Co-Integration Study of Relationship between Foreign Direct Investment and Economic Growth

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Abstract

Based on basic theories and methods of co-integration study, in this paper the author chooses data of Foreign Direct Investment (FDI) and Gross Domestic Product (GDP) as samples and makes a co-integration study of relationship between FDI and economic growth. Granger Causality Test results show that China's economic growth would inevitably cause a rise of FDI and the relationship tends to be a one-way causality. Error correction term has a stronger conversely-adjusted effect on the long-term equilibrium relationship between economic growth and FDI.

Keywords: Foreign direct investment, Economic growth, Error correction model, Co-integration study

1. Introduction

With the further deepening reform and opening up and the sustained growth of domestic economy, foreign direct investment tends to be rising. In 1985, the number of FDI projects reached 3073, with the contract amount of 6.333 billion US dollars. And the actual utilization of foreign investments was only 1.956 billion US dollars. In the year 2010, 27,406 FDI enterprises were newly approved in non-financial fields, increasing 16.9% over last year. And the actual utilization of foreign investments was 105.7 billion US dollars, increasing 17.4% over last year. The fast growth of FDI drives China to introduce advanced foreign technologies and learn latest foreign experiences, promoting China's economic development.

As for the relationship between FDI and China's economic growth, Chinese scholars have made fruitful studies from different angles. By analyzing the impulsive effect of FDI on domestic investment and economic growth (Wang Zhang) and a co-integration test based on the VAR model, scholars find that the inflow of FDI respectively has a positive effect on economic growth and a negative effect on domestic investment. Through Granger Causality Test and impulse response function analysis, scholars conclude that Chinese domestic investment shows a consistent tendency under the influences of FDI. In *An Empirical study of Relationship of China's Outward Foreign Direct Investment and Economic Growth based on the VAR Model* (Zhiqiang Jiang), results show that there is a long-term co-integration relationship between China's GDP and FDI. FDI has a long-term accumulated positive effect on GDP. And GDP has a positive effect on FDI in a short period. During a long term, the size of FDI tends to be stable. *The Econometric Analysis of Chinese Exports, Foreign Direct Investments, and Economic Growth* (Rui Xu & Fei Zhao) shows that FDI has a long-term effect but not a short-term effect on economic growth. And economic growth has a long-term effect on FDI. FDI affects itself in a short period. In the paper *The Empirical Analysis of Impacts of FDI on China's Economic Growth* (Li Huang, Jing Wang & Xiuzhu Ji), authors use various cross-section samples to form panel data and study the effects of FDI on local economic growth. Results show that the FDI has different effects on local economic growth because of different areas and times.

2. The relationship analysis of sample analysis

The sample data in this paper covers the annual data of FDI in actual utilization and the data of GDP. Data sources include *China Statistical Yearbook 2010* and *Statistical Report of Republic of China on National Economy and Social Development 2010*. For convenient calculation and analysis, GDP stands for Gross Domestic Product, with the unit of 100 million, and FDI is short for Foreign Direct Investment, with the unit of 100 million in this paper. In order to eliminate the impacts of price changes, the author uses the CPI (Consumer Price Index) in 1985 as the base to process the data of GDP. In order to reduce errors, the author gets the natural logarithms of sequence GDP and FDI, respectively LGDP and LFDI.

Generally speaking, the fast development of national economy and the accelerated pace of opening up can absorb more foreign investments. However, whether is there a causality relationship between GDP and FDI? If there is, is the causality relationship one-way or two-way? We can confirm it by Grander Causality Test. Using Grander Causality Test to confirm the causality relationship between the two sequences can be achieved by a regression model as follow.

$$Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + \mu_{1t}$$
$$X_t = \lambda_0 + \sum_{i=1}^{m} \lambda_i Y_{t-i} + \sum_{i=1}^{m} \delta_i X_{t-i} + \mu_{2t}$$

Test the causality relationship of sequence LGDP and LFDI at different lag periods. Results are in Table 1.

According to Table 1, as the lag period is 5, the AIC of test model reaches the minimum and the sequences in the test model have no correlation. Here, the probability is 0.0078 when LGDP is not the Grander cause of LFDI. Reject the original assumption at the 5% significance level, and agree that economic growth is the Grander cause of FDI, that is, economic growth makes FDI increase. The probability is 0.0779 when LFDI is not the Grander cause of LGDP. Accept the original assumption at the 5% significance level, and agree that FDI is not the Grander cause of economic growth. It is for sure that there is a one-way causality relationship between GDP and FDI. Therefore, build a regression model, LFDI as the dependent variable, and study the quantitative relationship between LGDP and LFDI.

3. Sequence stability test

For a regression analysis, there is an important assumption in a classical regression model, that is, the sequence must be stable. If the sequence is unstable, the test will be invalid or the regression will be false, as we make regression analysis based on the regression model with unstable sequence. In practice, the sequence stability test is usually completed by ADF test, which needs to test the three models in turn.

$$\Delta Z_t = \delta Z_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Z_{t-i} + \varepsilon_t$$

$$\Delta Z_t = \alpha + \delta Z_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Z_{t-i} + \varepsilon_t$$

$$\Delta Z_t = \alpha + \beta t + \delta Z_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Z_{t-i} + \varepsilon_t$$

Based on data of sequence LGDP and LFDI, the author uses ADF test to make stability test of three models. Results are in Table 2.

