

2018 WEA ON LINE CONFERENCE

MONETARY POLICY AFTER THE GLOBAL CRISIS

How Important Are Economic (Divisia) Monetary Aggregates for Economic Policy?

(in honour of William A. Barnett)

15th February to 15th March, 2018

Title of the paper

The macroeconomic effects of RMB internationalization: The perspective of overseas circulation

Authors

Cong Wang,

Xue Wang

Abstract

The RMB Internationalization has a great impact on China's domestic economy. This paper applies the Gap Estimation approach to estimate the RMB overseas circulation amount from 1997 to 2015, as the indicator of RMB internationalization. Using the recently developed Directed Acyclic Graph (DAG) method for the model identification and contemporaneous causality analysis. The SVAR model is constructed between the economic indicators (the interest rate, the CPI and the exchange rate) and the RMB overseas circulation. The dynamic relationship and degree of mutual influence are further studied between the economic indicators and overseas circulation. The results show that there exist contemporaneous causalities of "from RMB overseas circulation to inflation rate", "from

exchange rate to overseas circulation" and "from exchange rate to the inflation rate". The influence of interest rate adjustment on macro economy presents the time lag effect. The internationalization of the RMB encourages the currency appreciation. The China's central bank passively loosens monetary policy to meet the needs of internationalization and reduce the shock of the international hot money, thereby further deepening the domestic inflation.

Authors Affiliation and Email

Jinan University, China

Jinan University, China, wangxue1207@hotmail.com or
yukiwang1207@gmail.com

The Macroeconomic Effects of RMB Internationalization: the Perspective of Overseas Circulation

Cong Wang Xue Wang*

Department of Finance, Jinan University, China

Abstract: The RMB Internationalization has a great impact on China's domestic economy. This paper applies the Gap Estimation approach to estimate the RMB overseas circulation amount from 1997 to 2015, as the indicator of RMB internationalization. Using the recently developed Directed Acyclic Graph (DAG) method for the model identification and contemporaneous causality analysis. The SVAR model is constructed between the economic indicators (the interest rate, the CPI and the exchange rate) and the RMB overseas circulation. The dynamic relationship and degree of mutual influence are further studied between the economic indicators and overseas circulation. The results show that there exist contemporaneous causalities of "from RMB overseas circulation to inflation rate", "from exchange rate to overseas circulation" and "from exchange rate to the inflation rate". The influence of interest rate adjustment on macro economy presents the time lag effect. The internationalization of the RMB encourages the currency appreciation. The China's central bank passively loosens monetary policy to meet the needs of internationalization and reduce the shock of the international hot money, thereby further deepening the domestic inflation.

JEL Classification: E42; F33

Keywords: Overseas circulation of RMB; Gap Estimation approach; Directed acyclic graph; Contemporaneous causality analysis

1. Introduction

The internationalization of the currency refers to the local currency, which circulates across national boundaries and become an internationally recognized currency of the valuation, settlement and reserve (Kenen, 2009). To some extent, currency overseas circulation marks the beginning of currency internationalization. Despite that the current RMB overseas circulation does not mean that RMB has become an international currency, but the expansion of the RMB circulating overseas will eventually realize the internationalization of RMB. Therefore, the growth of the overseas circulation of RMB can measure the development degree and speed of the RMB internationalization to a certain extent. With the improvement of China's comprehensive national strength (Barnett & Tang, 2015), the RMB internationalization has become the significant issue, which both domestic and foreign scholars have been focusing on. RMB overseas circulation in neighboring countries started from 1997. Then, the overseas circulation has significantly increased with the bilateral swap agreements signature and the initiation of RMB cross-border payment &

* Corresponding author, Department of Finance, Jinan University, Guangzhou, China, 510632. E-Mail: wangxue1207@hotmail.com, Tel: +86 18620525808.

settlement pilot in 2009. In December 2015, RMB was incorporated by IMF into the SDR (Special Drawing Rights), which is an important step in the RMB internationalization development. In the promoting process of RMB internationalization, we are curious about what kind of impacts of the RMB internationalization on China's domestic macro economy? In recent years, the appreciation of RMB, the market-based reform of the interest rate and rising inflation rate are the main focus in Chinese economy. The effects of RMB internationalization on China's domestic macro economy and the dynamic transmission mechanism has an important realistic and long-term effect on China's financial and fiscal monetary policy reform. Scientifically evaluating the macroeconomic effects of RMB internationalization can facilitate us to prevent the risk from international financial markets and foreign exchange market in the process of internationalization. How to avoid the risk to the greatest extent and obtain the benefit from the currency internationalization are significant issues in China now.

2. Literature review

The study on the macroeconomic effects brought by the currency internationalization can be roughly concluded into three aspects: the issuers' welfare effects, the cost of internationalization and the policy effects of internationalization.

Aliber (1964) and Cohen (1972) find currency internationalization will finance for foreign debt and trade deficit, and Bergsten (1976) and Frankel (1991) also agree that currency internationalization allows the issuer financing at lower interest rates, without paying interest for domestic currency circulating overseas, so the issuer can get the seigniorage revenues. Tavlas (1997) argues that the financial institutions of international currency issuing country will get better profits because of the increase demand for investment, loans and other services. Kannan (2007) find that monetary internationalization will enhance the monetary credit, thus improving the purchasing power of money. However, there also great cost of currency internationalization, Triffin (1960) proposes the "Triffin dilemma" problem, pointing out that the US dollar as the international money has the contradiction that the international solvency and currency value stability cannot coexist, which is a insurmountable problems as long as the international money is sovereign country currency. Griton and Roper (1981) believe that because the currency internationalization needs to open the domestic capital market and to relax foreign exchange controls , which will lead to the conduction of financial crisis and risk more directly, and also large amounts of capital transfer will lead to the instability of financial markets. Bergsten (2009) agreed that because the issuer is able to finance at low cost from abroad to cover its huge trade deficit, which will cause excess domestic liquidity and induce financial crisis. As to the policy effect of currency internationalization, Tavlas (1997) points out that under the pegged exchange rate, capital international transfer due to money internationalization will reduce government's control over the base monetary and affect the operation of domestic macro economy; under the floating exchange rate, it may cause exchange rate fluctuations and influence monetary policy independence. Chan (2001) find that under the fixed exchange rate system, currency internationalization has no

significant impact on macro economy, but it will narrow the interest rate spread and reduce the possibility of currency crisis. Maziad, Farahmand, Wang, Segal & Ahmed (2011) illustrate that monetary internationalization will bring currency appreciation, consequently reducing the competitiveness of the export products and resulting in inflation. Cohen (2012) believes that international currency will lead to an unstable currency demand, and it is difficult for the government to estimate a reasonable interest rates and money supply.

