Cointegration Analysis of Government R&D Investment and Economic Growth in China

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Abstract Government R&D investment has been playing a very important role in the economic development. Based on the data from 1978 to 2008 issued by China Statistical Bureau, this paper analyzes the dynamic equilibrium relationship between government R&D investment and economic growth by using cointegration analysis in econometrics. The results show that there is stable long-term balancing relationship between the government R&D investment and economic growth in China, and government R&D investment is main causation which brings about economic growth.
Key words Economic growth; Government R&D investment; Granger causality; Error correction model

1 Introduction

At present, China is being in the strategy opportunity time, and enhancement independent innovation ability has become the current economy development an important topic in China. Although China has initially established a diversified R&D investment patterns, the Government R&D investment till plays an important role in a long time due to the enterprises' size limit. In 2008, the proportion of government funds in collection of R&D funds has reached 23.1% and accounts for a large proportion, however, how government R&D investment impact on economic growth in China, and how to play a more effective of government R&D investment in economic growth and improve capacity for independent innovation. In this paper, we studied the relation between the government R&D investment and economic growth of China from the demonstration aspect in the time-serial dynamic balanced relation's cointegration analysis technique in econometrics, with the statistical data issued by China statistic bureau from 1978to 2008.

2 The Model and Method of the Cointegration Analysis

Cointegration Analysis is a technique used to estimate the long-term equilibrium parameter in the nonequilibrium variable equation, and it has been broadly used in the dynamic model enactment, estimating and test, also, it has strong stability and reliability and can avoid illusive regression, overcome various difficulties of the traditional measure analysis used in nonequilibrium economic time-serial analysis. When carrying out the cointegration analysis, the general order is test the stability of time-serial variable and its single-order difference serial firstly, then, test the cointegration relationship of the variables, establish the error correction equation between the cointegration variable and the equilibrium, at last, furtherly test the causality of the cointegrated time-serial variables again.

2.1 Equilibrium test of the time-serial variables

Generally speaking, if the mean and variance of a time-serial keep stable at any time, and the covariance (or autocovariance) between the period of t and $t+k$ only depends on the distance (interval or lag) k of the two periods, and irrelevant with the real period t of these covariances, then the time-serial is smooth. The time-serial won't be smooth if those three conditions are not all meeted. Another method to express non-stability is known as unit root, which can transform the test of non-stability into the test of unit root. The variable x_t has unit root if the single-order difference of which is stable, and this process is known as unit root test. In this paper, the ADF method is used to test the variables' stability, analyse as follows:

$$\Delta x_t = \alpha_0 + \alpha_1 t + \alpha_2 x_{t-1} + \sum_{i=1}^{k} \alpha_{3i} \Delta x_{t-i} + \mu_t \quad (1)$$

and then, carry out hypothesis test: H_0: $\alpha_{0;}$ H_1: α_2<0. If accept the hypothesis H_0, and reject H_1, then the serial has unit root, and the serial is not smooth; otherwise, the serial x_t has no unit root, and the serial is smooth. We have to add k lag items into equation (1) which can transform the residual error to flat noise.

It needs to test stability of the single-order difference (or growth rate), if the variable is not smooth. The variable is I (1) if its single-order is smooth. All the variables' single-order are smooth is the requirement that the variables have cointegration relationship.

2.2 Cointegration analysis of the time-serial variables

Cointegration stands for that two or more time-serial's linear combination is smooth, though a single time-serial is not smooth. The variables involved in the cointegration analysis are all non-smooth, but they drift together. This collective drift of the variables make that there are long-term linear relation among the variables, and then, the study of the long-term equilibrium relationship among the economic variables becomes possible. The significance of cointegration is that it exposits a long-term stable equilibrium relationship, meets the situation that the economic variables can't be too distant from each other, a single time attack only can make them leave the balanced station in short time, and will return to the balanced station automatically in the long term. The economic significance of the cointegration is that there is a long-time equilibrium relationship if there are two variables, which both have long time fluctuant discipline, and it is cointegrated between these two variables. Whereas, there is no long time balanced relation between the two variables if they are not cointegrated. Now, there are many idiographic technique models about the test and estimation to the cointegration relation, such as Engle-Granger two-step process, Johnhansen maximum likelihood method, frequency domain non-parameter spectrum regression method, etc. We choose the Johnhansen maximum likelihood method to test the cointegration relation of the variables in this paper. Johnhansen maximum likelihood method can determine the number of cointegration equation, and this number is called cointegration order. The cointegration likelihood ratio is hypothesized as:

H_0: There are r cointegration relations at most H_1: There are m cointegration relations

Test the trace statistics

$$Q_r = -T\sum_{i=r+1}^{m}\log(1-\lambda_i)$$

λ_i is the i th eigenvalue, T is the observation period's total number. This is a series of test corresponding to r's different value, not an unaided test. From the null hypothesis that the test has no cointegration relation, to there is only one cointegration relation at most, to there are m-1 cointegration relation at most, there are m tests and the alternative hypothesis don't change.

