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A Study on the Impact of China's Monetary Policy on South Korea's Exchange Rate

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Abstract

Purpose - The adjustment of one country's monetary policy can cause the macroeconomic change of other countries. Due to this, this paper attempts to analyze the impact of China's monetary policy on South Korea's exchange rate.
Research design, data, and methodology - Based on the flexible-price monetary model, sets of annual time series from 1980 to 2017 are employed to perform an empirical estimation. The vector error correction model is also used to exploit the short-run relationship between both of them. Of course, the South Korea's real GDP, the China's real GDP, South Korea's interest rate, the South Korea's interest rate and the South Korea's monetary supply are treated as independent variables in this paper.
Result - The long-run findings reveal that the China's money supply has a negative effect on South Korea's exchange rate. Respectively, the short-run findings depicts that the China's money supply has negative a effect on South Korea's exchange rate. Of course, other variables selected in this paper also have an effect on South Korea's exchange rate whatever positive or negative.
Conclusions - As the empirical evidence shows, the China's monetary policy has a negative effect on South Korea's exchange rate whenever in the long run or in the short run.

Keywords: China's Monetary Policy, South Korea's Exchange Rate, Flexible-Price Monetary Model.

JEL Classifications: A10, C10, E51, E52.

1. Introduction

In an increasingly globalized world, China and South Korea are conducting more coordination and cooperation in regional and global economic affairs. Both belong to the northeast Asian economic circle. Geographically, there is only one sea between the two countries. Historically, the two countries are friendly and close neighbors. And the economic structure is highly complementary and culturally similar.

At present, China is the largest trading partner and largest investor to South Korea. Meanwhile, South Korea is China's fourth largest trading partner and third largest in source importing. Although the establishment of diplomatic relations between China and South Korea is not long, the economic cooperation and achievements of the two countries are obvious to the world. Especially, On December 20, 2015, the sign of <China-South Korea Free Trade Agreement> reflects that the economic cooperation between both countries have stepped into a new stage. So, it is with the deepening of the integration of the two countries that the change of any economic variable between China and South Korea can affect the economic situation of each country more or less. Especially, the economy suffers from great attack such as the financial crisis in Asia in 1997 and the global economic crisis in 2008. A change of a country's macroeconomic policy can impact another country's economic most. Of course, both should be closely related with each other. Therefore, this paper tries to analyze the impact of China's monetary policy on South Korea's exchange rate. Based on the flexible-price monetary model,

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sets of annual time series from 1980 to 2017 are employed to conduct an empirical estimation. Furthermore, some econometric methods are also applied to analyze both of them. The empirical findings exhibit in the long run and short run, respectively. The long-run findings reveal that the China's real GDP, the South Korea's interest rate and the South Korea's money supply have a positive effect on South Korea's exchange rate. Meanwhile, the China's interest rate, the China's money supply and the South Korea's real GDP have a negative effect on South Korea's exchange rate. Respectively, the short-run findings depicts that the China's interest rate, the China's money supply, the South Korea's money supply and the South Korea's money supply have negative effect on South Korea's exchange rate. The China's real GDP and the South Korea's money supply have a positive effect on South Korea's exchange rate.

The rest of this paper will be organized as follows. Section 2 presents the literature review which is a conclusion of the previous studies. Section 3 reports the methodology which is treated as a base for this paper. Section 4 exhibits the empirical analysis which provides theoretical evidence for this paper. Section 5 presents the conclusion which is regarded as a summary of this paper.

2. Literature Review

Despite a menu of studies on the impact of monetary policy on exchange rate which are based on different methods, no absolute result has been achieved. While there are quantities of reasons for this, the most vital one is to use of different methods for different countries in different times. For this reason, some previous studies are selected to conduct a comparative study so as to distinguish the difference between this paper and others.

Voss and Willard (2009) present a two-country structural vector autoregressive model of monetary policy and the exchange rate for the US and Australia. They find that the monetary policy can explain little of the variation in the exchange rate. They also consider the effects of exchange rate innovations and find evidence of slow but substantial pass through to domestic prices with evidence that the response of monetary policy is at least partially responsible for the slow adjustment. Kalyvitis and Skotida (2010) examine the impact of U.S. monetary policy shocks on the cross exchange rates of sterling, yen and mark. Their major finding is a delayed overshooting pattern for all currency cross rates examined (Sterling & Yen, Yen & Mark, Mark & Sterling) following an unexpected U.S. monetary policy change, which in turn generates excess returns. They also provide evidence that the delayed overshooting pattern in cross exchange rates is accompanied by asymmetric interventions by central banks in the foreign exchange markets under consideration triggered by a U.S. monetary policy shock. Bouakez and Normandin (2010) study the effects of U.S. monetary policy shocks on the bilateral exchange rate between the U.S. and each of the G7 countries. They also estimate deviations from uncovered interest rate parity conditional on these shocks. Their results indicate that the nominal exchange rate exhibits delayed overshooting in response to a monetary expansion, depreciating for roughly ten months before starting to appreciate. The shock also leads to large and persistent departures from uncovered interest rate parity. Variance decomposition results indicate that monetary policy shocks account for a non-trivial proportion of exchange rate fluctuations.