From the Table 2, after the inspection of sequence LGDP, the ADF is -4.0746 as the type of test is (c, t, 1). And the probability is 0.0203. It's stable at the 5% significance level. Reject the assumption that sequence LGDP has unit root. The sequence LGDP is a first-order single sequence. After the inspection of sequence LFDI, the ADF is -3.2438 as the type of test is (c, 0, 1). And the probability is 0.0302. It's stable at the 5% significance level. Reject the assumption that sequence LFDI has unit root. The sequence LFDI is a first-order single sequence. Therefore, there may be a long-term equilibrium relationship between sequence LGDP and LFDI.

4. Co-integration test

Co-integration is a statistical description of long-term equilibrium relationship between unstable variables, which is also the precondition for making causality regression of variables. However, for many unstable variables, we can not use classical regression model to make analysis. Otherwise, it may cause an issue of false regression. Economic theories confirm the existence of certain long-term equilibrium relationship between some economic variables. This equilibrium indicates that there is not an internal mechanism destroying the equilibrium in an economic system. The co-integration test is to find out whether there is a long-term equilibrium relationship between variables. We can constitute a regression model by classical regression methods to make further analysis. The most regular method for co-integration test is to use OLS to make co-integration regression of variables. Suppose the time sequence Y and X. The procedures of co-integration test include:

First of all, make co-integration regression and test whether there is a long-term equilibrium relationship between variables. The regression model is:

$$Y_t = \hat{\beta}_0 + \hat{\beta}_1 X_t + e_t$$

Secondly, use the ADF to test the stability of residual sequence. Because there is an intercept in the co- integration model, the testing of stability of residual sequence should use a test model without an intercept.

$$\Delta e_t = \delta e_{t-1} + \sum_{i=1}^{p} \theta_i \Delta e_{t-i} + \varepsilon_t$$

When reject the original assumption, the residual sequence is stable, that is, the time sequence Y and X are co-integrated. It indicates that there is a long-term stable equilibrium relationship between sequence Y and X.

Because the stability test shows that there might be a long-term equilibrium relationship between time sequence LGDP and LFDI, use the OLS to make co-integration regression of two sequences. And the Grander Causality Test shows that there is a one-way causality relationship between LGDP and LFDI. Take LFDI as the dependent variable

to make a co-integration regression. Get the long-term equilibrium relationship model of two sequences:

$$LFDI_t = -11.204 + 1.637\,LGDP_t$$

(-6.585) (9.799)

The determination coefficient of long-term equilibrium relationship model is 0.800025, which means a high correlation. The D.W statistic is 0.1417. By Lagrange Multiplier Test of residual sequence in the mode, there is a serious correlation between residual sequences in the long-term equilibrium relationship model. In order to confirm the validity of model prediction, it is necessary to add proper lag variables into the model to eliminate the self correlation. After repeated experiments and simulations, the data of long-term equilibrium relationship model is finally established. See Table 3.

The adjusted sample determination coefficient in the model is 0.9778, indicating a high correlation between variables. D.W statistic is 1.414. By LM test, results show that there is no correlation between residual sequences in the model. So, the adjusted model might be correct. Whether there is a long-term equilibrium relationship between LGDP and LFDI is determined by the stability of residual sequences. ADF, the stability test of residual sequences in adjusted model, is -5.3612. And the probability is 0.0013, lower than the critical value -3.6220 at the 5% significance level. It indicates that the residual sequence is stable. Besides, it means that there is a long-term equilibrium relationship between FDI and economic growth in China.

5. Error correction model

The co-integration test confirms the long-term equilibrium relationship between variables. The causality test determines the form of the relationship. On this basis, take the long-term equilibrium relationship of sequences as the error correction term. The error correction term, as an explanatory variable, and other variables that influence short-term fluctuations constitute an error correction model.

Usually, the regular form of error correction model is:

$$\Delta Y_t = \beta_1 \Delta X_t - \lambda ecm_{t-1} + \mu_t$$

In this model, ecm is the error correction term. Therefore, ecm has a corrected effect on the long-term tendency. If the observation value is greater than the long-term equilibrium relationship at the t-1 period, the ecm_{t-1} is positive and the $-\lambda ecm_{t-1}$ is negative. Then, make a reverse adjustment to the short-term deviation so that the deviation comes back to an equilibrium state. Conversely, if the observation value is smaller than the long-term equilibrium relationship at the t-1 period, the ecm_{t-1} is negative and the $-\lambda ecm_{t-1}$ is positive. Then, make a positive adjustment to the short-term deviation so that the deviation comes back to an equilibrium state.

For the long-term equilibrium relationship between FDI and GDP confirmed by the co-integration test, build an error correction model based on sequence LGDP and LFDI.

