Study on Relationship between R&D Expenditure and Economic Growth of China*

Li Peng
Zhengzhou Institute of Aeronautical Industry Management, Zhengzhou, P.R. China, 450015
(E-mail: li-peng@hotmail.com, lipengzz@126.com)

Abstract R&D provides impetus for science and technology, which plays an essential role in Chinese economic growth. But R&D expenditure in China is lower than other countries although it grows rapidly which is above 15% since the 2000s. The aim of this paper is to explore the relationship between R&D expenditure and GDP by means of unit root tests, co-integration model and granger causality test. The empirical study of this paper shows that R&D expenditure and GDP from 2000 to 2007 are co-integrated, which means a long-run relationship really exists. The conclusion of this paper is, in detail, the elasticity of R&D to GDP is 0.9243 which means the growth rate of GDP will increase 0.9243% if the R&D expenditure increases 1%.According to our analysis, Chinese government should increase the R&D expenditure continuously to foster the economic growth.
Key words R&D expenditure; Economic growth; Co-integration; Granger causality

1 Introduction

Science and technology are the primary productive force which was Deng Xiaoping's famous saying. Now with the advent of knowledge economy, high-tech enterprises have become the new economic force and the important engine for economic development. However, R&D provides impetus for science and technology which plays more and more essential role in economic growth in the future.

In the middle of last century, R. Solow (1956) and T. Swan (1956) proved that technology and science is the key factor of economic growth for one country. And in the late 1980s, Romer and Lucas initiated the endogenous economic growth theory which R&D is an endogenous viable in the economic growth model. In this model, the technological innovation is created in the R&D investment through human capital and the existing knowledge stock. The empirical studies of endogenous growth models generally involve testing the effects of R&D variables on either output growth rate or total factor productivity growth. Some scholars such as Jones test the validity of R&D based on growth model on data from France, Germany, Japan and United States by use of the time series plots of the TFP growth and the growth rate of the numbers of scientists and engineers. The conclusion of his analysis is that there is no obvious evidence to prove the causal relationship between R&D investment and economic growth rate. In the last decade China economy grows in the average rate of ten percent which arouse many economists' interests. The aim of this paper is to explore the relationship between R&D expenditure and GDP by use of unit root tests, co-integration model and granger causality test to partly explain the reason of China economic growth.

However, R&D expenditure in China is lower than other countries although it remains high growth rate since the 1990s. Let's take R&D/GDP as an example which is averaged as 2%-3% in general for most countries. Table 1 shows how the R&D expenditure in 2002-2007 changes.

Table 1 R&D Expenditure in 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
R&D expenditure (100millionRMB)	895.66	1042.5	1287.6	1539.6	1966.3	2449.9	3003.1	3710.2
Percent to the previous year (%)	31.9	16.4	22.78	16.55	19.44	19.61	18.68	23.5
R&D/GDP (%)	0.9	0.95	1.07	1.13	1.23	1.33	1.42	1.49

From Table1, it's obvious that the R&D expenditure grows rapidly which is above 15% since the 2000s. And at the same time the economic grows rapidly too. But what's the relationship between R&D

*Support by National Science Foundation of China(No:70971121),Foundation of He'nan Science and Technology Development Funds (No: 092400420080)

and economic growth? It's a very important question for the academic and the government. And it's also the aim of this paper.

2 Methodology

2.1 Unit root tests

Unit root tests are first conducted to establish the stationary properties of the time series data sets. Stationary entails long run mean reversion and determining a series stationary property avoids spurious regression relationships, which will occur when we regress series having unit roots into one another. The presence of non-stationary variables might lead to spurious regressions where regressing a series having a unit root onto another is most likely to produce high R^2 and significant *t*-distribution results even though the two variables are independent in reality. This could lead to erroneous inferences and nonobjective policy implications. The Dickey Fuller (DF) and Augmented Dickey Duller (ADF) tests are used for this purpose in conjunction with the critical values computed by MacKinnon which allows for calculation of DF and ADF critical values for any number of regressors and sample size.