Rosa (2011) investigates the impact of US monetary policy on the level and volatility of exchange rates using an event study with five currencies (the US dollar exchange rate versus the euro, the Canadian dollar, the British pound, the Swiss franc, and the Japanese yen). He constructs two indicators of news about monetary policy stemming separately from policy decisions and from balance of risk statements. His results show that both policy decisions and communication have economically large and highly significant effects on the exchange rates, with the surprise component of statements accounting for most of the explainable variation in exchange rate returns in response to monetary policy. Jääskelä and Jennings (2011) examine the ability of vector autoregressive models to properly identify the relationship between monetary policy and exchange rate in a controlled experiment. Simulating data from a small open economy dynamic stochastic general equilibrium model estimated for Australia, they find that sign-restricted VAR models do reasonably well at estimating the responses of exchange rate to monetary policy shocks. Lueangwilai (2012) examines whether or not the Bank of Thailand considers exchange rate movement, which is uncertain, in setting the policy rate. Jovanovic and Petreski (2012) applies the New Keynesian model for monetary policy analysis in a small open economy with a fixed exchange rate. Their results highlight that the monetary policy in Macedonia has had some room for reaction to domestic inflation despite the fixed exchange rate.

Jovanovic and Petreski (2014) try to assess whether the levels of unionization and the rigidity of exchange rates represent a constraint for the monetary policy in South-Eastern Europe and the Commonwealth of Independent States, with a particular focus on the recent economic crisis. Toward that end, a New Keynesian model with price and wage rigidity is used. Their results show that monetary policy responded counter-cyclically during the crisis only in countries with weak trade unions and in countries with flexible exchange rates. Demir (2014) studies the relationship between monetary policy responses to the exchange rate by using an identification method based on the heteroscedasticity in the high-frequency data. His results suggest that the European Central Bank systematically responds to exchange rate movements but that quantitative effects are small. Such a significant but small reaction coefficient seems consistent with the hypothesis that the central banks do not target the fluctuations in the exchange rate but consider them only to the extent they impact on the expected inflation and output path. Kohlscheen (2014) investigates the impact of monetary policy shocks on the exchange rates of Brazil, Mexico and Chile. He finds that even a focus on 1 day exchange rate changes following policy events-which reduces the potential for reverse causality considerably-fails to lend support for the view that associates unexpected interest rate hikes with immediate appreciations. Aleem and Lahiani (2014) propose a semi-structural vector autoregressive model with exogenous variables to examine the exchange rate pass-through to domestic prices. They find that the exchange rate pass-through is higher in Latin American countries than in East Asian countries. The exchange rate pass-through has declined after the adoption of an inflation targeting monetary policy.

Abouwafia and Chambers (2015) employ a structural vector autoregressive model to investigate the impact of monetary policy and real exchange rate shocks on the stock market performance of Kuwait, Oman, Saudi Arabia, Egypt and Jordan. The heterogeneity of the results reflects the different monetary policy frameworks and stock market characteristics of these countries. Mainly, monetary policy and the real exchange rate shocks have a significant short-run impact on the stock prices of the countries that apply a relatively more independent monetary policy and flexible exchange rates. Bouakez and Eyquem (2015) uses a model to predict that in response to an unexpected increase in public expenditure, the long-term real interest rate rises less than the country's debt elastic interest-rate premium. As a result, the long-term real interest rate differential vis-a-vis the rest of the world falls, leading the domestic currency to depreciate in real terms. We establish this result both analytically, within a special version of the model, and numerically for the more general case.

Ghosh, Ostry, and Chamon (2016) examine the case for using two instruments - the policy interest rate and sterilized foreign exchange market intervention - in emerging market countries seeking to stabilize inflation and output while attenuating disequilibrium currency movements. They estimate policy reaction functions for central banks, documenting that indeed both instruments tend to be deployed. They show that whether discretionary monetary policy or inflation targeting is preferable depends on the volatility of shocks relative to the central bank's time inconsistency problem. Fisher and Huh (2016) estimate structural vector autoregressive for four small and three large economies. Sign restrictions are used to identify all the shocks in the structural vector autoregressive, while being agnostic about the sign of the response of the real exchange rate to a relative monetary policy shock. The large number of sets of impulse responses to be judged by sign restrictions for either retention or rejection is generated by a newly proposed method which utilizes instrumental variable estimation. The responses show an absence of an exchange rate puzzle in each economy. The peak appreciation following a contractionary monetary policy shock occurs with at most a one quarter delay in the small countries and, for the United States, on impact. For the Euro region and Japan, the peak appreciation is in the long run. There is considerable model uncertainty in the responses.

