ISSN: 2288-2766 © 2018 EABEA. http://eajbe.jams.or.kr
doi: http://dx.doi.org/10.20498/eajbe.2018.6.3.24

A Study on the Impact of Real Exchange Rate Volatility of RMB on China's Foreign Direct Investment to Japan

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Received: June 18, 2018. Revised: August 7, 2018. Accepted: August 12, 2018.

Abstract

Purpose – From establishing China-Japan diplomatic relations in 1972, the relations between two states has improved a lot, from which makes the government and the people reap much benefit. Owing to this reason, this paper aims at exploiting the impact of exchange rate volatility of RMB on China's foreign direct investment to Japan.

Research design and methodology – The quarterly time series data from 2003 to 2016 will be employed to conduct an empirical analysis under the vector error correction model. Meanwhile, a menu of estimated methods such the Johansen co-integration test and the Granger Causality test will be also used to explore the impact of exchange rate volatility of RMB on China's foreign direct investment to Japan.

Results – The empirical analysis results exhibit that the real exchange rate has a positive effect on China's foreign direct investment to Japan in the long run. Conversely, the real exchange rate volatility of RMB, the trade openness and the real GDP have a negative effect on China's foreign direct investment to Japan in the long run. However, in the short run, the China's foreign direct investment to Japan, the real exchange rate, the trade openness and the real GDP in period have a negative effect on China's foreign direct investment to Japan in period. Oppositely, the real exchange rate volatility of RMB in period has a positive effect on China's foreign direct investment to Japan in period.

Conclusions – From the empirical evidences in this paper provided, it can be concluded that an increase in the exchange rate volatility of RMB can result in a decrease in the China's foreign direct investment to Japan in the long run. However, an increase in the exchange rate volatility of RMB can lead to an increase in the China's foreign direct investment to Japan in the short run. Therefore, the China's government should have a best control of the real exchange rate volatility of RMB so as to improve China's foreign direct investment to Japan.

Keywords: Foreign Direct Investment, Real Exchange Rate Volatility of RMB, Vector Error Correction Model.

JEL Classification Code: C02, E23, F19, F43.

1. Introduction

Since the Bretton woods system collapses, the international exchange rate system has been dominated by floating exchange rate system with multiple exchange rate systems coexistence. Since the People's Republic of China founds, China has adopted a fixed exchange rate system. Until to January 1th, 1994, China starts to use the managed floating exchange rate system. After July 21th, 2005, a floating exchange rate system is implemented on the ground of the market demand and the market Supply, by referring to a basket of currency and the managed floating exchange rate system.

Since 1973, Japan has shifted from a fixed exchange rate (pegged to the dollar) to a floating exchange rate. In April 1998, Japan amends and implements <Foreign Exchange and Foreign Trade Act> which stipulates that Japan's current account and capital account are basically fully open, and the exchange rate is decided by the market supply and the market demand. At present, Japan carries out the unified exchange rate. The yen exchange rate is a floating exchange rate determined by market supply and demand, and the Japan's government will take measures to stabilize the exchange rate when necessary. The main currencies that Japan's government operates in the foreign exchange market are the dollar and the yen.

Since the establishment of diplomatic relation ties between China and Japan on September 29th, 1972, the two countries have witnessed rapid development in the cooperation of economy, politics and culture. In particular, after the founding of the Shanghai cooperation organization in 2001, co-operations between two countries in all areas deepen. However, the China's foreign direct investment to Japan is growing faster with a down and up fluctuation. This is closely related to the volatility of exchange rate between the two countries. Therefore, this paper employs quarterly data from the first quarter of 2003 to the fourth quarter of 2016 to analyze the impact of exchange rate volatility of RMB on China's foreign direct investment to Japan under the vector error correction model. This paper exhibits two aspects to investigate the relationship between both of them. One is to exploit the long-run relationship between China's foreign direct investment to Japan and exchange rate volatility of RMB. Another is to expose the short-run relationship between China's foreign direct investment to Japan and exchange rate volatility of RMB.

Today, as the economic globalization develops in depth, China's future and destiny are increasingly tied with the world's future and destiny, of course, including Japan. Therefore, in order to have a bright and glorious future and destiny both China and world, it is very essential to analyze relationship both China and world in economics. Thus, this paper sets China and Japan as an example to exploit the impact of exchange rate volatility of RMB to China's foreign direct investment to Japan. Only by making the operating mechanism between both of them fully known can China and Japan benefit most. The rest of this study will be constructed as the following indicates. Section 2 is the literature review which is mainly focused on previous studies. Section 3 is the theoretical framework which is a base for the empirical analysis. Section 4 is the empirical analysis which provides theoretical evidence for this paper. Section 5 is the conclusion which is a summary of this paper.

