



UDK: 336.717.3
DOI: 10.2478/jcbtp-2023-0026

Journal of Central Banking Theory and Practice, 2023, 3, pp. 87-109
Received: 25 June 2023; accepted: 02 July 2023

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Econometric VAR Analysis of the Effect of the Foreign Exchange Reserves on Macroeconomic Variables in Emerging Countries: The Case of BRIC Countries

Abstract: This paper analyses the effects of the foreign exchange reserves accumulation on the key nominal and real macroeconomic variables (GDP, employment, prices and exchange rates) in BRIC countries (Brazil, Russia, India, China). VAR model was used to empirically examine the effect of accumulation of foreign exchange reserves on macroeconomic variables. The empirical results in this paper show that after the initial shock of foreign exchange reserves, the exchange rate appreciation occurs, which can be explained by the fact that a higher level of foreign exchange reserves gives investors and rating agencies a lower risk of the country, which can consequently lead to appreciation of the foreign exchange rate. In this way, the price reaction would be neutralized. Consequently, the growth of foreign exchange reserves leads to the growth of economic activity measured by GDP growth.

Key words: foreign exchange reserves, VAR, exchange rate, employment, economic growth, inflation.

JEL Code: E52, E58, F31, C50.

1. Introduction

The trend of increasing foreign exchange reserves began around 1990, which marks the beginning of the era of financial globalization. In early 1990s, foreign exchange reserves of emerging countries (China, Brazil, Russia, Argentina, Singapore, South Africa, India, Indonesia, etc.) significantly increased. The FX reserves accumulation trend was first spotted in emerging countries, especially those in Asia, Latin America, Eastern Europe, and in oil-exporting countries. Due to the potential impact on global interest rates, economic growth and financial stability, the accumulation of foreign exchange reserves in these countries proved to have been essential. The rapid increase in foreign exchange reserves in emerging countries in recent years is part of complex variable global trends.

The primary reason for the accumulation of a large stock of foreign exchange reserves in emerging countries is the security for expensive foreign currency crisis. Foreign exchange reserves are necessary to maintain the chosen exchange rate regime, facilitate the management of foreign currency and prevent a speculative attack. Also, foreign reserves are part of the state portfolio that generates interest on the foreign market. The accumulation of foreign reserves and political variables that can be used for accelerating economic growth.

The basic hypothesis to be tested in the paper is whether the foreign exchange reserves accumulation affects the key nominal and real macroeconomic variables (GDP, employment, prices and exchange rates) in BRIC countries (Brazil, Russia, India, China). To empirically examine the effect of the accumulation of foreign exchange reserves on macroeconomic variables, we used a VAR model.

The rest of this paper is organized as follows. Section 2 considers a preliminary examination of literature from the relevant scientific field. The hypotheses of interest are given in Sections 3 and 4. Section 3 describes the econometric model to be used in the analysis of how the foreign exchange reserves accumulation affects the key nominal and real macroeconomic variables in emerging markets and considers the data, methodologies and variables used in the study. A discussion of the results and implications is given in Section 4. Section 5 provides concluding observations and recommendations for future research based on empirical research in this paper.