Kim and Lim (2018) investigate the effects of monetary policy shocks on exchange rates in four small open economies (United Kingdom, Canada, Sweden, and Australia) by using vector autoregressive models in which sign restrictions on impulse responses are imposed to identify monetary policy shocks. Their findings are that a contractionary monetary policy leads to significant exchange rate appreciation. The delay in overshooting is relatively short, at best six months. The deviation from the uncovered interest parity condition is relatively small, although significant at short horizons in a few cases. To obtain results without strong puzzles, constructing an empirical model that reflects the features of the small open economy and estimates the model for the recent inflation-targeting period during which monetary policy operating procedure does not change substantially are important.

Compared with the previous studies listed above, the biggest innovation of this paper is that we attempt to exploit the impact of monetary policy on exchange rate in terms of money supply with a two-country model.

3. Methodology

The flexible-price monetary model is the earliest and most basic exchange rate decision model in modern exchange rate theory. Its main representatives are J, Frenkel, M, Mussa, P, Kouri, and J, Bilson. It is presented at an international seminar on “floating exchange rates and stability policies” near Stockholm, Sweden, in 1975. A basic idea of flexible monetary law is that the exchange rate is the relative price of two currencies, not the relative price of two commodities, so the exchange rate should be determined mainly by the supply and demand of currency in the money market.

As for the flexible-price monetary model, there are two important assumptions. One is the stable monetary demand equation (monetary demand has a stable relationship with some economic variables). Another is that the purchasing power parity continues to be effective. Moreover, if both hold, four prerequisite of assumption should be satisfied.

1) Commodity prices are fully flexible. Namely, when the money supply changes, a rapid adjustment in the price level will be happened. However, the interest rate and the real national income have nothing to do with money supply. This will not result in the further impact on output due to a fall in

interest rate.

2) Purchasing power parity holds.

3) Flow of capital in the world is completely free.

4) Domestic assets and foreign assets can be completely replaced. The interest rate in both countries are endogenous variables. The interest rate of the two countries have been handled in a technical way broad money model. So, it is not the natural log but it's the interest rate itself.

In the money market, the condition of equilibrium is that the supply is equal to demand. The equation gives:

$$\underbrace{\frac{M}{P}}_{\substack{real\\money\\supply}} = \underbrace{Y \times L(i)}_{\substack{real\\money\\demand}} \tag{1}$$

Where M denotes the money supply; P denotes the price level; Y denotes the real income; i denotes the interest rate.

Taking the logarithm of both side of equation (1) gives:

$$\log M - \log P = \log Y - \log i \tag{2}$$

Domestic price level gives:

$$\log P = \log M - \log Y + \log i \tag{3}$$

Similarly, the foreign price level gives:

$$\log P^* = \log M^* - \log Y^* + \log i^* \tag{4}$$

Where $*$denotes the foreign country.

Purchasing power parity provides a linkage between domestic price level and foreign price level.

Purchasing power parity gives:

$$E = \frac{P}{P^*} \tag{5}$$

Where E denotes the nominal exchange rate.

Taking the logarithm of both side of equation (5) gives:

$$\log E = \log P - \log P^* \tag{6}$$

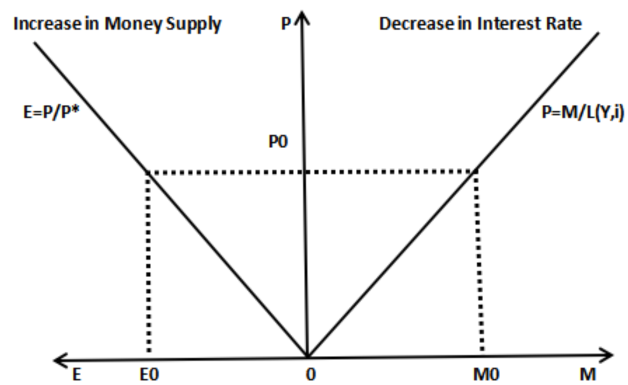
Putting equation (3) and equation (4) into equation (6) gives:

$$\log E = \log M - \log Y + \log i - \log M^* + \log Y^* - \log i^* \tag{7}$$

Rewriting equation (7) gives:

$$\log E = \log \frac{M}{M^*} - \log \frac{Y}{Y^*} + \log \frac{i}{i^*} \tag{8}$$

Equation (8) is flexible-price monetary model. It mainly attributes the decision of the nominal exchange rate to three sets of variables (the relative money supply, the relative real income and the relative interest rate between two countries). Considering the impact of the long-run factor exchange rate, an increase in the supply of domestic money will immediately lead to the corresponding improvement in the domestic price level. Since the purchasing power parity holds in the short run, an increase in the price level will bring about a corresponding depreciation of the domestic currency. In the case of other factors, When the national income increases, it will lead to an increase in the money demand. At the current price level, because the money supply does not increase correspondingly, the decrease in expenditure reduces the domestic price level. Because of the purchasing power parity, it will result in an increase in the domestic exchange rate. In order to make flexible-price monetary model more intuitive, it will be shown in <Figure 1>.