2. Literature Review

Despite of the fact that the impact of volatility in macroeconomic variables on foreign direct investment has received a great deal of attention, the symbols and magnitude of the volatility in foreign direct investment, the existing literatures are still inconclusive.

Osinubi and Amaghionyeodiwe (2009) use the second time series data from 1970 to 2004 to analyze the impact of exchange rate fluctuation on Nigeria's foreign direct investment. Based on the estimation of error correction model and ordinary least squares, their results show that the exchange rate volatility should not be a source of concern for foreign investors in other countries. Furthermore, this study also reveals the significant positive correlation between real foreign direct investment and exchange rate. Yu and Cheng (2010) examine the impact of volatility effect of real exchange rate of RMB on the level of foreign direct investment inflow in the process of exchange rate regime transformation. they also canvass different effects of exchange are on resource-seeking foreign direct investment and market-seeking foreign direct investment. They come into a conclusion that the expected appreciation and the temporary exchange rate volatility of RMB can promote the foreign direct investment inflow in the short run. However, the long-run effect is ambiguous. Moreover, an increase in the exchange rate will decrease the resource-seeking foreign direct investment inflow while an increase in the exchange rate will increase the market-seeking foreign direct investment inflow. Parajuli and Kennedy (2010) anaylze Mexico's exchange rate and foreign direct investment from twenty-five OECD developed countries. Their findings do not support the significant relationship between exchange rate and exchange rate volatility to determine foreign direct investment in Mexico. Conversely,

wages, exports and distance are considered as important variables that determine the foreign direct investment of Mexico, which is supported by the literature. Dhakal, Nag, Pradhan and Upadhyaya (2010) employ panel data to verify the influence of the uncertainty of exchange rate on foreign direct investment in China, Indonesia, Malaysia, Philippines, South Korea, and Thailand (their countries have kept to attract considerable foreign direct investment inflows when also experiencing a lot of volatility in exchange rates). Their results show that the exchange rate volatility has a good effect on foreign direct investment in these countries.

Abbott and Vita (2011) investigate the influence of a quantity of country-pair exchange rate regime combinations on bilateral foreign direct investment. They figure that the currency union has a favorable effect on cross-border investment. Nonetheless, the fixed exchange rate between two countries leads to the impact on bilateral foreign direct investment being inconsistent. Therefore, their relationships are also ambiguous. Ellahi (2011) finds the influence of the volatility of exchange rate on foreign direct investment for the Pakistan economy. A secondary time series data set is utilized over the period from 1980 to 2010. And the most robust and modern technique of auto regressive distributed lag has been applied to find the short run and the long run estimates of his study. His major findings show that the exchange rate volatility has negative effect on foreign direct investment inflow in short run while the exchange rate volatility has positive effect on foreign direct investment inflow in long run. Omankhanlen (2011) finds that the exchange rate has a bidirectional effect with foreign direct investment in Nigeria. Nasir and Hassan (2011) examine the character of economic freedom, market size and exchange rates in appealing to south Asian countries' foreign direct investment for the year of 1995 to 2008 via employing panel data to conduct an analysis in fixed effect setting. They find that a depreciation of host country currency has negative influence on the foreign direct investment inflow to that country. Their study also provides that the trade openness, efficient monetary, fiscal policies and freedom from corruption can help South Asian countries to attract more foreign direct investment.

Sharifi and Mirfatah (2012) evaluate the determinants of inward foreign direct investment particularly volatility of exchange rate in Iran by employing the Johansen and Juselius's cointegration system approach model which is covering from 1980-Q2 to 2006-Q3. Their findings reveal that the GDP, the trade openness and the exchange rate have a positive relationship with foreign direct investment. But the world crude oil prices and the volatility of exchange rate have a negative relationship with foreign direct investment. Abbott, Cushman and Vita (2012) examine the influence of exchange rate regimes on flows of foreign direct investment to developing countries. Employing the estimation of the system generalized methods of moments on a panel of seventy developing countries for the period from 1985 to 2004, they find that in attracting the foreign direct investment flows, the developing countries with a virtually fixed or an intermediate system are significantly better at choosing a flexible exchange rate regime. No statistically significant differences in the foreign direct investment-inducing properties of fixes, intermediates and floats are detected using the International Monetary Fund official classification. Chaudhary, Shah, and Bagram (2012) investigate the impact of volatility in exchange rate on foreign direct investment in Asian economies. Using the Auto Regressive Distributed Lag approach to cointegration and Error Correction Model, their results show a mixed trend with memorizing the impact of volatility of exchange rate on foreign direct investment in some countries. However, nearly, in the half of the countries tested, the relationship among variables cannot found. Kumarasamy and Velan (2012) use the same approach to study this proposition, their results show that exchange rate volatility deters foreign direct investment in India. But the flexible and stable exchange rate system may be needed to successfully attract foreign direct investment inflows in India.

