An Empirical Study on the Relationship between Fiscal Expenditure on Science and Technology and Technology Innovation in China

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ABSTRACT: Base on the data in China from 1985 to 2012, this paper studies the relationship between fiscal expenditure on science and technology and technology innovation (patent applications) by using co-integration analysis and Granger cause test. The results show that: Although the fiscal expenditure on science and technology and technology innovation (patent applications) are fluctuant respectively, the long term relationship between them is stable and co-integrative. China's fiscal expenditure on science and technology has a great role in promoting technological innovation and they are Granger cause of each other.
KEYWORD: Fiscal Expenditure on Science and Technology; Technology Innovation.

1 INTRODUCTION

With the continuous rise of the knowledge economy and the acceleration of global economic integration process, the importance of technological innovation for a country or business has been widely recognized and accepted. Due to technological innovation is a quasi- public goods and it has the characteristics of high investment risk, long cycle, earnings uncertainty etc, the enthusiasm of enterprises for independent innovation is generally is not high. So it is objective demand governments at all level to come up with some fiscal resources to support and encourage enterprise to innovate. Base on the data of china from 1985 to 2012, this paper studies the relationship between fiscal expenditure on science and technology and technological innovation by using co-integration analysis and Granger cause test hoping to provide some empirical evidence for evaluation of fiscal investment in science and technology and innovation policy effect.

2 DATA SOURCE AND DESCRIPTION

Because domestic patent applications in China began in 1985 and the Statistical Yearbook data disclosed only to 2012, the paper selects the number of patent applications (Pa, unit: piece) as a measure of technological innovation and selects fiscal expenditure science (Fexp, unit: million) as a measure of fiscal expenditure on science and technology indicators in china from 1985 to 2012. The data of patent applications is from the State Intellectual Property Office website People's Republic of China (http://www.sipo.gov.cn/tjxx/) and the data of fiscal expenditure is from Chinese Statistical Yearbook. In order to eliminate the effects of inflation on actual value, this paper, firstly adjust the book value of fiscal expenditure (Fexp) to the actual value (PFexp) on the base of constant prices in 1978, and then calculate the natural logarithm of the actual fiscal expenditure (PFexp) and the natural logarithm of patent (LnPa). This treatment can not only avoid the volatility in the data, but also can eliminate the influence of heteroscedasticity. This change does not affect the long-term and stable relations between variables.

There are many reasons for choosing the data of patent application rather than patent license as the measure tool of technological innovation but the main three are as follows: (1)There is a strong positive relationship between patent application and patent license and the data of patent application contains a large mount of the information of patent license; (2) The information lag of the patent license is larger then the patent application and there are more information distortion in the data of the patent license then the patent application; (3)the gap between them is due to the more the for license, the imperfect intermediary organizations and the inefficiently of the licensing authority.

Table 1: Fiscal expenditure on science and technology and patent application in china from 1985 to 2012

Year	Book value of fiscal expenditure (Fexp,100 million)	Price index (P)	The natural logarithm of PFexp (LnPFexp)	The data of patent application (Pa)	The natural logarithm of Pa(LnPa)
1985	102.59	1.311	4.35995	14372	9.57304
1986	112.57	1.396	4.38996	18509	9.82601
1987	113.79	1.498	4.33022	26077	10.16881
1988	121.12	1.779	4.22073	34011	10.43444
1989	127.87	2.099	4.10955	32905	10.40138
1990	139.12	2.164	4.16338	41469	10.63270
1991	160.69	2.238	4.27389	50040	10.82058
1992	189.26	2.381	4.37560	67135	11.11446
1993	225.61	2.731	4.41414	77276	11.25514
1994	268.25	3.390	4.37109	77735	11.26106
1995	302.36	3.969	4.33310	83045	11.32714
1996	348.63	4.299	4.39563	102735	11.53991
1997	408.86	4.419	4.52746	114208	11.64578
1998	438.6	4.384	4.60563	121989	11.71169
1999	543.85	4.322	4.83496	134239	11.80738
2000	575.62	4.340	4.88757	170682	12.04756
2001	703.26	4.370	5.08096	203573	12.22378
2002	816.22	4.335	5.23796	252631	12.43969
2003	975.54	4.387	5.40435	308487	12.63943
2004	1095.34	4.558	5.48194	353807	12.77651
2005	1334.91	4.640	5.66190	476264	13.07373
2006	1688.5	4.710	5.88191	573178	13.25895
2007	1783.04	4.936	5.88952	693917	13.45011
2008	2129.21	5.227	6.00967	828328	13.62716
2009	2744.52	5.190	6.27063	976686	13.79192
2010	3250.18	5.361	6.40732	1222286	14.01623
2011	3828.02	5.650	6.51845	1633347	14.30614
2012	4452.63	5.797	6.64391	2050649	14.53367

