An Empirical Research on Relationship between Foreign Direct Investment and Technological Innovation Capability in Hubei Province of China

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Abstract Using data from Hubei province of China, this paper employs co-integration tests and Granger causality to investigate the relationship between FDI and patent authorization during the period of 1988 to 2008.The empirical evidence verifies that stable equilibrium relationship exists between FDI and patent authorization in the long run. Known by Granger causality test, FDI is the Granger cause of enhance Hubei Province's technological innovation capability. And based on the conclusion, the author puts forward policy recommendations.

Key words Foreign direct investment; Technological innovation capability; Co-integration test; Granger causality test

1 Introduction

Some empirical studies have shown that flow into developed countries (E.g. Australia, UK and USA) are positive and significant FDI spillover effects of technology (Caves[1], 1974; Keller and Yeaple[2], 2003). FDI flows to developing countries for technology diffusion effect is difficult to get consensus. Haddad and Harrison[3] (1993), Aitken and Harrison[4] (1999), Djankov and Hoekman[5] (2000) and Konings [6](2001) and others studies have shown, FDI in Morocco, Venezuela, Czechoslovakia, Bulgaria, Romania, Poland and other developing countries does not exist technology spillover effect. And Blomstrom & Persson[7]1983), Kokko & Zejan[8] (1994), and Kokko [9](1996), and others found, FDI technology spillover effects assumption Uruguay, Indonesia, Mexico and other countries set up.

Domestic scholars technology spillover effect of FDI has been a large number of documents. Dian-Chun Jiang[10] (2004), the comparative static analysis, that the competitive effect of FDI often brings deterioration of domestic research and development financing capacity, its overall conclusion is that in most cases, multinational corporations will weaken the competitive impact study of Chinese enterprises engine and capabilities. Wang Xiaohong and Hu jinyan[11] (2006) that, FDI technology spillover effect of investment in developing countries using their ability of independent innovation, to achieve rapid industrial upgrading and economic development generated by leaps and bounds one of the most important effect. Xian Guoming and Bo Wenguang [12] (2006) study shows, FDI for the Chinese regions of technical innovation will play a positive effect, but this influence by human capital, the region's infrastructure, the smooth functioning of the market economy has the system environment, legal environment, "the threshold" effect. Liu Chen[13] (2007), the Yangtze River Delta region through the 1987-2003 panel data analysis of local technology innovation and FDI technology spillover effects of economic growth in the region, it concluded that, after taking into account the factors of local innovation, FDI technology spillover is no longer demonstrate the significant economic growth with positive effects; and that the local innovation in the region's economic growth, there exists a significant positive correlation. From the above literature review can be found, previous research focused on the study and the existence of the existence of positive or negative spillover effect of FDI technology.

2 Variables, Data and Models

2.1 Variables and data

This paper selects the number of Hubei Province, FDI and licensing as an alternative indicator of FDI on regional innovation capacity of Hubei Province. Here, we Hubei Province Bureau of Statistics released the actual use of foreign direct investment FDI as an indicator variable.

For innovation, we use authorized by State Intellectual Property Office 1990-2005 the number of patents as a proxy. Which contains a number of patents invention (Invention), utility models (Utility model) and design (Design). This is why not choose the number of patent applications to choose the number of patents granted, based on the following two grounds: (1) patent applications through the review process, to enter the authorization stage. Yet, not all patent applications will be approved as a patent. From The People's Republic of China Ministry of Science and published patent application and authorization number of terms, a greater difference between the two (see Table 1). (2) from the patent application of results, granted patents, patent applications filed more than novelty, innovation capability as a substitute for more appropriate indicators.