Asmah and Andoh (2013) use a dynamic linear panel model with data from twenty-seven African countries to examine exchange rate volatility on foreign direct investment flows to Africa. They find a robust negative and significant influence of volatility of exchange rate on African countries' foreign direct investment. Lily, Kogid, Mulok, Thien Sang, and Asid (2014) analyze relationship between exchange rate movements and foreign direct investment by using annual data on ASEAN economies. They are Malaysia, Philippines, Thailand, and Singapore. By employing Auto Regressive Distributed Lag bounds test approach, their findings show that the significant long-run cointegration relationship between exchange rate and foreign direct investment exists for the case of Singapore, Malaysia, and Philippines. Along long with the recording negative coefficient of all countries, this implies that the Singapore dollar appreciation, the Malaysian ringgit appreciation, and the Philippine peso appreciation has a positive effect on foreign direct investment inflows. Using the error correction model which is based Auto Regressive Distributed Lag approach for causality test, both Singapore and Philippines indicate the long-run bidirectional causality between exchange rate and foreign direct investment whereas the long-run unidirectional causality which is running from the exchange rate to foreign direct investment in Malaysia. Furthermore, this study also finds that the short-run unidirectional causality which is running from the exchange rate to foreign direct investment exists in Singapore. Bilawal, Ibrahim, Abbas, Shuaib, Ahmed, Hussain and Fatima (2014) find that the significant positive relationship between exchange rate and foreign direct investment in Pakistan exists. Elly and

Ojung (2015) reveal that exchange rate volatility has extremely minimal effects on foreign direct investment in Nigeria.

Khandare (2016) finds that there is positive correlation between foreign direct investment and exchange rate in India. For China the correlation between foreign direct investment and exchange rate is negative. Zakari (2017) indicates the significant positive relationship between foreign direct investment and exchange rate exists in Nigeria. His study also finds that there is a significant inflow of foreign direct investment from 2005-2014 due to rise in exchange rate in the same period. Dal Bianco and Loan (2017) investigate the impact of price and real exchange rate volatility on foreign direct investment inflows in a panel of ten Latin American and Caribbean countries, which are covered from 1990 to 2012. The series of price and exchange rate fluctuations are estimated by the generalized auto regressive conditional heteroscedasticity model. The results obtained by using fixed effect estimation method verify the lag theory and option value, and the negative impact of exchange rate volatility on foreign direct investment is statistically significant.

To sum up, the listed previous researches mentioned above take use of different kinds of models and variables with different samples to exploit the relationship between real exchange rate volatility of RMB and China's foreign direct investment to Japan. In order to reduce the impacted factors that can influence the accuracy of research result, this paper only sets china and Japan as an example to study between both of them. Additionally, the trade openness and the GDP is also an important factor that can impact a country's foreign direct investment to another country. Therefore, both of them are added to this paper, which are treated as independent variables. Of course, this is a biggest innovation of this paper when compared with others. Furthermore, this paper also tries to explore the relationship between both of them in the long run and in the short run. this is also an innovation of this paper.

In order to make the previous achievements seen more intuitively, all previous researches in details cited in this will be shown in <Table 1>.

Table 1: Results of Previous Researches

Author	Year	Result
Osinubi and Amaghionyeodiwe	2009	Significant positive relationship
Yu and Cheng	2010	Positive short-run relationship; Ambiguous long-run relationship
Parajuli and Kennedy	2010	Not significant relationship
Dhakal, Nag, Pradhan and Upadhyaya	2010	Positive relationship
Abbott and Vita	2011	Ambiguous relationship
Ellahi	2011	Negative short-run relationship; Positive long-run relationship
Omankhanlen	2011	Bidirectional relationship
Nasir and Hassan	2011	Negative relationship
Sharifi and Mirfatah	2012	Negative relationship
Abbott, Cushman and Vita	2012	Ambiguous relationship

Chaudhary, Shah and Bagram	2012	Mixed relationship
Kumarasamy and Velan	2012	Positive relationship
Asmah and Andoh	2013	Significant negative relationship
Lily, Kogid, Mulok, Thien Sang and Asid	2014	Significant short-run relationship
Bilawal, Ibrahim, Abbas, Ahmed, Hussain and Fatima	2014	Significant positive relationship
Elly and Ojung	2015	Extremely minimal relationship
Khandare	2016	Positive relationship
Zakari	2017	Significant positive relationship
Dal Bianco and Loan	2017	Negative relationship

Note: Result indicates what kind of relationship between China's foreign direct investment to Japan and exchange rate volatility of RMB is.