2. Literature Review

Fatum and Yetman (2018) assessed whether the accumulation of foreign exchange reserves in the Asia-Pacific region may have unintended consequences in the form of increased private sector risk-taking. Their results suggest that foreign exchange reserves accumulation exerts no significant influence on risk-taking. Yun (2018) showed that sterilized foreign exchange reserve accumulation had contractionary effects. Banks reduce loans to firms and hold more risk-free central bank debts, and firms end up borrowing less from the banks. Foreign exchange reserve accumulation not only works against exchange rate appreciation, but also partially offsets the expansionary effect of capital inflows. This explains why foreign exchange reserve accumulation is a favoured tool to cope with capital inflows in many countries. Khabibullin, Ponomarenko and Seleznev (2018) showed that foreign exchange reserve accumulation by a central bank (even when sterilized, meaning that it does not affect the short-term interest rates) will result in acceleration of commercial banks' balance sheet expansion rate. This happens due to an increase in money creation through external transactions that is not fully offset by the reduction in money creation through lending. Zhou, Yan and Luo (2018) showed that the main reason for the fast growth of the Chinese foreign exchange reserve is the structural trouble of its double international payment surplus, which creates long-term appreciation expectations for the exchange rate that make it difficult for international capital inflows and excess foreign exchange reserves to enter the real economic growth mechanism under the model of China's export-driven economy growth; the average optimal foreign exchange reserve in case of the sudden stop of capital inflows was calculated through parameter estimation and numerical simulation to be 13.53% of China's gross domestic product between 1994 and 2017; with the function of the foreign exchange reserves changing from meeting basic transaction demands to meeting financial security demands, the effect of the foreign exchange reserve maintaining the state's financial security is becoming more and more obvious.

Alfaro and Kanczuk (2017) showed sovereign debt sustainability under the assumptions that countries can accumulate foreign exchange reserves and borrow internationally using their own currency. As opposed to traditional sovereign-debt models, asset-valuation effects occasioned by currency fluctuations act to absorb global shocks and render consumption smoother. Countries do not accumulate foreign exchange reserves to be depleted in "bad" times. Instead, issuing domestic debt while accumulating foreign exchange reserves acts as a hedge against external shocks. Neely (2017) showed that the value of Chinese foreign exchange reserves at just over \$4 trillion in June 2014, but has since declined to \$3.19 trillion as of August 2016 and explains the reasons for this large decline in

foreign exchange reserves, what China's policy choices are, and how these choices could affect the U.S. economy. In the absence of the unlikely event of very large, sudden sales of the foreign exchange reserves portfolio, the situation in China is unlikely to substantially affect the U.S. economy or monetary policy. Aizenman (2017) showed that the links of foreign exchange reserves, exchange rates and monetary policy can be understood through the lens of a modern incarnation of the "impossible trinity" (aka the "Trilemma"), based on Mundell-Flemings's hypothesis that a country may simultaneously choose any two, but not all of the following three policy goals: monetary independence, exchange rate stability, and financial integration. However, in the 1990s and 2000s, emerging markets and developing countries found that deeper financial integration comes with growing exposure to financial instability and the increased risk of "sudden stop" of capital inflows and capital flight crises. The original Trilemma has morphed into a Quadrilemma, wherein financial stability has been added to the Trilemma's original policy goals. Successful navigation of the open economy Quadrilemma helps in reducing the transmission of external shock to the domestic economy, as well as the costs of domestic shocks. The Global financial crisis, and the subsequent Eurozone crisis, have validated that no country is immune from exposure to financial instability and from the modern Quadrilemma. Azar and Aboukhor (2017) showed positive and significant relationships between foreign exchange reserves accumulation on one hand, and oil prices, GDP, the ratio of current account to GDP, and the ratio of broad money to GDP on the other hand in the Gulf and Cooperation Council countries (GCC countries), namely, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. However, the results show that the stockpile of foreign exchange reserves in the GCC countries is not sensitive to nominal effective exchange rates, neither to the ratio of imports to GDP, and nor to interest rates on the US Dollar. Poongothai and KalaiPriya (2017) analysed the impact of the foreign exchange reserve holdings on Inflation (both consumer price index and wholesale price index) in India and showed the better influence posed by the foreign exchange reserves on inflation. Dash, Shylajan and Dutta (2017) found that in the long run, variables such as inflation and short term external debt/GDP affects the foreign exchange reserves. One percent increase in inflation reduces the foreign exchange reserves by 0.12% whereas one percent increase in short term external debt/GDP increases the foreign exchange reserves by 0.46%. On the other hand, in the short run, exchange rate affects positively foreign exchange reserves of India. Sunner (2017) examines the overall growth trend as well as the potential causes of the compositional shift in foreign exchange reserves, including a decline in yields offered by traditional reserve assets and higher reserve balances. Abid and Jhawar (2017) analysed the trend in foreign exchange reserves and its components in India and showed that two fac-

tors which can be stated as responsible factors for increasing foreign exchange reserves are capital inflows and low current account deficit.