Although the economic effect of currency internationalization has been discussed a lot, the measure indicator of currency internationalization as well as its transmission mechanism and dynamic effects on domestic macroeconomic variables are lack of empirical analysis. We establish the SVAR model between the economic variables and RMB internationalization, and further study the transmission mechanism and path among the RMB internationalization and interest rate, exchange rate and inflation, which may offer certain enlightenment and reference to guard against financial risks in the process of RMB internationalization.

The contributions can be concluded to the following aspects. First, the mostly used indicator of currency internationalization is the internationalization index released by the IMF, while we use the Gap Estimation method to estimate the RMB overseas circulation scale, which is used to measure the RMB internationalization degree. Second, we use a new method to identify the structure of VAR model. Rather than identifying the SVAR model based on the economic theory, which is lack of consistency and unconvinced, we apply the directed acyclic graph (DAG) method to identify the model's contemporaneous causality structure which is based on the data statistical characteristic and need not any theoretical assumption, so it can avoid the subjectivity of the previous identification methods and provides a strong evidence for the identification of SVAR model.

3. Empirical approach and analysis

We apply the Gap Estimation approach to estimate the scale of RMB overseas circulation from 1997 to 2015 as a indicator of the RMB internationalization degree and build the SVAR model about RMB circulation, exchange rate, interest rate and inflation rate. Then we use the directed acyclic graph (DAG) method to study the influence of RMB internationalization on domestic macro economies and the transmission mechanism of them, and by using the impulse response method to analyze the dynamic relationship between variables and the degree of mutual influence.

3.1. Estimation of the RMB overseas circulation scale from 1997 to 2015

About the estimation of the scale of RMB overseas circulation, mainly including two categories: direct estimation method and indirect estimation method. However, direct estimation method has many defects: there are many ways of the cross-border outflow so it is difficult to collect comprehensive data, and it may have certain subjective randomness, while the indirect estimation method is to use econometric analysis method to estimate the local currency in

circulation overseas the indirect, mainly including the Gap Estimation approach and maximum likelihood method (MLE), etc. Because the indirect method depends on the economic theory and the continuity of macroeconomic data are more easily obtained, the estimated results are more reliable (Ho, 2006). Gap estimation method is based on the money demand function, which needs two key assumptions: first, the country's currency demand is steady during the observation period, that is, there is a stable money demand function; Second, the observation period can be divided into two steps. Step 1: there exists no domestic currency outflow phenomenon; Step 2: domestic money supply not only meets domestic demand, but also needs to satisfy the demand of overseas. Therefore, we can use the data of step 1 to estimate the monetary demand function, and then plug the step 2 data into the function to calculate out the demand of domestic currency. By using the actual money supply to minus the currency demand of step 2, we can estimate out the overseas money demand in step 2.

Considering the availability of data and the effectiveness of statistics, we choose the indirect estimation method, the Gap Estimation approach to estimate the scale of RMB circulation overseas since 1997. Assuming that there exists a long-term stable equilibrium relationship among the domestic demand for RMB, economic development and interest rate, the sample data can be divided into two stages: the first phase is from 1978 to 1996, when the RMB overseas circulation is very small, almost negligible. The second phase is from 1997 to 2015, when the RMB internationalization degree is continuous increasing. The domestic demand can be estimated out in the first stage, and by calculating the gap between the real M0 and estimated domestic currency demand, we can obtain the RMB overseas circulation scale in the second stage.

We have tried the monthly and quarterly data for analysis, but find that the volatility is high in overseas circulation size, and the net outflows even become negative during some periods, which is likely due to the influx of international hot money. To study the overall trend of the overseas circulation, we cut the frequency of the data, using the annual data to estimate the overseas circulation scale of RMB.

According to Keynes's theory of money demand, money demand mainly comes from two aspects: One is trade demand related to income, and another is speculative money demand related to interest rate. We select the real interest rate which has eliminated inflation factor as speculative demand variable, GDP as the transaction demand variable. Referring to Ball L. (2012), assuming the domestic monetary demand, economic development and interest rate have a long-term stable equilibrium relationship, we can build the half logarithm model of money demand about the money supply, national income and interest rate:

$$\ln(M_t^s / P_t) = \beta_0 + \beta_1 \ln Y_t + \beta_2 i_t + \mu_t \quad (1)$$

Where M^s is the monetary demand, using the data of cash in circulation (M0); P is inflation, using the fixed base CPI (the base year is 1990); M^s / P is the real demand for money, using M to represent; Y is the real GDP after the deflator, i is real interest rates after eliminating inflation factor. Where β_1 is the long-term income elasticity of money demand, and β_2 is the semi-

elasticity of interest rate for money demands. The raw data of M0, CPI, GDP and GDP deflator is from National Bureau of Statistics of China, the nominal interest rates data from the database of Wind, where the annual interest rates are calculated using the weighted average number of different interest rates¹. Then we estimate the RMB overseas circulation in following two stages.

Firstly, we need to estimate of China's domestic money demand function. According to Hafer and Kutan (1993, 1994), we need to determine whether there exists a long-run equilibrium relationship between the money supply, national income and interest rate. We do so by applying the Johansen co-integration test. For time series, we first make a stationary test of each variable to prevent the "spurious regression" problem in non-stationary variables. We test for unit roots using the familiar ADF unit root test and get the results showed in Table 1.