3. Theoretical Framework

3.1. Variable description

The ratio of China's foreign direct investment to Japan to China's real gross domestic product is treated as a dependent variable. It will be marked as $ratio_{\frac{fdi}{rgdp}}$. The real exchange rate between China and Japan is treated as an independent variable. It will be marked as $E_{\frac{j}{c}}$. The magnitude of real exchange rate volatility is treated as an independent variable. It will be marked as Flu. The ratio of total export & import between China and Japan to China's real gross domestic product, often called trade openness, is treated as an independent variable. It will be marked as $openness$. The real gross domestic product is also treated as an independent variable. It will be marked as $rgdp$.

The big innovation in this paper is that the real gross domestic product ($rgdp$) and trade openness ($openness$) which are treated as independent variables are added to this theoretical model. There are two reasons: One is that the magnitude of a country's foreign direct investment is often related with its domestic economic state. Namely, if a country has a larger gross domestic product, it will have a higher comprehensive economic strength and greater purchasing power. Due to this, multinational enterprises are willing to conduct foreign direct investment more. Another is that the foreign trade has a great effect on foreign direct investment. A country performs international economic cooperation via cross-border trade and transnational direct investment. In general, the greater trade openness is, the lower the trade barrier will be. Therefore, a country will increase its amount of trade. Relatively, its foreign direct investment will decrease. In this sense, there is an alternative relationship between two of them.

3.2. Modeling

In this paper, we assume that the China's foreign direct investment to Japan is only affected by the real exchange of RMB ($E_{\frac{j}{c}}$), the real exchange rate volatility (Flu), the China's trade openness ($openness$) and the China's real gross domestic product ($rgdp$). The function of them can be expressed as following:

$$ratio_{\frac{fdi}{rgdp}} = f(E_{\frac{j}{c}}, Flu, openness, rgdp, A) \tag{1}$$

Where A represents the economic constitution and technological level. Often, it is treat as a constant in the model. Taking the total differential on equation (1) gives:

$$ratio_{\frac{fdi}{rgdp}} = \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial E_{\frac{j}{c}}} \times \partial E_{\frac{j}{c}} + \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial Flu} \times \partial Flu + \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial openness} \times \partial openness + \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial A} \times \partial A \tag{2}$$

Dividing both side of equation (2) by gives:

$$\begin{aligned} ratio_{\frac{fdi}{rgdp}} = & \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial E_{\frac{j}{c}}} \times \frac{E_{\frac{j}{c}}}{ratio_{\frac{fdi}{rgdp}}} + \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial Flu} \times \frac{Flu}{ratio_{\frac{fdi}{rgdp}}} \\ & + \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial openness} \times \frac{openness}{ratio_{\frac{fdi}{rgdp}}} + \frac{\partial ratio_{\frac{fdi}{rgdp}}}{\partial A} \times \frac{A}{ratio_{\frac{fdi}{rgdp}}} \end{aligned} \tag{3}$$

On equation (3), the $\frac{E_{\frac{i}{c}}}{ration_{\frac{fdi}{rgdp}}} \times \frac{\partial ration_{\frac{fdi}{rgdp}}}{\partial E_{\frac{i}{c}}}$ represents the elasticity of $ratio_{\frac{fdi}{rgdp}}$ to $E_{\frac{j}{c}}$, which will be marked as α; the $\frac{Flu}{ration_{\frac{fdi}{rgdp}}} \times \frac{\partial ration_{\frac{fdi}{rgdp}}}{\partial Flu}$ represents the elasticity of $ratio_{\frac{fdi}{rgdp}}$ to Flu, which will be marked as β; the $\frac{openness}{ration_{\frac{fdi}{rgdp}}} \times \frac{\partial ration_{\frac{fdi}{rgdp}}}{\partial openness}$ represents the elasticity of $ratio_{\frac{fdi}{rgdp}}$ to $openness$, which will be marked as γ; the $\frac{rgdp}{ration_{\frac{fdi}{rgdp}}} \times \frac{\partial ration_{\frac{fdi}{rgdp}}}{\partial rgdpu}$ represents the elasticity of $ratio_{\frac{fdi}{rgdp}}$ to $rgdp$, which will be

marked as δ ; the $\frac{rgdp}{ration_{\frac{fdi}{rgdp}}} \times \frac{\partial ration_{\frac{fdi}{rgdp}}}{\partial rgdpu}$ represents the elasticity of $ratio_{\frac{fdi}{rgdp}}$ to A , which will be marked as c .

