	-0.036	0.1009
Control Variable	popu	660	0.0057	0.0031	-0.019	0.0149
	inv	660	0.5777	0.2544	0.1921	1.4795
	open	660	0.2995	0. 3765	0.0168	1.7215
	ftrade	660	0. 5679	0. 1452	0. 1461	0. 9066
	gov	660	0. 1889	0. 0928	0. 0518	0.6269

Table 2 Inspection of the threshold effect of inflation on economic growth

Threshold model	F statistic	Threshold value	Critical value at		
			10%	5%	1%
Single	126.55***	0.029	18.8325	21.4667	26.0604
Double	4.58		11.3452	12.7466	17.8394
Triple	4.84		11.1356	13.2711	17.0528

*p < 0.1; **p < 0.05; ***p < 0.01.

According to the test results, at the level of 1% significance, F statistics reject the original assumption that there are no thresholds and two thresholds, but cannot reject the zero hypothesis of having a threshold. Therefore, the non-linear effect of inflation on economic growth can be examined by the single threshold regression model of panel data, and the narrow threshold confidence interval further indicates that the system divided by threshold is accurate. The results show that connection between the two will change with the inflation rate, there will be a single threshold effect of nonlinear structure transformation, and the structural mutation point is 2.9% inflation rate.

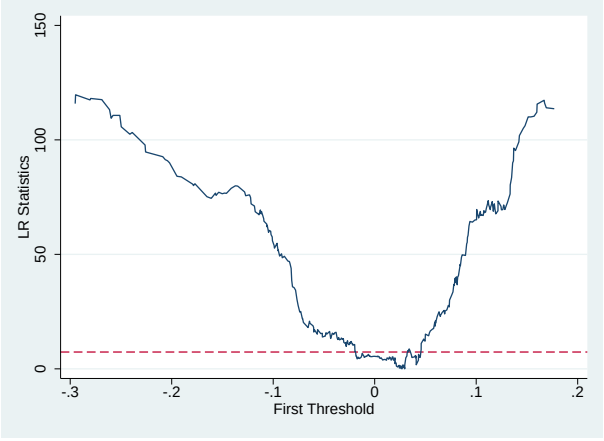

Figure2 The LR Statistic graph

4.2. PTR Estimation Results

Verify the outcomes according to the previous test, inflation has a single threshold effect on economic development, and characterized by a single threshold of 2.9 %. Therefore, the specific model can be determined as shown in formula (5) and the estimates are shown in Table 3.

$$GR_{it} = \mu_i + \beta_{11} infla_{it} \cdot 1(infla_{it} \leq 0.029) + \beta_{12} infla_{it} \cdot 1(infla_{it} > 0.029) + \beta_2 popu_{it} + \beta_3 inv_{it} + \beta_4 open_{it} + \beta_5 ftrade_{it} + \beta_6 gov_{it} + \varepsilon_{it} \quad (5)$$

Table 3 Estimation Results of Panel Threshold Model

Variable	Coefficient	Standard Error	T Statistic
_cons	0 .1066 ***	0.0098	10.93
popu	-5.5708***	0.7752	-7.19
inv	0.0062*	0.0066	0.94
open	0.0655 ***	0.0079	8.23
ftrade	0.0283**	0.0116	2.44
gov	-0.1060***	0.0272	-3.89
infla($infla_{it} \leq 2.9\%$)	-0.0939***	0.0144	-6.51
infla($infla_{it} > 2.9\%$)	0.2217***	0.0196	11.26

*p < 0.1; **p < 0.05; ***p < 0.01.

The empirical consequence indicates that the influence of inflation on economic development changes with the change of inflation rate, showing obvious single threshold characteristics. In particular, when inflation is below the threshold of 2.9%, there is a negative correlation between them. There is "Anti-Tobin Effect" on economic development when inflation rate is too low. On the other hand, if inflation rate is above the threshold of 2.9%, there is a positive correlation between them, with a "Tobin effect". This conclusion is in part in line with the conclusions of previous generations, but the empirical results in the previous literature suggest that there are two thresholds on how inflation acts on economic development. When inflation falls below the first threshold, inflation is good for economic growth; when inflation is between the second and third threshold, higher inflation will hold back economic growth to some extent; and hyperinflation will seriously hinder economic development when inflation is above the third threshold. By comparing the previous article, because of the different measures of inflation, the inflation calculated in this paper is less than the previous article, the maximum value is 10.09%, or even lower than the second threshold of some articles, because of the data used, there is only one threshold in the empirical results of this paper.