Table 1. ADF unit root test

Variables	T Statistic	1% level	5% level	10% level
$\ln M$	-0.805	-4.668	-3.733	-3.310
$\ln Y$	2.001	-2.708	-1.963	-1.606
i	-2.106	-3.920	-3.066	-2.673
$\Delta \ln M$	-3.776**	-4.728	-3.760	-3.325
$\Delta \ln Y$	-3.136**	-3.920	-3.066	-2.673
Δi	-3.411**	-3.959	-3.081	-2.681

- a. " Δ " means the first order differential sequence.
- b. The optimal lag order in the ADF test is selected according to the SIC information criterion.
- c. ***, ** and * means the original hypothesis is rejected at a significant level of 1%, 5% and 10%.

The results of unit root test show that all the variables are non-stationary time series, but the first order differential sequences are stationary, indicating that they are integrated of order 1, so we can carry on the co-integration test and the results are showed in table 2:

Table 2. Johansen co-integration test

H0: No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P Value
None	0.244	59.417	24.276	0.000
At most 1	0.073	17.925	12.321	0.005
At most 2	0.043	6.582	4.130	0.012

The test results show that at 5% significant level, there are at least 1 co-integration relationship among the non-stationary variables, which indicates that we cannot reject the hypothesis that there exists a long run money demand function of $\ln M$, $\ln Y$ and i , so we can use the OLS method to estimate the regression equation and get the equation (2):

$$\ln M = 1.3345 * \ln Y - 0.0051 * i - 5.3551 \quad (2)$$

(16.5758) (-6.3974) (-6.8713)

1 Annual interest rate data use weighted average numbers according to the days of different interest rates last in the year, to ensure the rationality of the interest rate data.

The income elasticity measures the speed of monetary expansion in the long-run while the interest rate elasticity represents the sensitivity of household's willingness to hold money with respect to the change of monetary policy. According to the estimated monetary demand model, we can see $\beta_1 > 0$, $\beta_2 < 0$, which is consistent with the Keynesian monetary demand theory and liquidity preference theory, that is, the increase of income will promote the money transaction demand, and the rise of interest rate will increase the opportunity cost and reduce the demand for money. Hafer and Kutan (1994) find the existence of a long-run stable relationship for nominal money demand. In the broad money (M2) case, the elasticities of income is 1.33. Furthermore, they report that the interest rate elasticities are 0.13 and 0.15 for M0 (currency in circulation) and M2, respectively. In another study, Huang (1994) reports that the income elasticities for M2 (nominal) are 2.12 while Chen (1997) shows that the income elasticities for M0 and M2 are 1.50 and 1.93, respectively. Furthermore, Bahmani-Oskooee and Wang (2007) show that the long-run income elasticities for M0 and M2 are 1.28 and 1.69 and the interest rate elasticities are -4.52 and -1.54, respectively. Compared with the other studies, our model shows that the income elasticity is almost consistent with the previous studies while the interest rate elasticity has been decreased during recent 20 years.

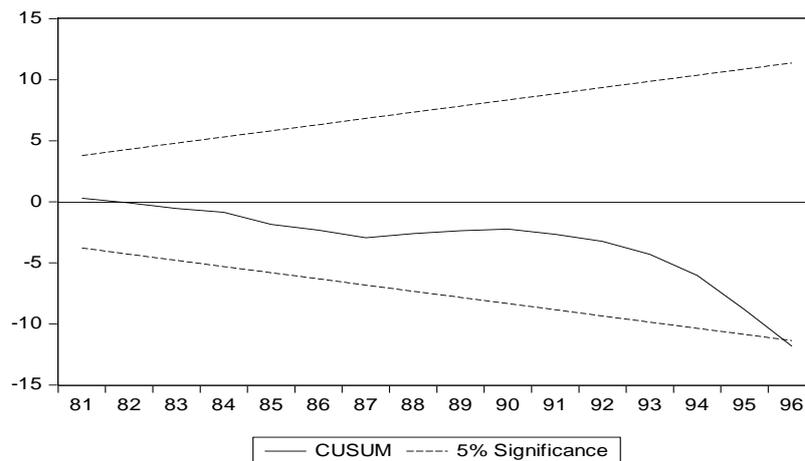


Figure 1. CUSUM test result

In order to test the stability of the money demand function (2), we further do the CUSUM test and the result is showed in Figure 1. From the CUSUM test, the Cumulative residuals sum of the equation is within the 5% significance critical line, indicating that the money demand function is robust and the parameters are stable.

Secondly, we can get the estimation of the size of RMB overseas circulation. Through the co-integration analysis, $\ln M$, $\ln Y$ and i have a long-term equilibrium relationship. We can put the data of 1997 to 2015 into the regression model (2) which has been estimated out in first phase, to estimate the RMB currency demand in the second phase, and the gap between the actual M0 and estimated domestic money demand can be seen as RMB overseas circulation approximately. The estimated overseas circulation size from 1997 to 2015 is showed in figure 1:

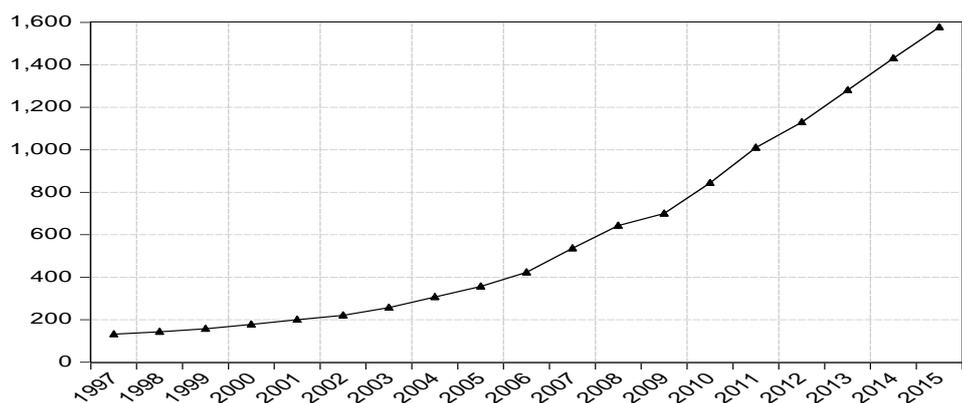


Figure 2. The scale of RMB overseas circulation from 1997 to 2015

Figure 2 shows that: during 1997 to 2004, RMB overseas circulation go up slowly, and since the exchange rate system reform in 2005, the overseas circulation size is growing significantly faster. The growth rate becomes slow during the global financial crisis from 2008 to 2009, which is due to the decline in foreign demand caused by the crisis. The RMB cross-border payment and settlement pilots are launched in 2009, which result in a sharp increase in RMB overseas circulation. By the year of 2015 the overseas circulation has reached 157.73 billion yuan, increased by more than ten times compared with 13.15 billion yuan in 1997. We can conclude that the overseas circulation keeps a double-digit growth rate per year on average, indicating that overseas demand for the RMB in terms of pricing, trading, settlement is increasing and the RMB internationalization process is developing rapidly. This will inevitably have an effect on China's macro economy, in recent years, domestic inflation, the appreciation of RMB, as well as interest rate marketization reform are all hot issues in China's economy, the significant increase of RMB overseas circulation will impose what kind of effect on China's macro economy and the influence mechanism are all worth further research and study.

This paper focuses on the three indicators of domestic interest rate, exchange rate and inflation rate, studying the impact of RMB overseas circulation on these indicators and the transmission mechanism among them, and puts forward some helpful policy recommendations.

3.2. The impact of RMB internationalization on China's macro economy and causal analysis

3.2.1. The empirical approach and data

Sims (1980) proposes the vector autoregressive model (VAR), which can predict correlated time series variables and analyze the dynamic impact of random disturbance, is widely used in dynamic conducting analysis of the economic system. Contracted type VAR (P) form:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + u_t \quad (3)$$

Where $t=1,2,\dots,T$, and T is the length of time series, $Y_t = (y_{1t}, y_{2t}, \dots, y_{nt})'$, and A_1, A_2, \dots, A_p are $n \times n$ parameter matrix, the disturbance u_t obeys white noise condition:

$$E(u_t) = 0, E(u_t u_t') = \Sigma, E(u_t u_s') = 0, (t \neq s).$$

But the VAR model has actually hidden the contemporaneous relationship into the random disturbance. Bernanke (1986) puts forward the structural vector auto regression (SVAR) model, which can not only test the variable's lagged effect, but also can analyze the contemporaneous relationship between the variables. To build a SVAR model, we need to identify the contemporaneous causality matrix A firstly:

$$Au_t = Be_t, e_t \sim i.i.d.(0, I) \quad (4)$$

Where k order matrix A gives the contemporaneous structural relationship of the different variables. u_t is observable (or simplified) residual item, and e_t is the "standard orthogonal random disturbance", the structure shocks of orthogonalization, and its variance-covariance matrix is unit matrix. Variance decomposition based on SVAR model is called the structure variance decomposition.

The model identification is critical for SVAR model analysis, which is usually based on the relevant economic theory and hypothesis to impose constraints on coefficient matrix, and it has obvious deficiencies: first, the identification is not based on the data itself, but on the beforehand judgment, so the credibility degree is low. Second, applying the different economic theories constraints can be of very different empirical results, so it is lack of uniformity in application and technology. Pearl (1995) and Spirtes, Glymour and Scheines (2000) develop Directed Acyclic Graph (Directed Acyclic Graph, DAG) approach to analysis the contemporaneous causality of variables. DAG approach is based on data driven and does not require theoretical assumptions, avoiding the subjectivity of the previous identification methods and provides a strong evidence for the identification of SVAR model.

The PC algorithm (Spirtes et al., 2000) is often used in the DAG analysis: first we need to draw the undirected complete graph of the variables, and the analysis of contemporaneous causality and directivity includes two stages, "removing edges" and "orientation". "removing edges" stage need to test the significance of the (partial) correlation coefficient between variables, and then remove the edges between variables (partial) which have no significant correlations, to get the undirected causality graph of variables. On "orientation" phase, we introduce the concepts of "adjacent" and "d-separation". In undirected complete graph, if there is an edge between variables X and Y , we say X and Y are "adjacent". The "d-separation" of X and Y mean a condition variables set which make the variables unrelated. For instance, the relationship between the variables X, Y, Z is " $X - Y - Z$ ", and on condition of Y , partial correlation coefficient of X and Z is not zero, so Z does not belong to the "d-separation" of X and Z , then we can infer the contemporaneous causality is " $X \rightarrow Y \leftarrow Z$ ". When Y belongs to "d-separation" of X and Z , i.e. $\rho(X, Z|Y) = 0$, the contemporaneous causality is " $Z \leftarrow Y \rightarrow X$ ". The significance test of (partial) related coefficient usually uses the Fisher's z statistic, to estimate whether the correlation coefficients between the variables are 0. The expression of Z statistic is as follows:

$$Z(\rho(i, j | k)n) = \left(\frac{1}{2}\sqrt{n-|k|-3}\right) \times \ln\{[1 + \rho(i, j | k)] \times [1 - \rho(i, j | k)]^{-1}\} \quad (5)$$

Where n is the sample size, $|k|$ is the number of condition variables, $\rho(i, j | k)$ is the when the partial correlation coefficient when the number of condition variables is k . It is generally believed that the RMB starts circulating overseas in 1997, so we select the sample range from 1997 to 2015. And the RMB overseas circulation (FC) is estimated above using the elimination of local demand approach, as the indicator of the RMB internationalization; the macroeconomic variables include the nominal interest rate (I), RMB exchange rate using a direct quotation (E), and consumer price index CPI (the base year is 2005), which measures the inflation. The raw data is from the NSBC and Wind database.