Therefore, rewriting equation (3) gives：

$$\frac{\partial ratio_{\frac{fdi}{rgdp}}}{ratio_{\frac{fdi}{rgdp}}} = \alpha \partial E_{\frac{j}{c}} + \beta \partial Flu + \gamma \partial openness + \delta \partial rgdp + c \partial A \tag{4}$$

Transferring equation (4) gives:

$$ratio_{\frac{fdi}{rgdp},t} = c + \alpha \log E_{\frac{j}{c},t} + \beta \log Flu_t + \gamma \log openness_t + \delta \log rgdp_t + \varepsilon_t \tag{5}$$

Equation (5) indicates the impact of real exchange rate, real exchange rate volatility, trade openness and real gross domestic product on China's foreign direct investment to Japan. ε_t is the white noise. c is the constant. α, β, γ , and δ are the coefficients of them. According to the value of β , three conclusions can be reached. the first is that if the value of β is greater than zero, the exchange rate volatility of RMB will have a positive effect on China's foreign direct investment to Japan; The second is that if the value of β is less than zero, the exchange rate volatility of RMB will have a negative effect on China's foreign direct investment to Japan; The third is that if the value of β is equal to zero, the exchange rate volatility of RMB will have no effect on China's foreign direct investment to Japan.

4. 4. Empirical Analysis

4.1. Unit root test

Most economic variables are non-stationary at their own levels. If they are employed directly to conduct an empirical estimation, the spurious regression usually occurs. Due to this, each variable will be estimated to confirm whether the unit root exists or not respectively. Moreover, all variable have been in log so as to remove off the outliner and heteroscedasticity. This paper will take use of the Augmented Dickey–Fuller test (ADF) to test the stationarity of each variable. The results of unit root test displays in <Table 2>.

Table 2: Result of Unit Root Test

Variable	t-Statistic	5% Test critical Value	Prob.	Result
$\log ratio$	-2.708	-2.916	0.079	Non-rejected
$\log E$	-2.445	-2.917	0.135	Non-rejected
$\log Flu$	-1.952	-2.918	0.307	Non-rejected
$\log openness$	0.383	-2.927	0.980	Non-rejected
$\log rgdp$	-1.755	-2.921	0.398	Non-rejected

$\Delta \log ratio$	-6.346	-2.917	0.000	Rejected
$\Delta \log E$	-8.429	-2.918	0.000	Rejected
$\Delta \log Flu$	-3.293	-2.918	0.020	Rejected
$\Delta \log openness$	-5.811	-2.925	0.000	Rejected
$\Delta \log rgdp$	-3.711	-2.921	0.007	Rejected

Note: *MacKinnon (1996) one-sided p-values. Δ represents the frist different operator.

<Table 2> reports that the absolute value of each variable's t-statistic is less than the 5% test critical value at its level. Namely, the original hypothesis that the time series exists unit root is non-rejected. It means that the time series is non-stationary at its level. However, after conducting the first difference, the absolute value of each variable's t-statistic is greater than the 5% test critical value at 5% significant level. Namely, the original hypothesis that the time series exists unit root is rejected at 5% significant level. It means that the time series is stationary at 5% significant level. Then, the long-run relationship among variable needs to be performed via cointegration test.

4.2. Co-integration test

The classical regression model is based on stationary variables. For non-stationary variables, the classical regression model cannot be used, otherwise there will be many problems such as spurious regression. However, Engle and Granger (1987) provide a new approach for non-stationary sequencers to conduct an cointegrtaion test. Although some economic variables are inherently non-stationary sequences, their linear combinations are likely to be stationary. This stationary linear combination is known as the cointegration equation. It can be interpreted as a long-run stable equilibrium relationship among variables. In this paper, Johansen cointegration test will be adopted to estimate the long-run relationship among variables. The cointegration test results will be shown in <Table 3> and <Table 4>.

Table 3: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
$r = 0$ *	0.495	76.166	69.819	0.014
$r \leq 1$	0.381	39.418	47.856	0.244
$r \leq 2$	0.167	17.693	29.797	0.589
$r \leq 3$	0.090	7.818	15.495	0.485
$r \leq 4$	0.049	2.729	3.841	0.099

Note: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) p-values.

Table 4: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
$r = 0$ *	0.495	36.748	33.877	0.022
$r \leq 1$	0.381	21.726	27.584	0.235
$r \leq 2$	0.167	9.874	21.132	0.756

$r \leq 3$	0.090	5.089	14.265	0.731
$r \leq 4$	0.049	2.729	3.841	0.099

Note: Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) p-values.

<Table 3> and <Table 4> exhibit the results of trace test and the results of maximum eigenvalue test. Both indicate that the hypothesis that there is no cointegration relationship among them is rejected at the 5% level. Namely, the long-run relationship among them exists. the cointegrating equation gives:

$$\log ration_t = 9.258 \log E_t - 0.621 \log Flu_t - 3.331 \log rgdp_t - 6.790 \log rgdp_t \quad (6)$$

Equation (6) documents the long-run relationship among them. Specifically, 1% increase in the real exchange rate will lead to 9.258% increase in China's foreign direct investment to Japan. 1% increase in the real exchange rate volatility will result in 0.612% decrease in China's foreign direct investment to Japan. 1% increase in trade openness will bring about 3.331% decreases in China's foreign direct investment to Japan. 1% increase in the real GDP will give rise to China's foreign direct investment to Japan. In order to make the causality among them, the causality test will be conducted in the next step.