<Figure 1> Flexible-price Monetary Model

<Figure 1> reports that when the foreign money supply, the real income and the interest rate are given and the foreign price level will be fixed. The first quadrant reflects the relationship between money supply and price level while the domestic monetary market reaches an equilibrium. On a given level of the income and the interest rate, the monetary equilibrium is an oblique that starts from the original point. When the money supply increases, the price level will also increase with the same proportion. The second quadrant exhibits the purchasing power parity. Due to the foreign price level given, the exchange rate is also an oblique line that starts from the original point. When the domestic monetary expansion drives the price level up, the exchange rate will be corresponding raised (domestic currency depreciation).

4. Empirical Analysis

4.1. Basic Statistics

This paper uses the datum from China and South Korea to conduct an empirical estimation to detect the operating mechanism between China's monetary policy and South

Korea's exchange rate. Specifically, there are seven variables (South Korea's real GDP, South Korea's interest rate, South Korea's money supply, China's GDP, China's interest rate, China's money supply and South Korea's exchange rate between China and South Korea). All of them are annual time series from 1980 to 2017 and they are sourced from the Organization for Economic Cooperation and Development. In this paper, China is treated as a foreign country for reference in terms of South Korea. Fortunately, the sector three provides a theoretical base for this paper to construct a general model as the following gives:

$$\log E_t = \alpha_0 + \alpha_1 \log M_t^{sk} + \alpha_2 \log GDP_t^{sk} + \alpha_3 \log i_t^{sk} + \alpha_4 \log M_t^{ch} + \alpha_5 \log Y_t^{ch} + \alpha_6 \log i_t^{ch} + \varepsilon_t \quad (9)$$

Where the E represents the exchange rate between China and South Korea; The M represents the money supply; The GDP represents the real income; The i represents the interest rate; the superscript sk represents South Korea; the superscript sk represents South Korea; The ch represents China; α_0 is the Constant; $\alpha_1 > 0, \alpha_2 < 0,$ $\alpha_3 > 0, \alpha_4 < 0, \alpha_5 > 0, \alpha_6 < 0$ (All of them are coefficient); ε_t is the white noise.

For the sake of disposing of the larger outlier and the heteroscedasticity, all variables are in log. To conceptualize this, all of them will be exhibited in <Table 1> in details.

4.2. Unit Root Test

The Classical regression model necessitates that all variables should be stationary and have as zero mean and a finite variance. In the presence of nonstationary variables, there might be what Ganger and Newbold (1947) call a spurious regression. A spurious regression has a high R^2 and t-statistics that appear to be significant, but the results are without any economic meaning. The regression output "looks good" become the least-squares estimates are not consistent and the customary tests of statistical inference do not hold. In this paper, the Augmented Dicky-fuller test will be employed to testify the stationarity of all variables. The result of Augmented Dicky-fuller test shows in <Table 2>.

<Table 1> Variables

Variables	Logarithmic From	Definition	Source
South Korea's real GDP	$\log GDP^{sk}$	Deflated by South Korea's GDP deflator	Organization for Economic Cooperation and Development
South Korea's money supply	$\log M^{sk}$	South Korea's broad money supply	Organization for Economic Cooperation and Development
South Korea's interest rate	$\log i^{sk}$	South Korea's interest rate	Organization for Economic Cooperation and Development
Exchange rate between China and South Korea	$\log E$	Exchange rate Between China and South Korea	Organization for Economic Cooperation and Development
China's real GDP	$\log GDP^{ch}$	Deflated by China's GDP deflator	Organization for Economic Cooperation and Development
China's money supply	$\log M^{ch}$	China's broad money supply	Organization for Economic Cooperation and Development
China's interest rate	$\log i^{ch}$	China's interest rate	Organization for Economic Cooperation and Development