The coefficient of $popu_{it}$ is significantly negative, which indicates that natural population growth rate acts on economic development negatively. Gao Xiaoying (2018) analyzed the relationship between them, found that population growth has different influences on GDP in different ranges, with a threshold of 0%. In the range of less than 0%, the influence of population growth acts on GDP is significant positive, but not in the range of more than 0%, and the natural growth rate of China's population is greater than 0% in the window period.

The coefficient of inv_{it} is significantly positive, as one of the three carriages that drive economic growth, investment plays a crucial part in promoting economic development. The coefficient of $open_{it}$ and $ftrade_{it}$ are significantly positive, under the background of economic globalization, the development of a country is no longer unique, but a win-win global cooperation, so the degree of openness and the level of foreign trade both play an crucial role in promoting economic development. The coefficient of gov_{it} is significantly negative, the reason may be that the use of government expenditure is not efficient, resulting in waste of resources, or the impact of government expenditure on GDP is non-linear, so the two are negatively correlated.

5. Conclusion

Through empirical analysis, it is found that the way inflation acts on economic growth in China has a "single threshold effect" of a threshold value of 2.9%, there is a non-linear connection between the two. When inflation is below the threshold, inflation plays the role of a negative hindrance, and when inflation is above the threshold, it plays the role of a positive stimulation. Such

statistical conclusions support the theory that "moderate inflation helps the economy maintain rapid growth".

But according to the literature, in addition to this threshold, there should be another threshold, once inflation is above the second threshold, inflation will create a negative headwind; and even seriously hamper economic development. Therefore, the relationship between inflation and economic growth is like walking a tightrope. The complicated relationship will bring difficulties to the formulation and operation of economic policies, but also bring profound enlightenment to the formulation and adjustment of economic policies. When inflation exceeds or falls below a certain level, it will produce a bad influence on a country's economic development. This means that there is an optimal level of inflation, which is salutary to maintain moderate economic development and prevent hyperinflation.

There is no single definite relationship between inflation and economic growth, and the relationship may be quite different in different countries (regions) or different periods of the same country(regions). China's inflation is generally low, so the government can flexibly use monetary policy to make the inflation rate rise moderately and control it within a reasonable limit, thus promoting China's economic growth.

Reference

[1] Alexander W R J. Inflation and economic growth: evidence from a growth equation[J]. Applied Economics, 1997, 29(2): 233–238.

[2] Bullard J, Keating J W. The long-run relationship between inflation and output in postwar economies[J]. Journal of Monetary Economics, 1995, 36(3): 477–496.

[3] Dunaev B B. Inflation function of the money supply and level of unemployment under equilibrium conditions in a market system[J]. Cybernetics and Systems Analysis, 2007, 43(4): 586–597.

[4] Liu J, Xie W. Dynamic correlation between economic growth and inflation in China[J]. The World Economy, 2003(06): 48–57.

[5] Kremer S, Bick A, Nautz D. Inflation and growth: new evidence from a dynamic panel threshold analysis[J]. Empirical Economics, 2013, 44(2): 861–878.

[6] Wang S. Research on the relationship between inflation and economic growth based on VAR model[J]. Economic Theory and Economic Management, 2009(01): 21–27.

[7] Tobin J. Money and Economic Growth[J]. Econometrica, 1965, 33(4):671-684.

[8] Zhou W, Zhao G. China's GDP growth and CPI: relationship, balance and "12th five-year plan" target control[J]. Economic Research, 2012, 47(05): 4–17.

[9] Guo X. Analysis of the influence of population growth and age structure change on economic growth[D]. Dongbei University of Finance and Economics, 2018.

[10] Zeng Z, Wang S. Inflation, economic growth and money supply -- an empirical study based on MS-VAR model[J]. Zhejiang Financial, 2015(08): 4–9.