4.3. Causality test

In this paper, the Granger causality test will be used to examine the direction of causality between China's foreign direct investment to Japan and other variables. If the causality between China's foreign direct investment to Japan and other variables exists, the past values of other variables can be used to predict the change of China's foreign direct investment to Japan. The results show in <Table 5>.

Table 5: Pairwise Granger Causality Test Result

Null Hypothesis	Obs	F-Statistic	Prob.	Result
$\log E$ does not Granger Cause $\log ratio$	54	4.848	0.012	Rejected
$\log ratio$ does not Granger Cause $\log E$	54	0.709	0.497	Non-rejected
$\log Flu$ does not Granger Cause $\log ati$	54	5.095	0.000	Rejected
$\log ratio$ does not Granger Cause $\log Flu$	54	0.469	0.628	Non-rejected
$\log openness$ does not Granger Cause $\log ratio$	54	3.378	0.042	Rejected
$\log ratio$ does not Granger Cause $\log openness$	54	0.148	0.863	Non-rejected
$\log rgdp$ does not Granger Cause $\log ratio$	54	3.639	0.034	Rejected
$\log ratio$ does not Granger Cause $\log rgdp$	54	0.162	0.851	Non-rejected

<Table 5> exhibits that the hypothesis that $\log E$ does not Granger Cause $\log ratio$ is rejected at 5% significant level. But the hypothesis that $\log ratio$ does not Granger Cause $\log E$ is non-rejected at 5% significant level. Thus, the value of $\log E$ can be used to forecast the change of $\log ratio$. The casualty relationship between $\log Flu$ and $\log ratio$ is found from $\log Flu$ to $\log ratio$. So, the past value of $\log Flu$ can be used to forecast the change of $\log ratio$. The causality between $\log ratio$ and $\log openness$

is unidirectional running only from $\log openness$ to $\log ratio$. It means that the past value of $\log openness$ can be used to forecast the change of $\log ratio$. The causality between and is also unidirectional running only from $\log rgdp$ to $\log ratio$. It means that the past value of $\log rgdp$ can be used to predict the change of $\log ratio$. Then, the short-run relationship between and other variables will be inspected via the vector error correction estimation.

4.4. Vector error correction estimation

In the previous tests, a long-run relationship between China's foreign direct investment to Japan and other variables has been found via the cointegration test. Due to this relationship, an error correction term can be established. Then, this term can be employed to construct a short-run model. The error correction term and other variables will be treated as independent variables in this model.

The basic model gives:

$$\begin{aligned}\Delta \log ratio_t &= \alpha \Delta \log ratio_{t-t} + \beta \Delta \log E_{t-1} + \gamma \Delta \log Flu_{t-1} + \delta \Delta \log openness_{t-1} \\ &+ \rho \Delta \log rgdp_t + \lambda ecm_t + c + \varepsilon_t\end{aligned} \tag{7}$$

Where $\alpha, \beta, \gamma, \delta, \rho$ and λ are coefficients. ε_t is the white noise.

Conducting estimation, the short-run relationship specifically gives:

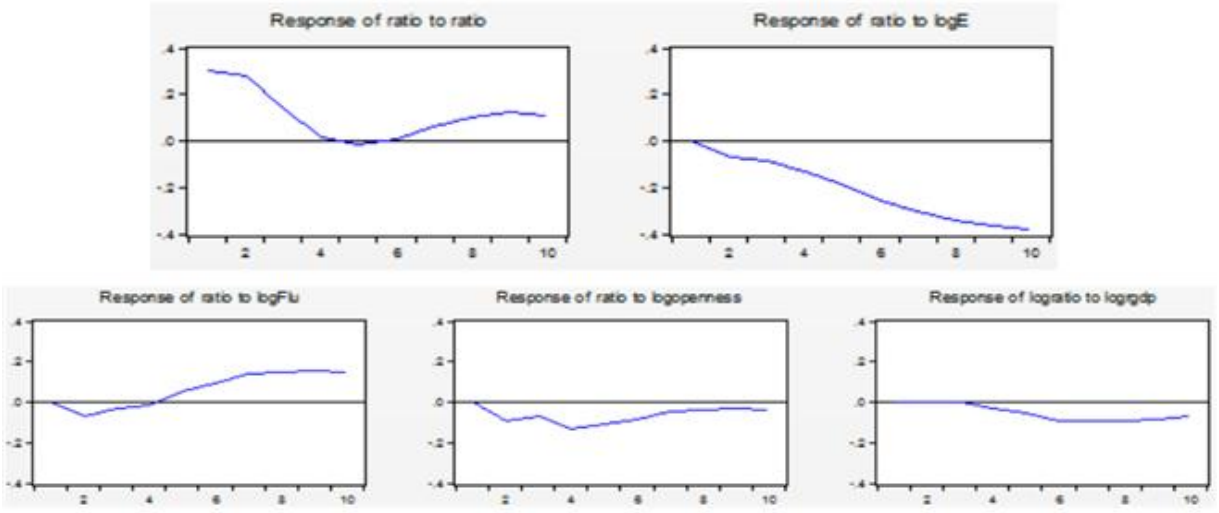
$$\begin{aligned}&\Delta \log ratio_t = \text{-}0.151 \Delta \log ratio_{t-t} \text{ - } 2.787 \Delta \log E_{t-1} + 0.088 \Delta \log Flu_{t-1} \text{ - } 2.492 \Delta \log openness_{t-1} \\ &\text{.....(}-10.310\text{).....(}-8.366\text{).....(}4.909\text{).....(}-7.519\text{)} \\ &\text{- } 0.714 \Delta \log rgdp_t \text{ - } 0.024 ecm_t + 1.209 + \varepsilon_t \\ &\text{...(}-2.128\text{).....(}-7.339\text{).....(}7.360\text{)}\end{aligned} \tag{8}$$