3.2.2. Contemporaneous causality analysis

SVAR model requires all the variables to comply with stationary random variables, and we perform unit root test to time series using ADF. The results show that under the 5% significant level, variables all obey the non-stationary I (1) process. According to the information criteria SC and FPE, the lag order is 1. Since the differential variables are stationary, we can conduct cointegration test of variables, and the results are showed in table 2:

Table 3. Johansen cointegration test

H0: No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P Value
None	0.771	39.390	40.175	0.060
At most 1	0.468	15.812	24.276	0.393
At most 2	0.268	5.711	12.321	0.472

Through the test results, we can see that at 5% significant level, we cannot reject the “no cointegration relationship” hypothesis, so there is no long-term stable relationship among the non-stationary variables FC, E, I and CPI. It also shows that the SVAR model is the appropriate model to describe relationships of the variables. Based on the above contracted type VAR (1) model, we can get the disturbance (conditional) correlation coefficient matrix¹

$$\begin{matrix} & \text{FC} & \text{E} & \text{I} & \text{CPI} \\ \begin{pmatrix} 1 & & & \\ -0.45 & 1 & & \\ 0.62 & -0.68 & 1 & \\ 0.20 & -0.23 & 0.40 & 1 \end{pmatrix} & & & & \end{matrix} \quad (6)$$

The identification of the SVAR model using the directed acyclic graph (DAG) approach is the premise to carry out the subsequent impulse response analysis. First we draw the undirected

¹ Due to the limited space, we do not give unconditional correlation coefficients matrix, the interested readers please contact the authors.

complete graph of FC, E, I and CPI, as shown in figure 2 (a). The four variables are connected through the undirected lines, suggesting that there may be contemporaneous causality among the variables, but the directivity of causal relationship is not yet clear. We use the built-in PC algorithm in Tetrad IV software, analyzing the (partial) correlation coefficients among variables through the disturbance correlation coefficient matrix, and gradually remove the edges between unrelated variables, thus obtaining the variables' contemporaneous causality and the directivity.

Usually the 5% significance level is used in *Fisher's Z* statistic analysis, and by analyzing the (partial) correlation coefficients of variable disturbance and the P value, we can remove the edges among the unrelated variables and get the directed graph 2 (b). The directed graph shows that there exists contemporaneous causality among overseas circulation scale, the exchange rate and the inflation, but the directivity of the causal relationship is unclear. Referring to Sprites et al. (2000), under the condition that the sample size is small, a higher significance level should be used (for instance, if the sample is less than 100 observations, the significance level can be 0.1), which will help to improve the analysis results of DAG approach. We only have only 72 observations in this paper, so we will relax the significant level to 10%.

In conditional correlation coefficients analysis, conditioning on the disturbance of exchange rate E, the partial correlation coefficient between FC and I $\rho(FC, I|E)$ is 0.48, and the P value of Z statistics is 0.36; Conditioning on the disturbance of CPI, the partial correlation coefficient between FC and I $\rho(FC, I|CPI)$ is 0.60, and the P value of Z statistics is 0.27. We can infer that under 10% significance level, FC and I have no contemporaneous causality, so we can remove the edge between FC and I. Similarly, the partial correlation coefficient between CPI and I conditioning on the disturbance of E $\rho(CPI, I|E)$ is 0.34, and the P value of Z statistics is as high as 0.45; conditioning on the disturbance of FC, the partial correlation coefficient $\rho(CPI, I|FC)$ is 0.35, the P value is 0.63. So under the significance level of 10%, CPI and I are mutually conditional independent, the edge between them can be removed. Also, conditioning on the disturbance of FC and CPI disturbance conditions respectively, the partial correlation coefficients between E and I, $\rho(E, I|FC)$, $\rho(E, I|CPI)$ are -0.57 and -0.66, and the P values were 0.85 and 0.39 respectively. E and I have no contemporaneous causality at 10% significance level, so the edge between the E and I is removed.

According to the above analysis of (partial) correlation coefficient, CPI does not belong to the "d-separate" of FC and E, so the contemporaneous causality among FC, E and CPI is "FC→CPI←E". And E is the "d-separate" of I and FC, so the relation among the FC, E, I is "FC←E→I". Because of the analysis above, there is no contemporaneous causality between E and I, so the relation between FC and E is a unidirectional causal relationship "E→FC". So under 10% significance level, the contemporaneous causality among the variables turn out into figure 2 (c): the exchange rate will directly cause contemporaneous changes in the inflation rate; also there exist the contemporaneous causality of "from the exchange rate to the oversize RMB circulation

scale”, as well as “from overseas circulation to the inflation rate”; But the interest rate has no obvious contemporaneous causality with other variables. To further verify the rationality and reliability of the DAG analysis results, we have carried on the likelihood ratio test (Sims, 1986), and the test results show that the LR statistic at 5% significance level can't refuse the null hypothesis of "excessive constraints is true", thus proving that the DAG analysis results is reasonable and reliable.

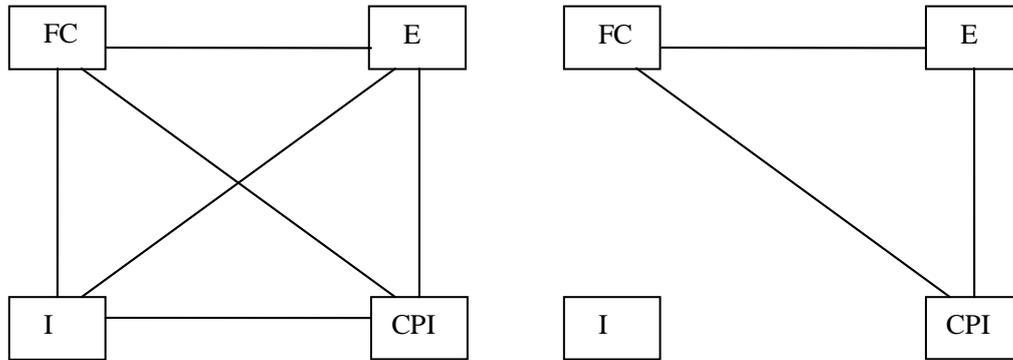
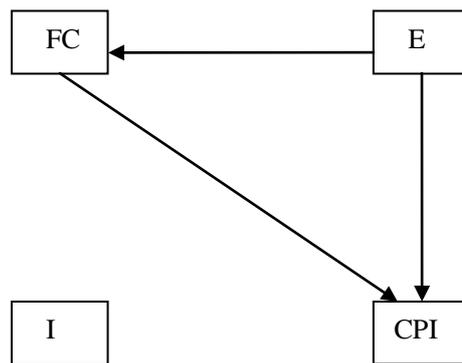