Fabris and Lazić (2022) found that the exchange rate represents a statistically significant variable only in the monetary policy reaction function of the emerging market economies. This can be justified by the higher levels of the exchange rate pass-through, recent hyperinflation episodes and crisis and, consequently, less stable inflation expectations in the emerging market economies.

Drama (2016) showed that the relationship between the change in foreign exchange reserves and inflation rate is positive for the countries West African countries (Cote d'Ivoire, Senegal, Ghana and Nigeria) in long run but the overall short run estimation of model is insignificant at the conventional level. This means that rise in foreign exchange reserves leads to increase in the rate of inflation. Krušković and Maričić (2015) analysed the effect of accumulation of foreign exchange reserves to economic growth in emerging countries. The empirical results in this paper show that the increase in foreign exchange reserves causes the growth of GDP, while causality in the opposite direction has not been proven. Exchange rate depreciation that occurs as a result of the accumulation of foreign exchange reserves is not inflationary because it is a one-time non-persistent shock, unlike the sudden depreciation of the exchange rate that occurs as a result of maintaining an overvalued exchange rate in the long term and leads to currency crisis. The accumulation of foreign exchange reserves does not lead to inflation if the rate of accumulation of foreign exchange reserves does not exceed the rate of economic growth. Slightly higher inflation is not necessarily harmful, particularly for developing economics and emerging economics. Krušković (2014) shows that foreign exchange reserves have a significant impact on economic growth and employment in emerging countries. Also, the accumulation of foreign exchange reserves is not inflationary if the rate of accumulation of foreign exchange reserves does not exceed the rate of economic growth. Brugger (2015) showed that Asian countries' foreign exchange reserve accumulation is caused by a paradigm shift. In Asia's former Development State paradigm, accumulation of huge foreign exchange reserves was not of central importance because of closed and heavily regulated financial markets. A new paradigm was built around the ideas of liberalism, the unconditional avoidance of any further financial crisis, and high employment. Hoarding foreign exchange reserves was a suitable strategy. Ayhan and Turgutlu (2015) found that the international reserve accumulation is mainly explained by current account balance, per capita income and past crisis experience.

Cheng (2013) argued that foreign reserve accumulation is a consequence of a growth strategy induced by strong capital investment in a financially constrained economy. Yazdani and Nikzad (2020) showed that the loss of foreign exchange reserves can lead to a foreign exchange crisis and significant output losses. Dimitrijević and Fabris (2009) showed that insufficient foreign exchange reserves hindered the implementation of stabilization programs and recovery after hyperinflation.

Bacchetta, Benhima and Kalantzis (2012) found that in a steady state, it is optimal for the central bank to replicate the open economy, i.e. to issue debt financed by the accumulation of reserves so that the domestic interest rate equals the foreign rate. However, when the economy is in transition, a rapidly growing economy has a higher welfare without capital mobility and the optimal interest rate differs from the international rate. They argued that the domestic interest rate should be temporarily above the international rate. They also found that capital controls can still help reach the first best when the planner has more fiscal instruments. Benigno and Fornaro (2012) found that by accumulating foreign reserves, the government induces a real exchange rate depreciation and a reallocation of production towards the tradable sector that boosts growth. Financial frictions generate imperfect substitutability between private and public debt flows so that private agents do not perfectly offset the government policy. The possibility of using reserves to provide liquidity during crises amplifies the positive impact of reserve accumulation on growth. They found that the optimal reserve management entails a fast rate of reserve accumulation, as well as higher growth and larger current account surpluses compared to the economy with no policy intervention. They also found that the welfare gains of reserve policy are large, in the order of 1 percent of permanent consumption equivalent. Dominguez, Yuko and Takatoshi (2012) focused not only on the total stock of official reserves held by countries, but also on the decisions by governments to purchase or sell reserve assets during the crisis period. Their findings support the view that higher reserve accumulations prior to the crisis are associated with higher post-crisis GDP growth.