Table 1 Hubei Province FDI and the Patent（1988-2008）

Year	FDI	Number of patents received				Number of patent certified			
		Total	Invention	Utility Model	Design	Total	Invention	Utility Model	Design
1988	0.22	1160	197	908	55	423	25	381	17
1989	0.23	1060	178	811	71	548	46	476	26
1990	0.29	1238	220	969	49	721	61	610	50
1991	0.4643	1302	260	986	56	671	64	565	42
1992	2.0308	1806	362	1345	99	744	59	661	24
1993	5.3441	1950	410	1458	82	1560	103	1372	85
1994	6.0183	1985	432	1421	132	1051	65	942	44
1995	6.2253	2004	384	1430	190	1017	55	868	94
1996	6.8878	2193	377	1557	259	998	48	826	124
1997	7.9019	2278	457	1543	278	1041	43	827	171
1998	9.2012	2629	494	1710	425	1266	67	922	277
1999	9.1488	2963	506	1887	570	2228	107	1628	493
2000	9.4368	3486	771	2102	613	2198	156	1573	469
2001	12.0993	4322	1085	2400	837	2204	186	1513	505
2002	14.0151	4960	1179	2905	876	2209	192	1475	542
2003	15.5702	6635	1627	3406	1602	2862	417	1854	591
2004	20.7126	7960	1674	3953	2333	3280	744	1966	570
2005	21.8475	11534	2038	4835	4661	3860	733	2238	889
2006	24.4853	14576	2827	5745	6004	4734	855	3031	848
2007	27.6622	17376	3705	7168	6503	6616	886	4400	1330
2008	32.4481	21147	4616	8793	7738	8374	1152	5732	1490

2.2 Theoretical model

Co-integration Test

Co-integration relationship between the variables reflecting the proportion of long-term stability of the relationship between two variables to test whether the co-integration, Engle and Granger in 1987 proposed two-step test, also known as EG test

The first step, the following equation using OLS to estimate

$$y_t = \alpha + \beta x_t + \varepsilon_t$$

$$\hat{y}_t = \hat{\alpha} + \hat{\beta} x_t$$

$e_t = y_t - \hat{y}_t$ This is Co-integration regression.

The second step is the whole of a single test. If the stationary sequence, then that variable, as (1, 1)-order co-integration. If the order one, then that variable for the (2, 1)-order co-integration. Single integrity test methods have DF or ADF test.

Granger causality test

Granger (1969) on the causal relationship between variables to do the following definition: If x is the reason for the change caused by y, then x should be useful in predicting y, ie y value of y in the past return, add the value of x in the past as an independent explanatory variable, should return a significant increase in explanatory power. At this point, saying that x, y reasons. If you add the lagged x variable, no significant increase in the explanatory power of regression model, claimed that x is not y reasons. According to the definition of Granger causality, y and x are about four kinds of relations between:

x is y because of changes, y changes not because of x, compared with one-way causal relationship between x to y;

y is the result of changes in x, x is not a result of changes in y, to x, y, compared with one-way causality;

x is y change because, y is the result of x changes, compared with two-way causality;

x is not a result of changes in y, y is not a result of changes in x, then there is no causal relationship between the two.

Granger test actually consists of two tests: First test whether x causes y changes, the other is whether y x change. When testing the former, the least square method to estimate the following two models:

$$y_t = \alpha_0 + \sum_{i=1}^{s} \alpha_i y_{t-i} + \varepsilon_{1t}$$

$$y_t = \alpha_0 + \sum_{i=1}^{s} \alpha_i y_{t-i} + \sum_{i=1}^{k} \alpha_i x_{t-i} + \varepsilon_{2t}$$

Then their residual sum of squares and F-statistic constructed as follows:

$$F = \frac{(RSS_2 - RSS_1)/k}{RSS_1/(n-k-1)} \sim F(k, n-k-1)$$

If x does not help to predict y, the two models should be very close to the residual sum of squares, F statistic elements that should be very small, ie, F value should be relatively small, if x helps predict y, the F value relatively large, therefore, determine the rules as follows:

If $F > F_\alpha$, then reject the null hypothesis, indicating Granger cause x is y;

If $F < F_\alpha$, then accept the original hypothesis, indicating x is not y Granger causes.

3 Measured Test Results

3.1 Unit root test

Since the natural logarithm transformation of data does not change the original co-integration, and to make it linear trend, to eliminate the existing time series heteroscedasticity, so FDI, PATENT for the natural logarithm transformation, the transformed variables were used LNFDI, LNPATENT said. I calculated all the results obtained by Eviews5.1. The trend of natural logarithm of each variable has been shown in Figure 1.

Can be seen from Figure 1, FDI and PATENT on after taking logarithm, the two trends have changed over time, thus non-stationary time series. That is, there is unit root in the data. In this case, the use of traditional estimation techniques (based on classical assumptions about the nature of the disturbance) will lead to incorrect inferences, which potentially leads to meaningless or false results. With the development of time series analysis, scholars have advocated the co-integration technique as a non-stationary variable model is estimated including the appropriate method.