Equation (8) depicts the short-run relationship between China's foreign direct investment to Japan and other variables. China's foreign direct investment to Japan, real exchange rate between China and Japan, trade openness and real GDP have a negative effect on China's foreign direct investment to Japan in the short run. However, the real exchange rate volatility has a positive effect on China's foreign direct investment to Japan. Specifically speaking, 1% increase in China's foreign direct investment to Japan at $t-1$ period will lead to 0.151% decrease in China's foreign direct investment to Japan at t period. 1% increase in real exchange rate at $t-1$ period will result in 2.787% decrease in China's foreign direct investment to Japan at t period. 1% increase in trade openness at $t-1$ period will give rise to 2.492% decrease in China's foreign direct investment to Japan at t period. 1% increase in real GDP at period will lead to 0.714% decrease in China's foreign direct investment to Japan at period. 1% increase in real exchange rate volatility at $t-1$ period will bring about 0.088% increase in China's foreign direct investment to Japan at t period. Furthermore, the coefficient of ecm indicates the adjustment ability when short-run equilibrium relationship is derivation from the long-run equilibrium relationship. Just as the estimated result gives, when short-run fluctuation is derivation from long-run equilibrium relationship, the system will be returned to long-run equilibrium relationship by 0.024% in the opposite direction.

4.5. Impulse response function

In economics, in particular in modern macroeconomic models, the impulse response function is employed to describe the response of the economic external impulse (which is usually called an impulse) over time and it is usually modeled in the context of vector auto regressive backgrounds. From a macroeconomic aspect, the impulse is generally considered to be exogenous. The results of impulse response function in this paper shows in <Figure 1>.

Figure 1: Response to Cholesky one S.D. Innovations



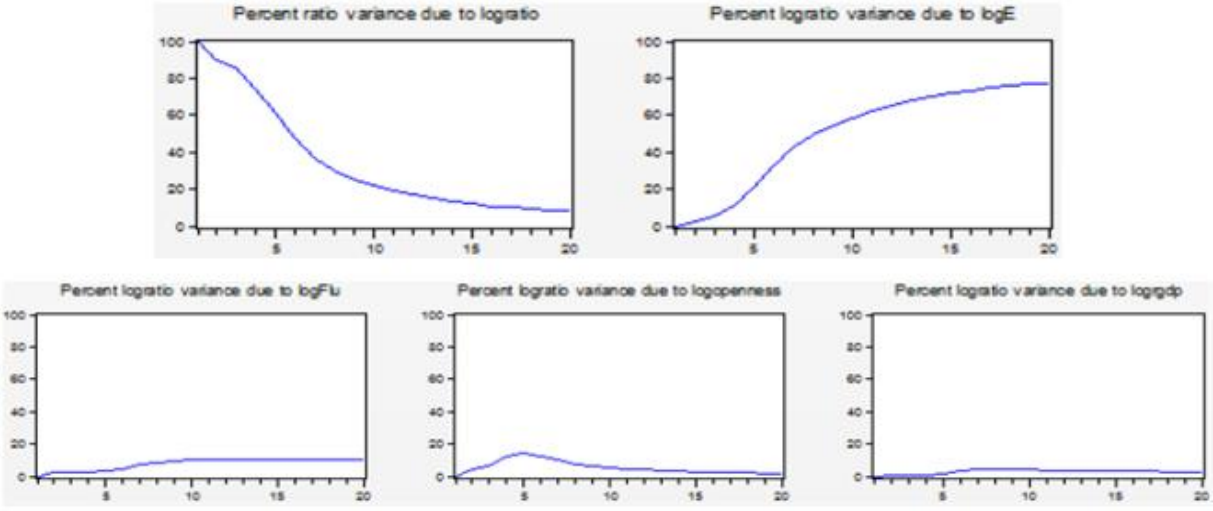
<Figure 1> demonstrates that the short-run dynamics between China's foreign direct investment to Japan and other variables can be examined by estimating a vector error correction model and interpreting it via the impulse response function and the variance decomposition. the impulse response function are reported for ten periods.