There are five possible situations in Johnhansen maximum likelihood method's analysis frame: the serial has mean value and the cointegration equation has no intercept item; the serial has mean value and the cointegration equation has intercept item; the serial has mean value and linear trend item, the cointegration equation has no intercept item; the serial has mean value and linear trend item, the cointegration equation has intercept item and linear trend; the serial has mean value, linear and quadratic trend item, and the cointegration has intercept item and linear trend item. To the given cointegration order, the five tests above are strictly decreasing.

2.3 Error correction model

Cointegration analysis also can be used in the estimation of the short-term of non-balanced parameter, according to Granger Theory, variable X_t has long-term equilibrium relationship with variable Y_t if these two variables are cointegrated. However, in short term, these variables can be not balanced. The turbulency item is the equilibrium error ξ_t, the dynamic structure of the short-term non-balanced relation between the two variables can be described by the error correction model (ECM). The EMC, which contacts short-term and long-term action of the two variables, can be specified in the following equation:

$$\Delta Y_t = lag(\Delta Y_t, \Delta X_t) + \lambda\varepsilon_{t-1} + v_t \quad (2)$$

in the equation, $Y_t \sim I(1)$, $X_t \sim I(1)$, Y_t, $X_t \sim CI$ (1), $\xi_t = Y_t - \beta_0 - \beta_1 X_t \sim I(0)$, v_t is flat noise; λ is short-term pondage factor。

2.4 The granger causality of the time-serial variables

In the regression analysis, the regression can measure the contact degree between the variables, but it can not testify the causality. The causality identification is very important in the study based on test. The basic idea of the causality test method advanced by Granger and Sim is: if variable X is helpful to forecast variable Y, and when carrying regression to Y according to Y's used value, and if it can boost up the regression's interpreting ability remarkably after adding up X's used value, then, X is called the Granger cause of Y, otherwise, called the non-Granger cause. The test process to the Granger causality between X and Y is: to test the original hypothesis"X is not the causation to arise the change of Y", and estimate the following two regression model:

Non-limited condition regression: $$Y_t = \sum_{t=1}^{m} a_i Y_{t-i} + \sum_{t=1}^{m} b_i X_{t-i} + \mu_t \quad (3)$$

Limited condition regression: $$Y_t = \sum_{t=1}^{m} a_i Y_{t-i} + \mu_t \quad (4)$$

The various regression's residual error quadratic sum and *F*'s static value are used to test if the coefficients $b_1, b_2, \ldots, b_m$ do not equals zero remarkably at the same time or not. If the above result is YES, then, we reject the original hypothesis "*X* is not the causation to arise the change of *Y*". And then, test the other original hypothesis "*Y* is not the causation to arise the change of *X*", carry out the same regression estimation, change *X* to *Y*, test *Y*'s lag item does not equal zero remarkably or not. If the result is YES, then reject "*Y* is not the causation to arise the change of *X*".

3 Demonstration Analysis of the Relation Between Government R&D Investment and Economic Growth

We choose GDP as economic growth measurement (PGDP as practice data after adjusting price index), and GST as government R&D investment (PGST as practice data after adjusting price index). We get logarithm of PGDP and PGST in table 1, then get LNPGDP and LNPGST, and make time list figure and dot figure. According to figure 1 and figure 2, we can see that both of variables are growing up, and with the same aspect. It means that there likely to exist relation. Figure 3 also shows that economic growth and government R&D investment exist strong relation. After count, the relation coefficient is great (0.9708).

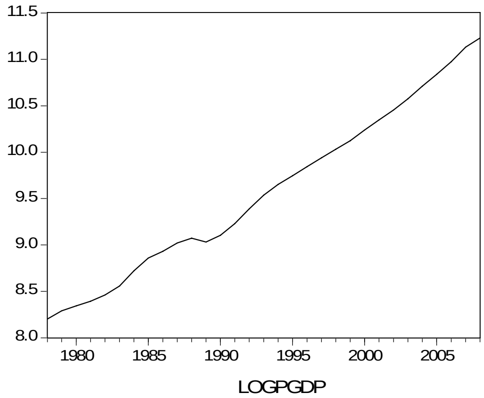

Figure 1 LNPGDP Trend

Figure 2 LNPGST Trend

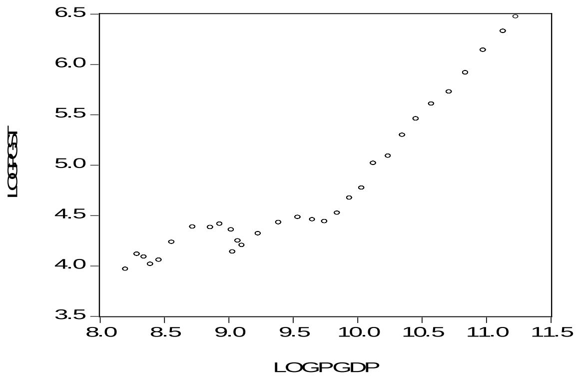

Figure 3 Dot of LNPGDP & LNPGST

In order to study this relation, normal method is to set up a regress equation basing on the stylebook data. When we make a traditional regress analysis, we need a balanced time list, or result in "fake-regress". However, in fact, economic time list usually is unbalanced (doesn't have obvious change trend), which destroyed the assume of balance. So for the regress makes sense, we can make it balance. General method is to differ the level list, then makes the difference list regress. But the result ignores some useful information in the level list, which is necessary and important for our analysis. Cointegration theory provides a method to deal with unbalanced data.