In order to determine the stationary of each variable for each time series of the sample, the augmented Dickey–Fuller (ADF) test is employed. The ADF model used is given as follows:

$$\Delta X_t = \alpha_0 + \alpha_1 t + \alpha_2 X_{t-1} + \sum_{i=1}^{k} \beta_{t-i} \Delta X_{t-i} + \mu_t \tag{1}$$

Whereα_0 is the intercept term, $\alpha_2$is the coefficient of interest in the unit root, μ_t is the white noise error term. In the case, the null hypothesis of the unit root test is H_0:α_2=0, while the alternative hypothesis is H_1:$\alpha_2 \neq 0$. If the t statistics of α_2 is at least smaller than the 95% Dickey–Fuller critical value, given by MacKinnon the null hypothesis of the unit root would be rejected. It is proved that $\{X_t\}$ is I(0).

2.2 EG co-integration test

In order to test for the long-run relationship between R&D expenditure and GDP I utilize the methodology ,EG co-integration， a technique becoming widely used in economic modeling ,suggested by Engle and Granger (1987) .The EG co-integration has two steps. In the first step, all dynamics are ignored and the co-integrating regression is estimated by the OLS. By it, the long-run co-integrating regression is got as $Y_t = \beta X_t + u_t$. where both Y_t and X_t are stationary variables and integrated of the same order(i.e. $Y_t \sim I(1)$ and $X_t \sim I(1)$). The second step is to test the residuals from the above regression which should be stationary (i.e. ut ~ I(0)) because of Y_t and X_t to be co-integrated using ADF tests.

2.3 Granger causality

Granger causality (Granger 1969) focus on understanding the relationships between two time series. And Granger (1969) defined the causality in terms of predictability, based on the fact that the effect cannot come before the cause. According to Granger (1969), Y is said to "Granger-cause" X if and only if X is better predicted by using the past values of Y than by not doing so with the past values of X being used in either case. In short, if a scalar Y can help to forecast another scalar X, then we say that Y Granger-causes X. To implement Granger test, I assume a particular autoregressive lag length k (or p) and estimate the following Equation (2) and (3)by OLS:

$$X_t = \lambda_1 + \sum_{i=1}^{k} a_{1i} X_{t-i} + \sum_{j=1}^{k} b_{1j} Y_{t-j} + \mu_{1t} \tag{2}$$

$$Y_t = \lambda_2 + \sum_{i=1}^{p} a_{2i} X_{t-i} + \sum_{j=1}^{p} b_{2j} Y_{t-j} + \mu_{2t} \tag{3}$$

3 Data

In this study the R&D expenditure and real GDP time series in 1987-2007 would be used in the model The data would use the real R&D expenditure and real GDP. The real R&D expenditure named as RRD and real GDP named as RGDP is expressed in 2000 constant 100 million Chinese Yuan (the local currency). The real R&D expenditure and GDP is computed by deflating the retail price index (2000=100). All the yearly data on the R&D expenditure and GDP were derived from China Economic Information Database and Comprehensive Statistical Data and Materials on 50 Year of New China and China Statistical Yearbook (1999-2009). To get a meaning result RGDP and RRD would be calculated by logarithmic transformation.

4 Empirical Study

4.1 Unit root test

To test for the presence of unit roots and identify the order of integration for each variable the Augmented Dickey–Fuller (ADF) statistics is used in which the null hypothesis is non-stationary. The Newey and West method is applied to choose optimal lag lengths automatically based on Schwarz criterion(SC) Criterion, which was found to be Four for all variables. ADF tests conducted on the logged variables of GDP and R&D differentiated by their order of integration are reported in Table2.

The results shows that it is evident that null hypothesis of the presence of a unit root at constant levels of statistical significance for the variables of LRGDP and LRRD could not be rejected because -1.01032>-3.0403, the 5% level critical value. But in 1st difference level, -5.9497<-3.0403, the null hypothesis would be rejected that means it could not exist a unit root. It's the same to the RRD and LRRD series.