Figures 1 is the time sequence graph of the natural logarithm of actual fiscal expenditure on science and technology (LnPFexp) and figure 2 is the time sequence graph of the natural logarithm of patent application (LnPa). It can be seen from the figure 1 and figure 2 that LnPFexp and LnPa change in the same direction and almost appear the same pace which indicates that there is a Long-run equilibrium relationship between them.

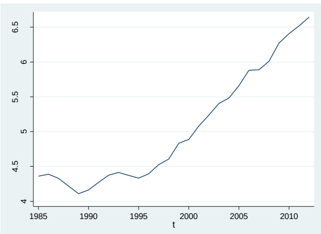

Figure 1: Time sequence graph of LnPFexp

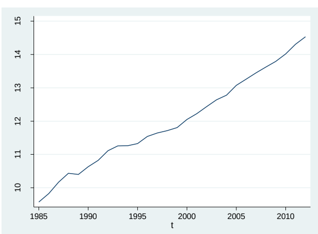

Figure 2: Time sequence graph of LnPa

3 MODEL AND THE RESULT ANALYSIS

Co-integration relationship reflects the existence of a long-run equilibrium relationship between the variables. In some economic sense, the co-integration relationship reveal it can be affected the change of one variable by changes in another variable. The two economic variables cannot be too far from each other. A shock can make them deviate from each other only in the short term and will automatically return to equilibrium position in the long term. Before using the co-integration test, you must first check whether the variables are stable, if the variables are not stable, it may be spurious regression. Due to the more commonly-used test method of DF test does not guarantee equation residuals are white noise, so Dickey and Fuller develop the DF test method to form the ADF test method which is currently application of common.

3.1 *The stability test*

In order to determine the integration ranks, this paper do the ADF test. Table 2 show that the ADF value of LnPFexp's original sequence, the first-order difference and LnPa's original sequence are greater than the critical value of 1% significance level, but the ADF value of LnPFexp's second-order difference, LnPa's first-order and second-order difference are less than the critical value of the 5% significance level. Therefore is LnPFexp the original sequence, the first-order difference and LnPa LnPFexp original sequence is not stable, but LnPFexp second-order difference, LnPa first difference and second order difference is stable, there will be a co-integration relationship between them. According to the co-integration theory, if the variables are not stable while its difference are stable and the linear combination of them is stable, so can preliminary determination that LnPFexp and LnPa reached a stable, namely LnPFexp and LnPa are the second order single whole sequence and it can further test the co-integration relationship between the two variables.

Table 2: Augmented Dickey-Fuller test results for unit root

Z(t)	ADF est statistic	Interpolated Dickey-Fuller		Conclusion
		1%	5%	
LnPFexp	1.346	-3.743	-2.997	No
LnPa	0.586	-3.743	-2.997	No
D.LnPFexp	-2.463	-3.750	-3.000	No
D.LnPa	-4.080	-3.750	-3.000	Yes
D2.LnPFexp	-5.374	-3.750	-3.000	Yes
D2.LnPa	-5.380	-3.750	-3.000	Yes

3.2 *The optimal lag order*

In general, before doing the co-integration analysis, we should determine the optimal lag order of VAR model. This paper will be based on the unconstrained (Unrestricted) VAR model level to determine the co-integration order. The method of determining the optimal lag order is from large lag order to small according to the corresponding the value of LR, FPE, AIC HQIC and SBIC. As shown in table 3, all the above five critical value indicate the optimal lag order is one, so the study will develop on the base of the VAR (1) model.