Fabris (2022) determined that the coronavirus pandemic has accelerated the movement towards a cashless society and the issuance of central bank digital currency, which will change the structure of foreign exchange reserves, and he emphasized that additional research needs to be carried out on how this change will affect macroeconomic performance and the financial system.

Aizenman, Yothin and Park al (2011) found that the 2008 global crisis was associated with an unprecedented rise of swap agreements between central banks of larger economies and their counterparts in smaller economies. They explore

whether such swap lines can reduce the need for reserve accumulation. The selectivity of the swap lines indicates that only countries with significant trade and financial linkages can expect access to such ad hoc arrangements, on a case by case basis. Pina (2011) argued that accumulation of foreign exchange reserves can be explained by a simple model in which the central bank smooths inflation and stabilizes the exchange rate. Foreign exchange accumulation is the consequence of an increase in the incidence and magnitude of banking crises. These crises impose exceptional costs that need to be financed with inflation related revenues. As a result, the central bank optimally accumulates foreign exchange reserves in order to spread the distortions associated with inflation over time.

3. Empirical Data and Results

VAR model was used to empirically examine the effect of the accumulation of foreign exchange reserves on macroeconomic variables. In the VAR methodology, each dependent variable is regressed on previous values of all variables in the system. This type of econometric model became very popular among economists in early 1980s. In early works, VAR analysis was presented as a non-theoretical tool since there are no restrictions in explanatory variables that are not based on strict differences between exogenous and endogenous variables. This approach is in stark contrast to the earlier models that were exclusively designed based on the known theoretical relations. The main drawback of this approach was that all shocks in the system were connected to each other, which made it impossible to isolate the effect of just one of them. However, today, VAR models are very rarely used in this way. The first step towards the introduction of the structure was the application of Cholesky decomposition of the VAR model by specifying the sequence of variables to the function of the impulse response. This sequence of user-defined sequence of reaction variables in the first instance, as a first step towards defining the structure of the model. In this way, the non-theoretical nature of this approach was bridged, and then the subsequent development of structural VAR models reconcile theoretical models with the VAR approach.

Influence of accumulation of foreign exchange reserves on macroeconomic variables was analysed through the VAR approach, primarily because it is a systematic approach that allows interaction between variables. In this way, we can examine how the growth of foreign exchange reserves influences key macroeconomic variables simultaneously. The selection of countries for analysis was based on the assumption that certain countries use a strategy, particularly the accumulation of foreign exchange reserves, such as Brazil, China, Russia, India.

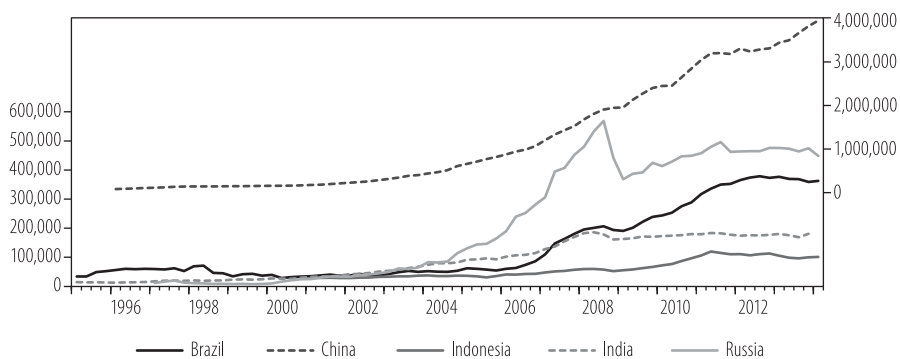
The following table presents the notation and definitions of variables that are used in the models, while Figure 1 shows the movement of foreign exchange reserves for selected countries. The data used for the analysis are quarterly. For interest rates, we used the interbank interest rate as the main rate at which the central bank influences their actions.