Therefore we can conclude that all series involved in the estimation procedure are regarded as I(1), and it is suitable to make co-integration test.

Table 2 ADF Unit Root Tests

Variables	ADF statistic	5% level	Prob.	conclusions
LRGDP	-1.1032	-3.0403	0.6906	Nonstationary
DLRGDP	-5.9497	-3.0403	0.0001	Stationary
LRRD	0.0190	-3.0207	0.9499	Nonstationary
DLRRD	-5.3683	-3.0299	0.0004	Stationary

4.2 Co-integration test

According to the EG co-integration, the first step is to get the long-run relationship between GDP and R&D by OLS. The result of OLS regression is detailed by equation (4)

$$LRGDP=5.2256+0.9243LRRD \quad (4)$$

(28.55) (32.96)

(0.1830) (0.0280)

Where, the R-squared of the variables is 0.9828, and F-statistic is 1086.652 (Prob.=0.0000).To test the co-integration ,I test the residual of equation (4) for the second step. The result is detailed as table 3.From Table2 at 10% level the residual of equation is stationary which proves that the co-integration relationship between GDP and R&D exists.

Table 3 ADF Unit Root Test

Variables	ADF statistic	10% level	Prob.	conclusions
Et(residual of equation (4))	-1.7524	-1.6074	0.0758	stationary

4.3 Granger causality test

Granger causality tests can be used to examine the nature of the relationship. The results of the Granger causality tests reported in Table 4

Table 4 Granger Causality Test

Null Hypothesis	Obs	Lags	F-Statistic	Prob.	Conclusion
LRRD does not Granger Cause LRGDP	19	2	8.4793	0.0039	lnR&D=>lnGDP
LRGDP does not Granger Cause LRRD			0.8222	0.4596	lnGDP≠>lnR&D
LRRD does not Granger Cause LRGDP	18	3	10.1441	0.0017	lnR&D=>lnGDP
LRGDP does not Granger Cause LRRD			2.1909	0.1046	lnGDP≠>lnR&D
LRRD does not Granger Cause LRGDP	17	4	9.9357	0.0034	lnR&D=>lnGDP
LRGDP does not Granger Cause LRRD			1.8276	0.2169	lnGDP≠>lnR&D
LRRD does not Granger Cause LRGDP	16	5	6.6494	0.0307	lnR&D=>lnGDP
LRGDP does not Granger Cause LRRD			1.9765	0.2363	lnGDP≠>lnR&D

5 Conclusion

By testing the co-integration and causal relationship between R&D expenditure and economic growth of China in 1987-2007, the empirical study shows that it's evident that these two variables are co-integrated which means a long-run relationship really exists. In detail, the elasticity of R&D to GDP is 0.9243 which means the growth rate of GDP will increase 0.9243% if the R&D expenditure increases 1%.And also the R&D expenditure is the granger cause of GDP, which evidenced that the R&D expenditure is the key factor of economic growth. There are some problems existed in the empirical study. For example, in the co-integration test only one viable is included in which some important viable could be neglected. But there is no effect on our conclusion of this paper. For China, the government should continue to increase the expenditure of R&D and take some measurements to expedite the transformation of high and new technology in order to maintain the high growth rate of GDP.

References

[1] Granger, C.W.J., P. Newbold. Spurious Regressions in Econometrics[J]. Journal of Econometrics, 1974, (2):111-120

[2] P.M. Romer. A Increasing Returns and Long Run Growth[J]. Journal of Political Economy, 1986:1002-1037

[3] R.E. Engle, C.W.J. Granger. Co-integration and Error-correction: Representation, Estimation and Testing[J]. Econometrica, 1987, (55):251-276

[4] Y. Wang, Y. Yao. Sources of China's Economic Growth 1952–1999: Incorporating Human Capital Accumulation[J]. China Economic Review, 2003,(14):32-52

[5] C.I. Jones. Time Series Test of Endogenous Growth Models[J]. Quarterly Journal of Economics, 1995:495-525