Table 3: The optimal lag order of VAR model

	LL	LR	P	FPE	AIC	HQIC	SBIC
0	-18.834			0.01946	1.7362	1.7622	1.8344
1	60.609	158.89*	0.000	0.00004*	-4.5507*	-4.4726*	-4.2562*
2	62.599	3.981	0.409	0.00004	-4.3832	-4.2530	-3.8924

Note: * indicates the optimal lag order decided by the judgment rule

3.3 *The number of co-integration equation*

Before co-integration analysis, we must not only determine the optimal lag order, but also determine the existence and number of co-integration. The test results of the rail statistics in table 4 are significant under 5% level, which indicate that there is at least one co-integration vector between the LnPFexp and the LnPa. That is to say, there is a long-term equilibrium relationship between LnPFexp and LnPa during 1985-2012.

Table 4: The test results to determine the number of Co-integration equation

The number of co-integration	LL	Eigenvalue	Trace statistic	5%
0	54.492004		27.5763	15.41
1	66.857748	0.61373	2.8448*	3.76
2	68.28016	0.10364		

3.4 *Co-integration test*

This paper is planed to test the co-integration relationship between LnPFexp and LnPa by using Engle-Granger' method. The result revealing the long-term equilibrium relationship and short-term dynamic relationship equations of them are as follows:

$$D.LnPFexp=0.1436689^{**}\times(D.LnPa-1.46973^{**}\times LnPFexp+0.109077$$
$$(2.85)\qquad(-17.20)$$
$$+[0.0821533\times D\_lnzl-0.3179513\times LnPFexp+0.52522^{**}]\qquad(1)$$
$$(0.42)\qquad(1.85)\qquad(2.86)$$
$$D.LnPa=-0.1475394^{**}\times(D.LnPa-1.46973^{**}\times LnPFexp-5.075141)$$
$$(-2.93)\qquad(-17.20)$$
$$+[-0.127117\times D\_lnzl+0.391878^{*}\times D.LnPFexp+0.1062155^{**}]\qquad(2)$$
$$(-0.65)\qquad(2.27)\qquad(2.78)$$

The data in brackets under co-integration equation is t test value of the parameter, ** indicates 1% significance level and * indicates 5% significance level. The estimated result shoe that, R2 is equal to 0.981262 and the value of the AIC and SC are relatively small which show that the degree of reliability estimation equation and fitting are good in a whole. The equation coefficient estimation has a high degree of reliability. At the same time, residual test results show that ADF test value is 4.54672 which corresponding the critical values is -4.183 under the 5% significant level, The null hypothesis should be rejected, so the residual is stable. There is long-term stabile co-integration relationship between fiscal expenditure on science and technology and technological innovation. The ratio between them is 1:1.46973 to changes.

In LnPa equation, LnPa adjust speed is negative 0.1475394 and significant at the 1 % level which indicate that LnPFexp is dominant on the co-integration. When the number of LnPa is relatively low or deviate from the long-run equilibrium state, it will quickly adjust toward LnPFexp. In LnPFexp equation, LnPFexp adjust speed is positive 0.1436689 and also significant at the 1 % level which indicate that LnPFexp is dominant on the co-integration. LnPFexp is not affected by LnPa.