Results in Table 4 show that all explanatory variables in the error correction model pass the significance test. The D.W statistic is 2.115. The LM test shows that there is no self correlation between residual sequences in the model. Make the white noise test to residual sequences of the error correction model and the ADF is -4.342. And the probability is 0.0144, lower than the critical value -3.6674 at the 5% significance level. Then the residual sequence possesses the nature of white noise. So, the model is correct. Meanwhile, the coefficient of error correction term in the model is 1.0334, which is consistent with the positive correction, reflecting that the long- term equilibrium relationship has a powerful adjusting effect on short-term fluctuation. The error correction term will draw the non-equilibrium state of FDI back to the long-term equilibrium state with the 1.0344 adjustment effect.

6. Conclusion

Based on the error correction model, in perspective of stability test, causality test, co-integration test, and error correction model, the author adopts econometric methods to make co-integration analysis of relationships between FDI and GDP since 1985 in China. Finally draw conclusions as follow:

(1) The stability test shows that LGDP and LFDI are both first-order single sequence. The co-integration test shows that there is a first-order co-integrated relationship between LGDP and LFDI. The two of them have a long-term stable equilibrium relationship.

(2) Grander Causality Test shows that China's economic growth would inevitably lead to the rise of FDI. However, the rise of FDI can promote economic growth but economic growth is not always the result.

(3) The error correction model indicates that the error correction term has a stronger negative adjustment effect on the long-term equilibrium relationship between economic growth and FDI.

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Table 1.

Lag length	Original assumption	Probability (F-statistics)	Probability (LM(1) test)	AIC	Conclusion
1	LGDP is not the Grander cause of LFDI	0.8678	0.0100	0.1308	Accepted
	LFDI is not the Grander cause of LGDP	0.8095	0.0256	-3.6155	Rejected
2	LGDP is not the Grander cause of LFDI	0.0259	0.5516	-0.3512	Rejected
	LFDI is not the Grander cause of LGDP	0.6713	0.0078	-3.6519	Accepted
3	LGDP is not the Grander cause of LFDI	0.0741	0.2133	-0.3811	Accepted
	LFDI is not the Grander cause of LGDP	0.5439	0.0512	-3.7915	Accepted
4	LGDP is not the Grander cause of LFDI	0.0177	0.0034	-0.5955	Rejected
	LFDI is not the Grander cause of LGDP	0.4444	0.0066	-3.7478	Accepted
5	LGDP is not the Grander cause of LFDI	0.0078	0.7609	-1.2197	Rejected
	LFDI is not the Grander cause of LGDP	0.0779	0.2474	-5.1545	Accepted

Table 2.

Variable	Type of test	ADF test	Probability of significance	5% critical value	Conclusion
LGDP	(c,t,2)	-1.9618	0.5914	-3.6220	Unstable
	(c,0,2)	2.2317	0.9998	-2.9981	Unstable
	(0,0,2)	3.1558	0.9990	-1.9564	Unstable
LFDI	(c,t,1)	-2.0376	0.5524	-3.6122	Unstable
	(c,0,2)	-1.9889	0.2892	-2.9981	Unstable
	(0,0,2)	1.4606	0.9597	-1.9564	Unstable
ΔGDP	(c,t,1)	-4.0746	0.0203	-3.6220	Stable
ΔLFDI	(c,t,1)	-3.5825	0.0539	-3.6220	Unstable
	(C,0,1)	-3.2438	0.0302	-2.9981	Stable

Table 3.

Variable	Regression coefficient	Standard error	t-statistic	Probability
C	1.095678	1.053289	1.040244	0.3101
LGDP	3.749668	1.161003	3.229679	0.0040
LGDP(-1)	-3.844959	1.206103	-3.187920	0.0044
LFDI(-1)	0.938473	0.069453	13.51232	0.0000
Sample determination coefficient	0.977845	Average of dependent variables		5.523253
Adjusted sample determination coefficient	0.974680	Standard error of dependent varaibles		1.284150
Regression standard error	0.204337	AIC		-0.192442
Square sum of residuals	0.876829	SC		0.002578
Log likelihood	6.405528	HQ		-0.138352
F statistic	308.9555	D.W statistic		1.414212
Probability (F-statistic)	0.000000			

Table 4.

Variable	Regression coefficient	Standard error	t-statistic	Probability
D(LGDP)	3.512571	0.114886	30.57444	0.0000
D(LFDI(-1))	0.148469	0.028072	5.288909	0.0001
D(LGDP(-2))	-1.175442	0.172913	-6.797882	0.0000
D(LGDP(-3))	-1.324774	0.185593	-7.138044	0.0000
D(LFDI(-3))	0.162312	0.018984	8.549924	0.0000
D(LGDP(-5))	-0.415137	0.136526	-3.040723	0.0095
-ECM	-1.033435	0.039378	-26.24400	0.0000
Sample determination coefficient	0.996558	Average of dependent variables		0.170595
Adjusted sample determination coefficient	0.994970	Standard error of dependent variables		0.271495
Regression standard error	0.019256	AIC		-4.792774
Square sum of residuals	0.004820	SC		-4.444267
Log likelihood	54.92774	HQ		-4.724741
D.W statistic	2.114961			