<Table 2> Unit Root Test

Variable	t-Statistic	1% test critical value	5% test critical value	10% test critical value	Prob.	Result
$\log GDP^{sk}$	-1.154	-.3654	-2.957	-2.617	0.682	Non-rejected
$\log M^{sk}$	-2.963	-3.933	-2.948	-2.613	0.085	Non-rejected
$\log i^{sk}$	-0.743	-3.639	-2.951	-2.614	0.822	Non-rejected
$\log E$	-2.545	-3.627	-2.946	-2.612	0.135	Non-rejected
$\log GDP^{ch}$	-1.909	-3.633	-2.948	-2.613	0.325	Non-rejected
$\log M^{ch}$	-1.160	-3.627	-2.946	-2.612	0.681	Non-rejected
$\log i^{ch}$	-1.821	-3.639	-2.951	2.614	0.364	Non-rejected
$\Delta \log GDP^{sk}$	-7.207	-3.621	-2.943	-2.610	0.000	Rejected
$\Delta \log M^{sk}$	-4.982	-3.639	-2.951	-2.614	0.000	Rejected
$\Delta \log i^{sk}$	-5.766	-3.633	-2.948	-2.613	0.000	Rejected
$\Delta \log E$	-4.542	-3.627	-2.946	-2.612	0.001	Rejected
$\Delta \log GDP^{ch}$	-5.328	-3.639	-2.948	-2.613	0.000	Rejected
$\Delta \log M^{ch}$	-3.116	-3.627	-2.946	-2.612	0.034	Rejected
$\Delta \log i^{ch}$	-13.041	-3.639	-2.951	-2.614	0.000	Rejected

Note: Δ denotes the first difference operator.

<Table 3> Unrestricted Cointegration Rank Test (Trance)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
$r=0*$	0.961	258.607	125.615	0.000
$r\le 1*$	0.717	141.504	95.754	0.000
$r\le 2*$	0.553	96.051	69.819	0.000
$r\le 3*$	0.538	67.097	47.856	0.000
$r\le 4*$	0.439	39.698	29.797	0.003
$r\le 5*$	0.331	15.495	15.195	0.015
$r\le 6*$	0.117	4.466	3.981	0.035

Note: 1) Trace test indicates 7 cointegrating eqn(s) at the 0.05 level.
2) *denotes rejection of the hypothesis at the 0.05 level.
3) **Mackinnon-Haug-Michelis (1999) p-values.

<Table 4> Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
$r=0*$	0.961	117.104	46.231	0.000
$r=1*$	0.717	45.452	40.078	0.011
$r=2$	0.553	28.953	33.877	0.173
$r=3$	0.538	27.340	27.584	0.053
$r=4$	0.439	20.762	21.132	0.056
$r=5*$	0.331	14.470	14.265	0.046
$r=6$	0.117	4.466	3.841	0.035

Note: 1) Max-Eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level.
2) *denotes rejection of the hypothesis at the 0.05 level.
3) **Mackinnon-Haug-Michelis (1999) p-values.

<Table 2> reports the results of unit root test. The absolute value of t-statistical is less than the absolute value of critical value at their levels. Namely, the null hypothesis that the sequence has a unit root is non-rejected. According to this result, it can be concluded that all variables are non-stationary at their levels. Nonetheless, when implementing the first difference, The absolute value of t-statistical is greater than the absolute value of critical value at their levels. Namely, the null hypothesis that the sequence has a unit root is rejected. Due to this result, it can be concluded that all variables are stationary at 5% levels. In view of this, it is very necessary to examine the long-run relationship between among them.

4.3. Cointegration Test

A principle feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from long-run equilibrium. After all, if the system is return to the long-run equilibrium, the movements of at least some the variables must respond to the magnitude of the equilibrium. Before proceeding further, be aware that will be examining the time paths of multiple non-stationary time-series variables. To do so in a traceable way, we will need to rely on the cointegration test. The cointegration test exhibits in <Table 3> and <Table 4>.

<Table 3> and <Table 4> report that the results of cointegration test. The combination of <Table 3> and <Table 4> documents that the long-run relationship among them exists. The normalized cointegrating equation gives:

$$\log E_t = 0.434\log GDP_t^{ch} - 0.055\log i_t^{ch} - 1.333\log M_t^{ch} - 0.682\log GDP_t^{sk} + 0.509\log i_t^{sk} + 1.422\log M_t^{sk} \quad (10)$$

Equation (9) demonstrates the long-run relationship among all variables. Concretely speaking, 1% increase in China's GDP will result in 0.434% increase in South Korea's exchange rate. 1% increase in China's interest rate will lead to 0.055% decrease in South Korea's exchange rate. 1% increase China's money supply will give a rise to 1.333% decrease in South Korea's exchange rate. 1% increase in South Korea's GDP will issue in 0.682% decrease in South Korea's exchange rate. 1% increase in South Korea's interest rate will make for 0.509% in South Korea's exchange rate. 1% increase in South Korea's money supply will generate 1.442% increase in South Korea's exchange rate. In terms of China, this results depict that China's money supply is a major determinant that can drive the movement of South Korea's exchange rate most. As a matter of fact, these results are also in keeping with the theoretical base in sector three.