Table 1: Definitions of variables

Notation	Definition
d_cpi	The rate of change in domestic prices
d_fx	The rate of change in foreign exchange reserves
d_er	The rate of change of the nominal exchange rate
d4_fxreserv	The change in the level of foreign exchange reserves
import	The volume of imports (seasonally adjusted)
ir	Interbank interest rate
d_gdp	The growth rate of real GDP (seasonally adjusted)
un	The unemployment rate
d_us_gdp	The growth rate of real GDP US (seasonally adjusted)
dummy	A dummy variable that takes the value 1 for the 4th quarter of 2008 (the beginning of the financial crisis), and the value 0 for all other periods

Source: Author

Figure 1: The level of foreign exchange reserves (in mln. US dollars) (right scale, China)



Source: Author

Define a vector time series at time t as follows:

$$Y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \\ \vdots \\ y_{nt} \end{bmatrix}$$

where y_{jt} represents the value of variable j at time t . Using this notation, we can define a VAR model of order p n dimensions:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + \varepsilon_t$$

Matrix A_1, A_2, \dots, A_p are the dimensions $n \times n$. ε_t represents the random component of the model, i.e. vector random process (white noise), dimensions $n \times 1$.

On the dimension of the VAR model affects the number of variables in the initial vector (n) and the order of the model (p), which describes the structure of a vector autoregression time series. The number of parameters is necessary to estimate equals $n^2 \times p$, and it grows progressively with increasing model order or with an increase in the number of explanatory variables.

The method of impulse response is commonly used to analyze the effects of shocks. After the assessment of the parameters of the reduced VAR model, the sequence of variables for the Cholesky decomposition method is defined in order to transform the model in structural analysis and allow the transmission of shocks in the model. Given that central banks in this case accumulate foreign exchange reserves in order to influence the economy, we have assumed that the variable “most exogenous”, i.e. that this variable is an instrument that operates on the other variables in the model.

Let Ω covariance matrix of random errors in the VAR model. Cholesky decomposition is based on the assumption that every positive definite matrix can be expressed as $\Omega = PP'$, where P is the lower triangular matrix:

$$P = \begin{bmatrix} P_{11} & 0 & \dots & 0 \\ P_{12} & P_{22} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ P_{1n} & P_{2n} & \dots & P_{nn} \end{bmatrix}$$

By transforming the covariance matrix, a covariance matrix of structural shocks is obtained that can be further used to analyze the impulse response:

$$E(u_t u_t') = P^{-1} \Omega (P^{-1})'$$

where u_t are the structural shocks.

Because the data sets for different countries were available in different shapes and time horizons, special attention is given to each country. In the case of Brazil, Russia and India, the estimated VAR model shows a clear link between the growth of foreign exchange reserves and economic activities. In the case of China, the VAR model did not give satisfactory results, and an AR model is estimated for this country, while no statistically significant results for Indonesia have been obtained.

4. Results and Discussion

Figure 2 shows the results and simulations of shock in foreign exchange reserves on the basis of the estimated model for Brazil.