Figure 3. (a) Undirected complete graph

(b) Directed acyclic graph (5% significance)



(c) Directed acyclic graph (10% significance)

From the analysis results of DAG, exchange rate fluctuations will direct cause the change of RMB overseas circulation and the inflation rate over the same period; at the same time overseas circulation can also cause changes in the rate of inflation contemporaneously; while the adjustment of the interest rates has no direct relationship with other variables over the same period. China's interest rate is controlled by the monetary authorities, adjusted according to the market volatility. Because monetary policy itself has a time lag, the Central bank's adjustment to the economy cannot show up immediately, so the interest rate has no contemporaneous causality with other economic variables. And at 10% significance level, the fluctuations of exchange rate will directly cause changes in the price level or overseas circulation, and at the same time, the change of overseas circulation size will affect the price level over the same period. We can infer that the overseas demand for the RMB has extremely high sensitivity to the changes in the exchange rate, indicating that RMB overseas circulation mainly focuses on the foreign exchange market, and there are still limitations in the field of consumption at present. Foreign exchange markets will do

a large amount of short-term monetary operations for chasing interests and for the purpose of hedging and speculation, which will cause the immediate impact on currency circulation scale. And according to the theory of purchasing-power parity (PPP), exchange rate reflects the price proportion of tradable goods measured by different currencies. Our country has been the major trade power in the world, the price change of import and export commodities caused by exchange rate changes will immediately reflect in the domestic market price level, leading to changes in the rate of domestic inflation over the same period. And RMB overseas circulation changes in terms of foreign exchange settlement will also affect the domestic price level contemporaneously.

Based on the results of directed acyclic graph, we can impose 0 constraints on the coefficients among variables which have no contemporaneous causality to identify the SVAR model:

$$\begin{pmatrix} 1 & 0 & 0 & a_{14} \\ 0 & 1 & 0 & 0 \\ a_{31} & 0 & 1 & a_{34} \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{pmatrix} \quad (7)$$

Referring to the conditional constraints type (7), we can identify the SVAR model, and use the full information maximum likelihood estimation (FIMLE) to estimate the parameters of the contemporaneous structure relation matrix. Based on the estimated SVAR model, we can further analyze the impulse response of the domestic macro economy to the internationalization of the RMB, to explore the dynamic relations and the mutual effect between RMB overseas circulation and China's macro economy.

3.3. *The dynamic relationship between RMB internationalization and the macro economy*

To estimate the shock of RMB overseas circulation to the macro economy and the time lag effect, we examine the impulse response and the cumulative impulse response of exchange rate, interest rate and inflation rate to overseas circulation change, the result is shown in following figures.

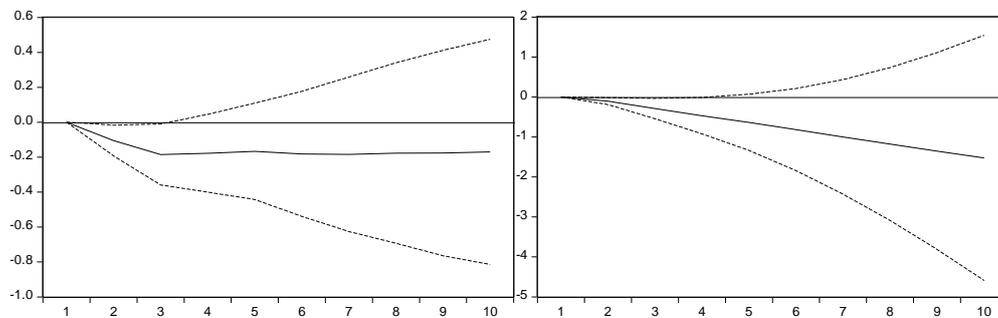
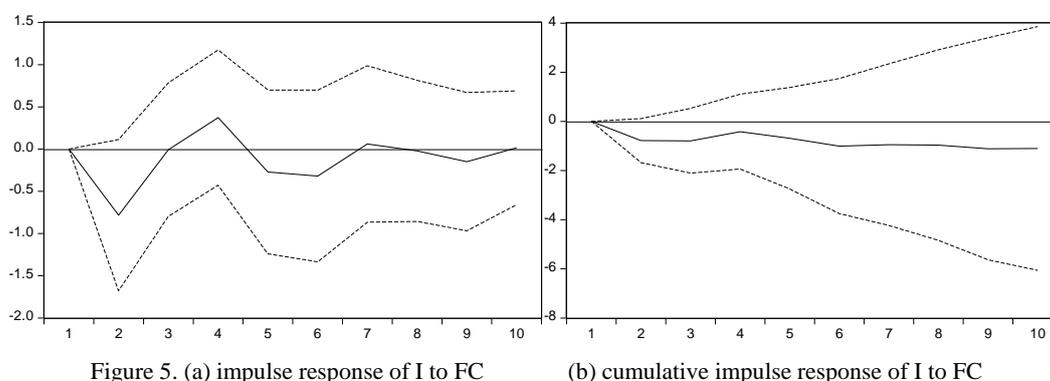


Figure 4. (a) impulse response of E to FC (b) cumulative impulse response of E to FC