4.4. Causality Test

Economists have developed a way of trying to analyze Granger causality between variables. The Granger causality test is pioneered by Clive w. j. Granger, winner of the 2003 Nobel Prize in economics, for the analysis of Granger causality between economic variables. His definition of

Granger causality is "dependent on the variance of the best least-squares prediction of all information at certain points in the past. According to this method, the Granger causality test will be carried out. And the results illustrate in <Table 5>

<Table 5> Pariwise Granger Causality Tests

lags	Null Hypothesis	Obs	F-Statistic	Prob.
2	$\log M^{ch}$ does not Granger Cause $\log E$	36	6.642	0.004
2	$\log E$ does not Granger Cause $\log M^{ch}$		0.333	0.719
2	$\log i^{ch}$ does not Granger Cause $\log E$	36	5.078	0.012
2	$\log E$ does not Granger Cause $\log i^{ch}$		2.592	0.091
2	$\log GDP^{ch}$ does not Granger Cause $\log E$	36	8.626	0.001
2	$\log E$ does not Granger Cause $\log GDP^{ch}$		1.469	0.246
2	$\log i^{sk}$ does not Granger Cause $\log E$	36	0.467	0.631
2	$\log E$ does not Granger Cause $\log i^{sk}$		5.450	0.009
2	$\log M^{sk}$ does not Granger Cause $\log E$	36	3.706	0.036
2	$\log E$ does not Granger Cause $\log M^{sk}$		0.069	0.933
2	$\log GDP^{sk}$ does not Granger Cause $\log E$	36	3.152	0.057
2	$\log E$ does not Granger Cause $\log GDP^{sk}$		0.992	0.382

<Table 5> presents the results of the Granger causality test. The relationship between South Korea's exchange rate and China's money supply is unidirectional running only from China's money supply to South Korea's exchange rate. Thus, then the past values of China's money supply can be used to predict the changes in South Korea's exchange rate. The relationship between South Korea's exchange rate and China's interest rate is unidirectional running only from China's interest rate to South Korea's exchange rate. Thus, then the past values of China's interest rate can be used to predict the changes in South Korea's exchange rate. The relationship between South Korea's exchange rate and South Korea's interest rate is unidirectional running only from South Korea's interest rate to South Korea's exchange rate. Thus, then the past values of South Korea's interest rate can be used to predict the changes in South Korea's exchange rate. The relationship between South Korea's exchange rate and South Korea's money supply is unidirectional running only from South Korea's money supply to South Korea's exchange rate. Thus, then the past values of South Korea's money supply can be used to predict the changes in South Korea's exchange rate. Even though the relationship between South Korea's exchange rate and South Korea's GDP is unidirectional. However, its direction is from South Korea's exchange rate to South Korea's GDP. Therefore, the past value of South Korea's GDP cannot be used to predict the changes of South Korea's exchange rate.

4.5. Vector Error Correction Estimation

In the Engle-Granger method, it is possible to estimate the long-run equilibrium relationship from a regression of interdependent variables on dependent variable or from a regression of dependent variable on independent variables. In the Johansen method, all variables are treated symmetrically. Hence, either method can be used in circumstances when you do not want to explicitly specify a dependent variable and a set of independent variables. This can be especially advantageous if the variables are jointly determined and you are not sure how to disentangle the interdependence among them. In other circumstances, the selection of a dependent variable and the set of independent variables might be clear. As discussed in this sector, there are potential benefits to be had by incorporating such information into a cointegration model. The starting point is to be precise about the econometric meaning of the term exogenous. To begin with the simplest case, due to the cointegrated of order (1,1), the error correcting model is represented as following:

$$\begin{aligned}\Delta\log E_t &= \alpha_1\Delta\log E_{t-1} + \alpha_2\Delta\log GDP_t^{ch} + \alpha_3\Delta\log GDP_{t-1}^{ch} + \alpha_4\Delta\log i_t^{ch} \\ &+ \alpha_5\Delta\log i_{t-1}^{ch} + \alpha_6\Delta M_t^{ch} + \alpha_7\Delta M_{t-1}^{ch} + \alpha_8\Delta\log GDP_t^{sk} + \alpha_9\Delta\log GDP_{t-1}^{sk} \\ &+ \alpha_{10}\Delta\log i_t^{sk} + \alpha_{11}\Delta\log i_{t-1}^{sk} + \alpha_{12}\Delta\log M_t^{sk} + \alpha_{13}\Delta\log M_{t-1}^{sk} + \lambda 1ecm_{t-1} \\ &+ c + \varepsilon_t\end{aligned} \tag{11}$$

Equation (10) indicates the error correction model. Where $\alpha_1,\alpha_2,\alpha_3,\alpha_4,\alpha_5,\alpha_6,\alpha_7,\alpha_8,\alpha_9,\alpha_{10},\alpha_{11},\alpha_{12},\alpha_{13}$, λ are the coefficient of variables. The ecm is the error correction term. c is the constant. ε_t is the white noise.