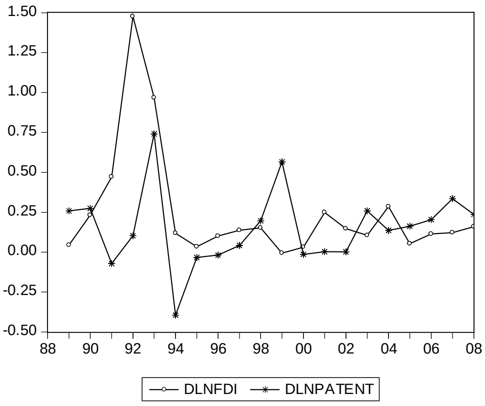

Figure 1 LNFDI and LNPATENT Time Series

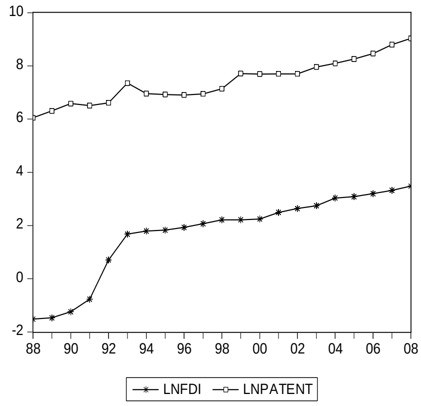

Figure 2 DLNFDI and DLNPATENT Time Series

Table 2 Stationary Test Variables

Variables	Test Type （C，T，K）	ADF Test Value	1 % Critical Value	5 % Critical Value	10 % Critical Value	Conclusion
LNFDI*	（C，T，1）	-3.052342	-4.532598	-3.673616	-3.277364	Non-Stationary
LNPATENT*	（C，T，0）	-2.503445	-4.498307	-3.658446	-3.268973	Non-Stationary
DLNFDI*	（0，0，0）	-1.794045	-2.692358	-1.960171	-1.607051	Stationary
DLNPATENT***	（C，0，0）	-4.993884	-3.831511	-3.029970	-2.655194	Stationary

Note：(1）***、**、*represent 1%、5% and 10% Significant Level respectively；
(2) "D" represents first difference；
(3）Test Type(C，T，K) represent Constant, Linear Trend and lag length respectively.

3.2 Co-integration

Based on the above analysis, two levels of variables are non-stationary time series, if the traditional regression method variables regression, as inferred relationship between the variables may be a spurious regression phenomenon.

In order to overcome the false return, the usual random walk approach is to transform the variables for a smooth sequence difference. But this in turn may lead to long-term relationship between the variables of information loss, recent studies have confirmed this. Another way is to use the so-called co-integration method. The basic idea of this approach is: If two (or more) of the variable non-stationary, but they might be a linear combination of smooth, in this case, we say exists between the various variables the ratio between a long-term stability, that co-integration. According to the coordination theory, if two (or more) random variables with the same order of a single whole, and the co-integration relationship between them, are among the variables under study there is a long-term stability of the equilibrium relationship, which can to avoid the spurious regression problem.

In general, if two variables test whether there is co-integration between, commonly used Engle-Granger two-step test (also known as EG method); If the test multiple co-integration relationship between variables, then use the Johansen-Juselius pole large likelihood. According to the needs of this article, we use the Engle-Granger two-step test (also known as EG method), the specific steps mentioned above.

First, using Eviews software LNPATENT and LNFDI for regression analysis, the results are as follows:

$$\begin{aligned} &LNPATENT = 6.6549 + 0.4467 LNFDI \\ &t = \quad (48.6935) \qquad (7.5518) \\ &R^2 = 0.7501 \quad Adjusted R^2 = 0.7369 \quad F = 57.0301 \end{aligned} \tag{1}$$

Residuals in the equation for ADF test.

$$u = LNPATENT - 0.4467 LNFDI - 6.6549 \tag{2}$$

Residual ADF test results as shown in Table 3.