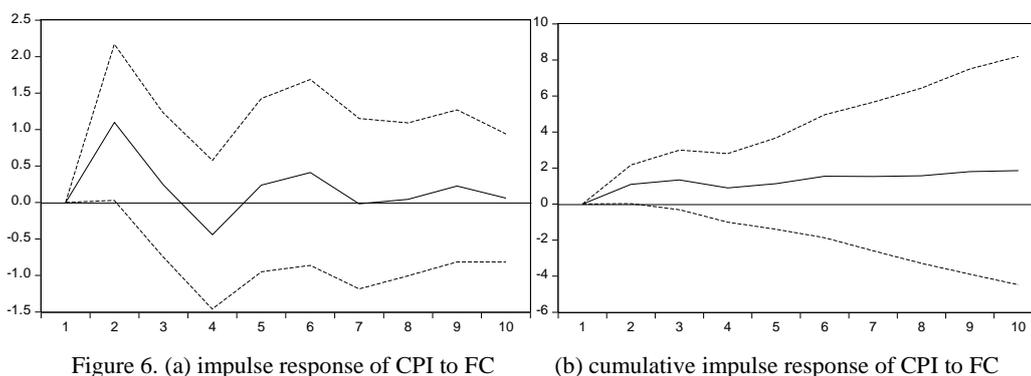
From figure 3 (a) we can see the impulse response of exchange rate to a standard deviation of

overseas circulation is negative, and the value reaches a stable level of about -0.2 after the 3rd year. From the cumulative response figure 3 (b), the negative response has longevity and durability, which indicates that along with the advancement of the internationalization, the RMB enters the rail of long-term appreciation. This is consistent with the theoretical expectations: in the process of RMB internationalization, the function of RMB in terms of valuation, settlement, trade and official international reserves has gradually enhanced, so foreign investors become more confident in RMB and have growing appetite for RMB assets, tending to increase their holdings of RMB assets in the portfolio, which makes the overseas demand for the RMB increase greatly, and under the condition of invariant money supply, the RMB appreciation pressure has been greatly strengthened. Although China's Central Bank has adopted policies of releasing money liquidity, in the case that China's capital account is not fully opened, the RMB in the foreign exchange market is still over-demand. At the same time, China's international trade surplus has existed for a long time, and the foreign exchange reserves ranks first in the world, so the foreign currency supply is greater than the demand in domestic market, which will bring foreign currency devaluation expectations and also increase the RMB appreciation pressure in a long run. Since the exchange rate reform in 2005, RMB has showed a trend of steady appreciation, from the fixed exchange rate of 8.28 (USD/CNY) gradually expanded to 6.23 in 2015 (USD/CNY), more than 20% within ten years. It can be seen that the increase of the overseas circulation scale is accompanied by the appreciation of RMB.



The impulse response of interest rate to overseas circulation shock is volatile, and the impulse response of interest rate is negative in short term, and reaches the maximum negative value in the 2nd year, about 0.8. The increasing overseas circulation strengthens the appreciation expectation of RMB, so the government has to cut interest rate to reduce the hot money inflows and relieve appreciation pressure. In the 3rd year the overseas circulation shock become positive, and in the 4th year it reaches the maximum positive value, about 0.4, which is because the domestic money market appears the situation of monetary tightening with the increasing RMB overseas circulation, so the government begins to raise interest rate to get the money back. Until 5-6th year under the influence of hot money inflow, the overseas circulation shock again impose slightly negative impact on interest rate, and the following response to impact become gradually stable. Seen from

cumulative response figure 4(b), the long-term response of interest rates to the shock of foreign circulation is negative, i.e. with the speeding up of the internationalization of RMB, domestic interest rate overall keeps a downward trend. Under the premise that the total money supply is fixed, the increase of overseas circulation can reduce the domestic money supply, and interest rate tend to rise. But to prevent deflation and stimulate the domestic economy, the central bank implements the expansionary fiscal policy, through the interest rate variation we can also know that monetary policy adjustment is always behind the change of impulse response of interest rate to overseas circulation shock, which also shows the time lag effect of monetary policy. This is in conformity with the practical economic conditions: the internationalization of RMB and have reduced interest rate spread and narrowed the international hot money arbitrage space.



The impulse response trend of inflation rate to the overseas circulation is almost the opposite of the impulse response trend of the interest rate. In 1st ~ 3rd year the response to RMB overseas circulation shock is positive, and in the 2nd year it reaches to the maximum value, about 1.1. It is because under the pressure of RMB appreciation, the government tends to take expansionary fiscal and monetary policy, causing the price level to rise. Then the positive impulse response weakens and in the 4th year it becomes negative. Under the premise that the total money supply is certain, overseas circulation increase causes a decline in the domestic money supply, so the inflation rate in the 4th year tends to go down, and then due to the appreciation expectations of RMB, the international speculative "hot money" inflows, leading to that the price level in 5-6th continues to rise. After that the impulse response of inflation stays relatively stable, maintaining a small-scope fluctuation. From cumulative impulse response figure 5(b), the long-term impulse response of inflation rate to the overseas circulation is positive. As the RMB internationalization process is accelerated, the appreciation expectations of RMB lead to the influx of foreign arbitrage capital, in order to reduce the impact of international capital on the domestic economy, the government adopts the easy monetary policy and credit expansion policy, injecting a lot of liquidity into the market, the price level tend to rise generally, and by the end of 2015 the cash in circulation (M0) has amounted to 63216.58 trillion yuan, about 6.2 times that of the end of 1997, and the great increase in domestic money supply has also pushed up the domestic price level. Therefore, the increase of the overseas circulation scale does not cause the domestic deflation, instead, under the

relatively loose monetary policy, the domestic price level continues to rise, that is, in the process of RMB internationalization, the central bank continuously release liquidity to meet the domestic and overseas currency demand. In the long run, under the condition that the enlarged RMB overseas circulation scale and the appreciation expectation of the RMB, the government adopts expansionary fiscal and monetary policy to improve the liquidity in the domestic market, which has caused t created he domestic inflation pressure.

4. Conclusions

This paper employs the Gap Estimation approach, using China's economic data from 1978 to 1996 to estimate the 1997 to 2015 RMB overseas circulation scale, as the indicator of RMB internationalization. And we use the directed acyclic graph (DAG) approach as well as impulse response function to analyze the contemporaneous causality and the dynamic mutual effect between RMB overseas circulation and the domestic macro economy. DAG analysis results show that there exist the contemporaneous causality of "from RMB overseas circulation to inflation", "from exchange rate to RMB overseas circulation" and "from exchange rate to inflation", which indicates the transfer effect of the appreciation expectations and expansion of circulating overseas caused by RMB internationalization to the domestic inflation is very fast and significant. Due to the time lag effect of monetary policy, interest rate adjustment has no significant influence on other economic variables over the same period.