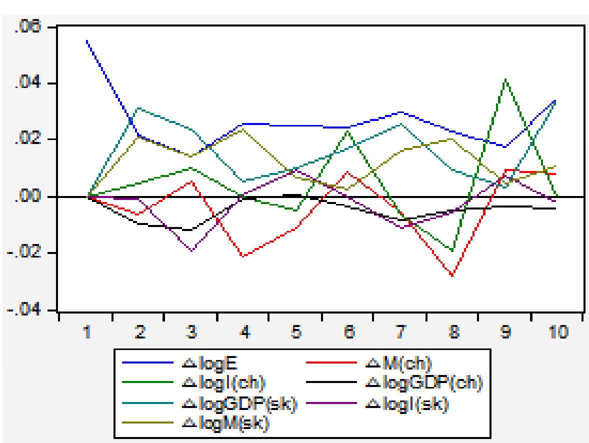
Conducting an estimation gives:

$$\begin{aligned}\Delta\log E_t &= 0.287\Delta\log E_{t-1} - 0.513\Delta\log GDP_t^{ch} + 0.625\Delta\log GDP_{t-1}^{ch} \\ &- 0.082\Delta\log i_t^{ch} - 0.033\Delta\log i_{t-1}^{ch} - 0.745\Delta M_t^{ch} - 0.290\Delta M_{t-1}^{ch} \\ &- 1.871\Delta\log GDP_t^{sk} + 1.572\Delta\log GDP_{t-1}^{sk} + 0.242\Delta\log i_t^{sk} - 0.072\Delta\log i_{t-1}^{sk} \\ &+ 0.284\Delta\log M_t^{sk} - 0.006\Delta\log M_{t-1}^{sk} - 0.021ecm_{t-1} + 0.074 + \varepsilon_t\end{aligned} \tag{12}$$

Equation (11) illustrates the short-run relationship between South Korea's exchange rate and other variables. In the short run, the exchange rate has a positive effect on itself. Namely, 1% increase in South Korea's exchange rate in $t-1$ period will lead to 0.278% increase itself in t period. The China's GDP has positive effect on South Korea's exchange rate. In the word, 1% increase in China's GDP in $t-1$ period will lead to 0.625% increase South Korea's exchange rate in t period. The China's interest rate has a negative effect on South Korea's exchange rate. Namely, 1% increase in China's interest rate in $t-1$ period will lead to 0.033% decrease in South Korea's exchange rate in t period. The China's money supply has negative effect on South Korea's exchange rate. In the word, 1% increase in China's money supply in $t-1$ period will lead to 0.290% decrease in South Korea's exchange rate in t period. The South Korea's GDP has a positive effect on South Korea's exchange rate. In the word, 1% increase in South Korea's GDP in $t-1$ period will lead to 1.572% increase in South Korea's exchange rate in t period. The South Korea's interest rate has a negative effect on South Korea's exchange rate. In the word, 1% increase in China's money supply in $t-1$ period will lead to 0.072% decrease in South Korea's exchange rate in t period. The South Korea's money supply has a negative effect on South Korea's exchange rate. In the word, 1% increase in South Korea's money supply in $t-1$ period will lead to 0.006% decrease in South Korea's exchange rate in t period. More importantly, when the system is derived in the short run from the long-run equilibrium. There exists a adjusting power back to the long-run equilibrium. Specifically, The short-run deviation will return to the long-run equilibrium by 0.021% (opposite direction) as time path goes by.

4.6. Impulse Response Function

In contemporary macroeconomic models, the impulse response function is used to describe the economic response to exogenous impulse. Economists, often, call this as a shock, and the model tends to be constructed in the context of vector self-regression. The impulse response function describes the endogenous macro-economic variables, such as the impact time and the subsequent time point. <Figure 2> depicts the responses of South Korea's exchange rate since suffering from one standard deviation shock of other variables.