Table 3 Residual ADF Test Results

			T Test Value	Probability values
ADF Test Value			-4.768841	0.0138
Significance level	1% level	Test critical values	-4.992279	
	5% level		-3.875302	
	10% level		-3.388330	

Test results show that the residuals at the 5% significance level rejected the null hypothesis, accept the conclusion there is no unit root, it can determine the residuals for a smooth sequence, the results show that: and there is co-integration between. Co-integration vector.

Co-integration equation shows that in the long run, the total patents in Hubei Province and the actual use of foreign direct investment in long-term stable equilibrium exists between the relationship that the actual granting of patents FDI have a positive impact. FDI on the elasticity of the number of patents granted 0.4467, indicating that FDI increased by 1 percentage point average, Hubei Province, will increase the number of patents granted 0.4467 percentage points

3.3 Granger causality test

Co-integration test shows that: the actual utilization of foreign capital of Hubei Province and Hubei Province, the number of patents exist between long-term equilibrium relationship, but it constitutes a long-term equilibrium relationship between cause and effect relationship? Even constitute a causal relationship, FDI is the reason the number of patents granted in Hubei Province, or FDI in Hubei Province is the number of patent licensing reasons? Here we continue to use the Granger causality test to illustrate the problem.

As the Granger causality test is very sensitive to the lag phases, so usually you can turn a few more lag period, lag phases of different lengths were examined to determine whether the consistent test results.

Table 4 Granger Causality Test Between FDI and Number of Patent Certified of Hubei in 1988 -2008

Original hypothesis	lag	F-Statistic	Prob.	conclusion
DLNPATENT does not Granger Cause DLNFDI	1	1.93815	0.1829	Accept
DLNFDI does not Granger Cause DLNPATENT		1.19879	0.2898	Accept
DLNPATENT does not Granger Cause DLNFDI	2	1.33497	0.2970	Accept
DLNFDI does not Granger Cause DLNPATENT		3.54239	0.0592	Accept
DLNPATENT does not Granger Cause DLNFDI	3	1.04557	0.4143	Accept
DLNFDI does not Granger Cause DLNPATENT		2.76009	0.0976	Accept
DLNPATENT does not Granger Cause DLNFDI	4	0.05604	0.9928	Accept
DLNFDI does not Granger Cause DLNPATENT		3.70843	0.0630	Accept

Test results show that in the case of the first order lag, the number of patents granted between change and changes in FDI are not Granger cause each other, and in the second, third and fourth-order situation, known by its probability of at least 90% confidence level, the changes that the FDI is the number of patents Granger cause changes, but change is not the number of patent licensing changes in FDI Granger causes that do not constitute a two-way Granger causality. Shows, FDI increased in the first year will not lead to the promotion of the increase in the number of patents granted, but in the next few years will be to promote the increase in the number of patents granted.

4 Conclusions and Recommendations

In this paper, Hubei Province in 1988 ~2 008 years, the actual use of foreign direct investment and the number of patents granted in Hubei Province, using time series data analysis methods, first time series data were stationary testing and treatment, and then use the theory and Granger co-integration causality test, an empirical analysis of the actual use of Hubei Province, the amount of foreign direct investment and licensing in Hubei Province and dynamic causal relationship between the number of long-term, the following conclusions: the actual use of Hubei Province, the amount of foreign direct investment and the number of patents granted between Hubei Province is some correlation between the growth of non-despite their stable, but in the long run, but between them constitute a long-term stability of the positive equilibrium relationship. At the same time, Hubei Province, foreign direct investment actually utilized amount of change will promote change in Hubei Province, the number of patents, although in the first year of this effect is not very obvious, but in the next three years, this effect has strong reflected.

Based on the above analysis gives the following several policy recommendations:

(1) from the government level, the Hubei Provincial government at all levels should adopt policies and measures to promote FDI inflows to increase the ability of technological innovation in Hubei Province; strongly encouraged to establish foreign-funded enterprises in Hubei high-level R & D institutions, to encourage its global market innovative research and development activities; the same time, should increase their efforts in protecting intellectual property rights to promote innovation and enthusiasm of foreign companies.

(2) from the enterprise level, the increase in Hubei technology absorptive capacity of local enterprises to increase the company's R & D investment, increase efforts to bring in professionals to enhance their technological innovation, while strengthening cooperation and foreign enterprises, through technical exchanges, joint research and development, " learning by doing "to improve the learning of local enterprises in Hubei and innovation.

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