According to related economic theory, the internationalization of RMB causes that the overseas demand for the RMB increases dramatically and the demand is greater than supply in the foreign exchange market, resulting in a long-term RMB appreciation pressure. While the increase of RMB overseas circulation will reduce the domestic money supply under the premise that the total money supply is stable, leading to domestic interest rates and deflation. In this paper, we show that the internationalization of RMB do bring the long-term appreciation, but at the same time the domestic interest rate has been on the decline, and the price level has also risen in successive years. By exploring the intrinsic mechanism, we conclude that due to the influx of foreign speculative capital as a result of appreciation of RMB, the government has adopted a series of expansionary monetary policy in order to reduce the impact of international hot money, and to maintain the value of the RMB relatively stable. In addition, the internationalization of the RMB requires the central bank to release liquidity, in order to meet the demands of RMB in the settlement, international trade and the international official reserve, etc. However, in the process of RMB internationalization, due to domestic capital has not realized the full flow, the increase in total money supply mainly imposes impact to the domestic macro economy. Brought by the RMB internationalization the significant increase in RMB overseas circulation and the high volatility in exchange rate in the short term will directly affect the level of domestic inflation and in the medium and long term will also fan the fire of the inflation's intensification. The price stability is one of the primary goals of the macroeconomic regulation and control, and is also the basis to maintain sustained and rapid economic growth, and the domestic macroeconomic stability will in

turn benefit the stability of the RMB value and the further deepening of the RMB internationalization. Therefore, we should be ready to deal with the possible adverse impact the internationalization of RMB may bring, to prevent vicious inflation and drastic fluctuations of exchange rate. The policy makers should balance the internationalization of the RMB process with the domestic macroeconomic stability and healthy development at the same time. This paper helps to clarify that in the process of RMB internationalization, how the increase of the RMB overseas circulation will influence the RMB exchange rate, domestic interest rate and inflation level, and also the transmission and dynamic effect mechanism between them, which will provide some suggestions to the smooth realization of the RMB internationalization and the steady running of China's domestic macro economy.

Reference:

- Aliber, R.Z. (1964). The Costs and Benefits of the U.S. Role as a Reserve Currency Country. *The Quarterly Journal of Economics*, 78(3), 442-456.
- Bahmani-Oskooee, M., Wang, Y. (2007). How stable is the demand for money for China. *Journal of Economic Development*, 32, 21-33.
- Ball, L. (2012). Short-run Money Demand. *Journal of Monetary Economics*, 59(7), 622-633.
- Barnett, W.A., Tang, B. (2015). Chinese Divisia Monetary Index and GDP Nowcasting. *Open Economies Review*, 27 (5) , 1-25.
- Bergsten, C.F. (1976). The Dilemmas of the Dollar: the Economics and Politics of United States International Monetary Policy. *British Journal of Dermatology*, 94 (94), 195-200.
- Bergsten, C.F. (2009). The Dollar and the Deficits: How Washington Can Prevent the New Crisis. *Foreign Affairs*, 88(6), 20-38.
- Bernanke B. (1986). Alternative Explanations of the Money-income Correlation. Working Paper in Karl Brunner and Allan Meltzer, eds., *Real Business Cycles, Real Exchange Rates, and Actual Policies*, Carnegie-Rochester Conference Series on Public Policy No. 25.
- Chan, K.S. (2001). The Internationalization of Hong Kong Dollar: An Analytical Framework. Hong Kong Institute for Monetary Research, Working Paper No.1.
- Chen, B. (1997). Long-run money demand and inflation in China. *Journal of Macroeconomics*, 19(3), 609-617.
- Cohen, B. J. (1972). The Future of Sterling as an International Currency. *International Affairs*, 48(1), s61-267.
- Cohen, B.J. (2012). The Benefits and Costs of an International Currency: Getting the Calculation Right. *Open Economic Review*, 23(1), 13-31.
- Frankel, J.A. (1991). The Cost of Capital in Japan: A Survey. Federal Reserve Bank of San Francisco, Pacific Basin Working Paper Series.
- Girton, L., Roper, D. (1981). Theory and Implication of Currency Substitution. *Journal of Money, Credit and Banking*, 13(1), 12-30.
- Hafer R.W., Kutan A.M. (1993). Further Evidence on Money Output and Prices in China. *Journal of Comparative Economics*, 17(3), 701-709.
- Hafer R.W., Kutan A.M. (1994). Economic Reforms and Long-Run Money Demand In China: Implications for Monetary Policy", *Southern Economic Journal*, 60(4), 936-945.
- Ho, Y.K. (2006). Money supply and equity prices : An empirical note on Far Eastern countries. *Economics Letters*, 11 (1), 161-165.
- Huang, G (1994). Money demand in China in the reform period: An error correction model. *Applied Economics*,

26, 713-719.

Kannan, P. (2007). On the Welfare Benefits of an International Currency. *European Economic Review*, 53(5), 588-606.

Kenen, B.P. (2009). Currency Internationalization: an Overview. *Bok-BIS Seminar on Currency Internationalization: Lessons from the Global Financial Crisis and Prospects for the Future in Asia and the Pacific*. Seoul, 34(4), 277-287.

Mazaid, S., Farahmand, P., Wang, S., Segal, S., Ahmed, F. (2011). Internationalization of Emerging Market Currencies: A Balance between Risks and Rewards. *IMF Staff Discussion Notes*, No.11/17.

Pearl, J. (1995). Causal Diagrams for Empirical Research. *Biometrika*, 82(4), 669-688.

Sims, C.A. (1980). Macroeconomics and Reality. *Econometrica*, 1980, 48(1), 1-48.

Spirtes, P., Glymour C., Scheines, R. (2000). *Causation, Prediction, and Search*. MIT Press, Cambridge, MA.

Tavlas, G.S. (1997). Internationalization of Currencies: The Case of the US Dollar and Its Challenger Euro. *International Executive*, 39(5), 581-597.

Triffin, R. (1960). Gold and the Dollar Crisis: the Future of Convertibility. *Journal of Research in Science Teaching*, 37(1), 251-256.