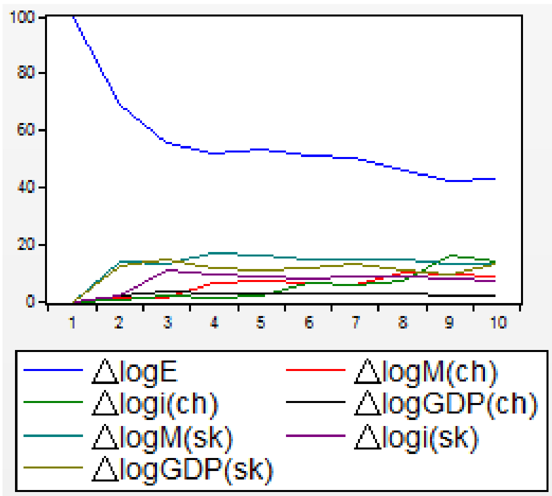
<Figure 2> Response of $\Delta\log E$ to Cholesky One S.D. Innovations

<Figure 2> reports the impulse response function for ten periods. $\Delta\log E$ decreases sharply in response to one standard deviation shock in itself in the third period. And then the effect of its shock becomes positive until to seventh period. Next, the effect of its shock becomes negative until to ninth period. After that, the effect of its shock becomes positive again. $\Delta\log E$ increases sharply in response to one standard deviation shock in $\Delta\log GDP^{sk}$ in the second period. Then, the effect of its shock fluctuates up and down. But after ten period, the effect of its shock will dampen out and fade away. $\Delta\log E$ decreases slightly in response to one standard deviation shock in $\Delta\log i^{sk}$ in the third period. Then, the effect of its shock becomes positive until to six period. Next, the effect of its shock becomes negative again. After that, $\Delta\log E$ increases sharply in response to one standard deviation shock in $\Delta\log i^{sk}$ in the ninth period. Then, the effect of its shock becomes negative. $\Delta\log E$ increases slightly in response to one standard deviation shock in $\Delta\log M^{ch}$ in the third period. Then the effect of its shock fluctuates up and down. $\Delta\log E$ increases slightly in response to one standard deviation shock in $\Delta\log i^{ch}$ in the third period. The movement locus of the effect of its shock is similar to that of $\Delta\log M^{ch}$. $\Delta\log E$ decreases very slightly in response to one standard deviation shock in $\Delta\log GDP^{ch}$ in the third period. Then the effect of its shock will become positive. After that, The movement locus of the effect of its shock will keep unchanged. Until to ninth period, hence, the effect of its shock will fluctuate a bit.

4.7. Variance Decomposition

Although an unrestricted vector auto-regression is likely to be overparameterized, understanding the properties of the forecast error is exceedingly helpful in uncovering interrelationships among the variables in the system. The variance decomposition tells us the proportion of the movement is a sequence due to its own shocks versus shocks to the other. The results of variance decomposition reports in <Figure 3>.

Regarding the variance decomposition, <Figure 3> exhibits the ten periods forecast of $\Delta\log E$ in which 42.7% of the forecast variance is attributed to $\Delta\log E$, while 20.1% to $\Delta\log GDP^{sk}$, 8.8% to $\Delta\log M^{sk}$, 8.7% to $\Delta\log i^{sk}$, 6.7% to $\Delta\log M^{ch}$, 12.7% to $\Delta\log i^{ch}$ and 0.3% to $\Delta\log GDP^{ch}$. This results support both the impulse response function results and Granger causality test results.



<Figure 3> Variance Decomposition of $\Delta \log E$

5. Conclusion

The monetary policy is a crucial method for a country to affect another country's macroeconomic operation. Due to this connection, this paper attempts to examine the relationship between China's monetary policy and South Korea's exchange rate. Based on the flexible-price monetary model, sets of annual time series from 1980 to 2017 are employed to conduct an empirical estimation. Furthermore, some econometric methods are also applied to analyze both of them. The empirical findings exhibit in the long run and short run, respectively. Via the unrestricted cointegration rank test (trance and maximum eigenvalue), the long-run findings show that China's monetary policy has a greatest effect on South Korea's exchange rate. Namely, 1% increase in China's money supply will result in 1.333% decrease in South Korea's exchange rate. Meanwhile, the China's real GDP, South Korea's interest rate and South Korea's money supply have a positive effect on South Korea's exchange rate. Conversely, China's interest rate and South Korea's real GDP have a negative effect on South Korea's exchange rate. Through the vector error correction model, the short-run findings report that China's money supply has a negative effect on South Korea's exchange rate. In other word, 1% increase in China's money supply will lead to 0.290% decrease in South Korea's exchange rate. More specifically, the impact of China's short-run money supply on South Korea's exchange rate is much less significant than that of long-run's. Oppositely, China's real GDP and South Korea's real GDP have a positive effect on South Korea's exchange rate. Simultaneously, the China's interest rate, South Korea's interest rate and South Korea's money supply have a negative effect on South Korea's exchange rate.

In summary, it can be concluded that the China's monetary policy has a huge effect on South Korea's exchange rate. If China expends its money supply, China's price level will go up and South Korea's price level will be kept unchanged. Therefore, the value of South Korea's currency will arise. Owing to this, China can adjust the monetary policy to affect South Korea's exchange rate. And then South Korea's economic entity such as the export & import and its domestic price level will be affected. Due to this, South Korea's government should form a good exchange rate regime so as to deal with the shocks from the outside.

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