As response of $\log ratio$ to $\log ratio$, $\log ratio$ decreases sharply in response to one standard deviation shock in itself until to five periods. Then $\log ratio$ will be beck to increase up to nine periods. After that, the effect will of shock will become negative again. As response of $\log ratio$ to $\log E$, $\log ratio$ does not change in response to one standard deviation shock in $\log E$ until to one period. Then $\log ratio$ will sharply decrease. As response of $\log ratio$ to $\log Flu$, $\log ratio$ does not change in response to one standard deviation shock in $\log Flu$ until to one period. Then, $\log ratio$ will start to decrease until two periods. Next, $\log ratio$ will turn to increase up to nine periods. As response of $\log ratio$ to $\log openness$, $\log ratio$ decreases in response to one standard deviation shock in $\log openness$ until to two period. Then, $\log ratio$ will increase at three period and decrease up to four periods. After five periods, $\log ratio$ increases again until to nine period. And then the effect of the shock dampens out and fades away by the nine periods. As response of $\log ratio$ to $\log rgdp$, $\log ratio$ decreases slightly in response to one standard deviation shock in until to two period. Then, it will start to decrease until six periods. After that, $\log ratio$ will begin to increase again. This result matches the result of vector error correction estimation.

4.6. Variance decomposition

The variance decomposition represents the amount of information each variable has contributed to other variables since the return. It determines how many of the prediction error variance of each variable can be interpreted using the exogenous impact on the other variables. <Figure 2> exhibits the variance decomposition of China's foreign direct investment to Japan.

Figure 2: Variance Decomposition



Regarding the variance decomposition, <Figure 2> reports the variance decomposition for ten periods forecast of $\log ratio$ in which 22% of the forecast variance is attributed to $\log ratio$ shocks, while 4% to $\log openness$ shocks, 59% to $\log E$, 2% to $\log rgdp$ shocks and 13% to $\log Flu$ shocks. This results support both results of impulse response function and Granger causality.

4. Conclusion

This paper aims to examining the impact of exchange rate volatility of RMB on China's foreign direct investment to Japan. A quarterly time series from 2003-Q1 to 2016-Q4 is employed to conduct an empirical analysis under the vector error correction model. In order to make the purpose of this study fully understood, a menu of econometric methods will be applied.

The results of cointegration test illustrates that there the long-run relationship between China's foreign direct investment to Japan and other variables exists. Namely, the impact of real exchange rate on China's foreign direct investment to Japan is positive. However, the real exchange rate volatility of RMB, trade openness and real GDP have a negative effect on China's foreign direct investment to Japan. Furthermore, the results of Granger causality depict that the real exchange rate, the trade openness, the real GDP and the real exchange rate volatility of RMB are the major reasons that can promote China's foreign direct investment to Japan. Therefore, the past values of the real exchange rate volatility of RMB, trade openness, real GDP and the real exchange rate can be used to predict the change of China's foreign direct investment to Japan. Then, the results of vector error correction model exhibit that China's foreign direct investment to Japan, real exchange rate, trade openness and real GDP in period have a negative effect on China's foreign direct investment to Japan in period. However, the real exchange rate volatility of RMB in period has a positive effect on China's foreign direct investment to Japan in period. The impulse response functions' results and the variance decomposition's results match the results of the previous tests.

In summary, this study explores that the impact of real exchange rate volatility of RMB on China's foreign direct investment to Japan. China's government should pay much attention to adjust the real exchange rate volatility of RMB so as to improve China's foreign direct investment to Japan. Only by having a best foreign direct investment can do favor of both China and Japan. Specifically speaking, in the short run, if the China's government is willing to increase the amount of China's foreign direct investment to Japan, the China's government can adjust the magnitude of real exchange rate volatility of RMB in proper so as to realize the government's aim. However, taking the long view into consideration, if the China's government is willing to increase the amount of China's foreign direct investment to Japan, the China's government should keep the magnitude of real exchange rate volatility of RMB

more steadily. Of course, in the short run, the China's government can moderate slowdown in GDP and shrink the trade openness so as to increase the amount of China's foreign direct investment to Japan. Simultaneously, in the long run, the China's government should be also kept same behaviors.

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