3.1 Equilibrium test of the variables serial

It must test the variables' equilibrium before the cointegration analysis. We do equilibrium test to *LNPGDP*, *LNPGST* in Table 1 and their single-order variables: *DLNPGDP* and *DLNPGST*, and the results are in Table 2.

Table 2 Equilibrium Test Result

Variable	ADF test value	Test class(c,t,k)	5%critical value	10% critical value	result
LNPGDP	-2.6840	(c,t,1)	-3.5742	-3.2217	Disequilibrium
LNZLSQ	0.4222	(c,t,1)	-3.5684	-3.2184	Disequilibrium
DLNPGDP	-4.7505	(c,t,1))	-3.5950	-3.2335	Equilibrium
DLNZLSQ	-2.04658	(c,0,1)	-1.9529	-1.6100	Equilibrium

note：① The c and t in test form state the const item and the trend item, and k states the lag exponent number；

② The critical value of ADF test comes from Eviews 3.1 software；

③ The chosen standard of the lag time, k, is according to the principle that the AIC value and the SC value are at minimum.

Figure 4 Single-order vary trend of GDP

Figure 5 Single-order trend of GST

3.2 Cointegration test and error correction model

We test the cointegration relationship of China's economic growth and government R&D investment from 1978 to 2008 in Johansen cointegration test method, and the test results are in Table 3.

Table 3 Johansen Cointegration Test Result

Eigenvalue	Likelihood ratio	5% critical vale	10% critical value	Original hypothesis	Alternative hypothesis
0.395986	14..62057	15.89210	20.16121	r=0	r=1
0.280739	9.556404	9.164546	12.76076	r<=1	r=2

The likelihood ratio states: there is a cointegration relationship at the 10%conspicuous level. And the cointegration vector, (*LNPGDP*, *LNPGST*, *C*), turns to (1.0000, 1.1656, 4.0223) after being standardized, and then, the long time equilibrium equation of the government R&D investment and the economic growth is:

$$LNPGDP=1.1656*LNPGST+4.0223321$$

The error correction model of the adjustment to the short term fluctuation to long time equilibrium of the government R&D investment's change is:

$$DLNPGDP=-0.0081437*EC_{-1}+0.227312*DLNPGDP_{-1}+0.265867*DLNGST_{-1}-0.126309*DLNGST_{-3}+0.069186$$

The above analysis results show that:

(1) During 1978-2008, government R&D investment and economic growth in China exist a long

and balanced relation.

(2) In short order, the change of GDP is affected by government R&D investment and its own. Thereinto, economic growth variable laging one year and government R&D investment variable lagging one years and three years affects change of GDP markedly, and other laging period affects change of GDP inconspicuously.

(3) EC is the error correction item, and this coefficient reflects the action mechanism of the error correction scale, which corrects the biased equilibrium error. The GDP and government R&D investment in the prime year would adjust to equilibrium state in the following year when the correction coefficient is 1. The coefficient of this model is only -0.0081, which means GDP growth change is affected by many other factors. The balanced relation between GDP and government R&D investment doesn't affect current unbalanced error correction ability greatly.

3.3 Causality test

Cointegration test results indicate that government R&D investment and economic growth in China exist a long and balanced relation. However, government R&D investment growth results in economic growth, or economic growth results in government R&D investment, it needs a further improved. We use the data of government R&D investment and GDP in figure 1 to do Granger Causality test, results as table 4. The first row is a null hypothesis as Granger cause and effect test, the first line in other rows is statistic F, and the second line is probability of notability level, when statistic F under the null hypothesis.

Table 4 Granger Causality results

null hypothesis	observations	Statistic F	Notability level
The change of government R&D investment is not the reason for the change of GDP	29	2.9671	0.0706
The change of GDP is not The change of government R&D investment		2.3257	0.1193

Table 4 indicates that government R&D investment is main causation that brings about economic growth and economic growth is not main causation that brings about government R&D investment, which means in China, government R&D investment growth result in economic growth, but economic growth doesn't result in government R&D investment growth.

4 Conclusion

According to the analysis above, we can draw a conclusion that government R&D investment and economic growth in China exist a strong relation. Though neither growth is steady, for a long period, they have a long, steady and equipoise relation. A short lag economic growth and government R&D investment affect actual GDP greatly, but economic growth and government R&D investment do a weak effect of unequipoise error. As a whole, there is single way causality between government S&T investment and economic growth from 1978 to 2008, and government S&T investment is main causation that brings about economic growth. These phenomenon indicate that we should pay much attention to the gross of government S&T investment so as to enhance the independent innovation ability and promote China's economy to a rapid growth.

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