3.5 *The graph of pulse reflected*

LnPFexp dominates on the co-integration relationship which is clearly described in the graph of pulse reflected. Figure 3 is the pulse reflected graph of LnPFexp to LnPa. Figure 3 shows that the impact pulse begins to rise, and then gradually is stable at 0.55 in the third period which indicate LnPFexp growth will cause LnPa growth in the behind growth period, and the elasticity coefficients is stable. Figure 4 is the pulse reflected graph of LnPa to LnPFexp. Figure 4 shows that the impact pulse begins to rise, and then decline from the peak of 0.71 in the third period and financially is stable at 0.66 in the ninth period which indicate LnPFexp growth will cause LnPa in the behind growth period and the elasticity coefficients is stable. The increase of LnPa can also cause the increase of LnPFexp. The slightly fluctuations in figure 4 may be due to the degree of industrialization is not high.

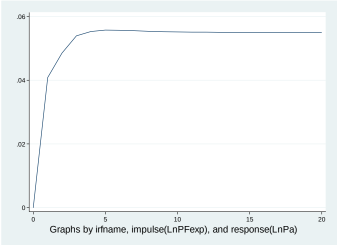

Figure 3: The pulse reflected graph of LnPFexp to LnPa

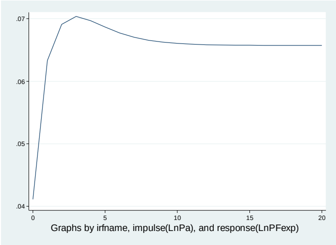

Figure 4: The pulse reflected graph of LnPa to LnPFexp

3.6 *Granger-cause test*

The co-integration test results show that there exists a long-term co-integration relationship between fiscal expenditure on science and technology and patent, while the co-integration relationship can not determine whether there is statistically a causal relationship between them but it can reveal it is possible to have Granger cause. Whether this equilibrium relationship form the increase of Granger cause is from fiscal expenditure on science and technology and patent need to further verify. Base on VAR model, this paper uses granger cause test to verify the causal relationship between them. It is showed that fiscal expenditure on science and technology and patent are granger cause each other at the 95% critical level in the lag period of 1 year, 2 year and 3 year.

Table 5: Granger-cause test result between variables

H0	Lag	F(1,24)	Prob> F	Conclusion
LnPFexp does not Granger-cause LnPa	1	10.81	0.0031	No
LnPa does not Granger-cause LnPFexp		7.00	0.0141	No
LnPFexp does not Granger-cause LnPa	2	5.87	0.0095	No
LnPa does not Granger-cause LnPFexp		4.37	0.0260	No
LnPFexp does not Granger-cause LnPa	3	4.21	0.0202	No
LnPa does not Granger-cause LnPFexp		3.62	0.0334	No

4 CONCLUSION AND SUGGESTION

By using co-integration analysis and granger cause test, this paper empirically investigate the relationship between fiscal expenditure on science and technology and technological innovation in China from 1985 to 2012. The results show that: (1) According to the co-integration test, there is a strong relationship between fiscal expenditure on science and technology and technological innovation. Although their growth is not stable, but the second order difference is stable. There is a long-term stable equilibrium relationship between them. The elasticity coefficient is 1.46973 and the corresponding adjustment speed is 0.1475394 which show that China's fiscal expenditure on science and technology has a great role in promoting technological innovation; (2) According to the Granger cause test, fiscal expenditure on science and technology and patent are granger cause each other at the 95% critical level in the lag period of 1 year, 2 year and 3 year. The increase of fiscal expenditure on science and technology will promote the increase of technical innovation, in turn, the increase of technical innovation also has an obvious effect on the increase of fiscal expenditure on science and technology. It can be form a virtuous mutual promoted mechanism.

Based on the above analysis, the writer proposes that, it should be further strengthen fiscal expenditure on science and technology. LnPFexp is not only to increase the total amount, but also optimize the structure, and should be institutionalized to ensure the sustainability of LnPFexp. at the same time, the writer suggests to strengthen the protection of intellectual property rights and to follow the principle of "who invests, who benefits" and to establish a diversified investment organization such as government, enterprises and civil institutions, so that the virtuous mutual promoted mechanism can play its due role.

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