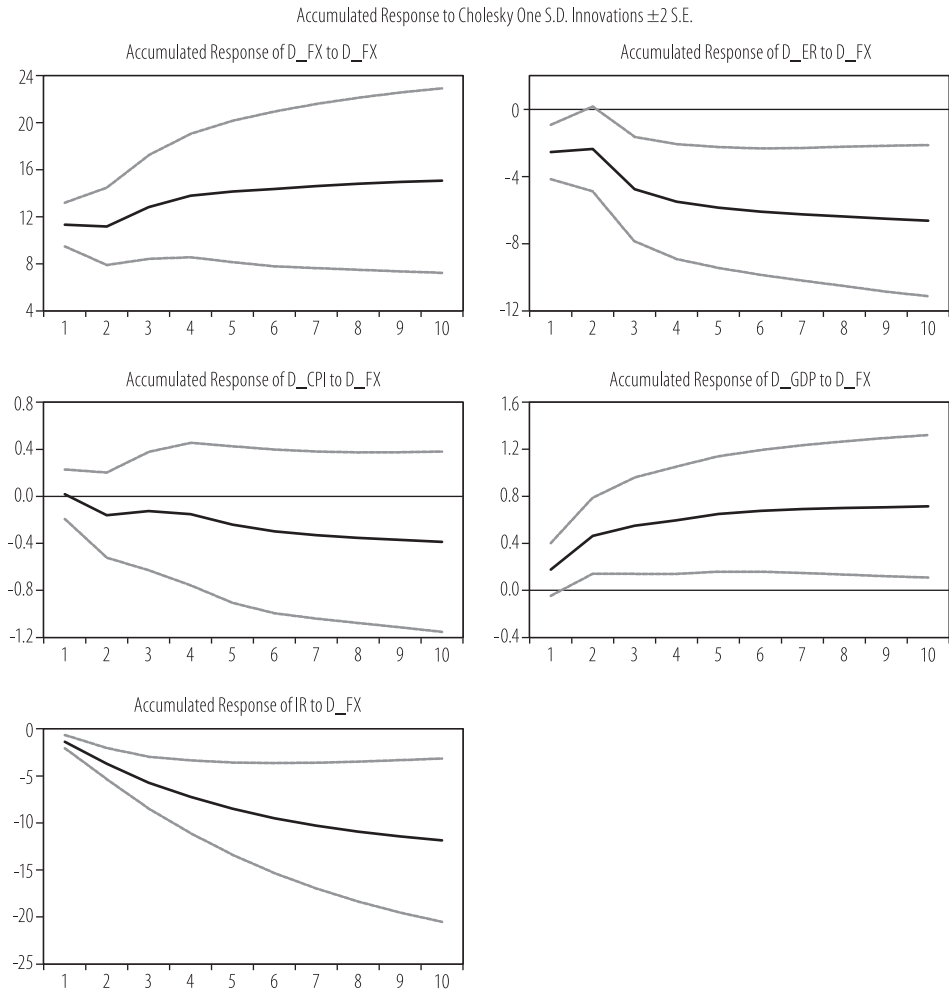
In the case of Brazil variables that were used for model evaluation are: the rate of change in foreign exchange reserves (d_{fx}), the rate of exchange rate changes (d_{er}), the rate of price change (d_{cpi}), the rate of change of GDP (d_{gdp}) and interbank interest rate (ir). Table 2 shows the results of the evaluation of the corresponding VAR model with two delays for the period from 1999 to the end of 2013. As an extra (exogenous) variable is used the rate of change of GDP of America (d_{us_gdp}) which has a role in controlling the growth of economic activity that is global in character. Each column in the table corresponds to one variable that is explained a delays and of all other variables in the system. The numbers in the table represent the estimated parameters of the corresponding variable with a delay while the numbers in parentheses are the corresponding t statistics.

Table 2: VAR model evaluation for Brazil for the period 1999 – 2013

Vector Autoregression Estimates					
Sample (adjusted): 1999Q4 2013Q4					
Included observations: 74 after adjustments					
Standard errors in () & t-statistics in []					
	D_FX	D_ER	D_CPI	D_GDP	IR
D_FX(-1)	0.077715 [0.58735]	0.087591 [1.03909]	-0.002385 [-0.22446]	0.011096 [0.97269]	-0.094112 [-2.54796]
D_FX(-2)	0.276171 [2.02336]	-0.260472 [-2.99541]	0.019288 [1.75963]	-0.005733 [-0.48720]	0.010972 [0.28796]
D_ER(-1)	-0.007242 [-0.03446]	0.256890 [1.91859]	0.032781 [1.94225]	-0.019951 [-1.10107]	-0.045958 [-0.78335]
D_ER(-2)	0.240891 [1.19096]	-0.134962 [-1.04734]	0.036880 [2.27050]	-0.027363 [-1.56911]	0.050347 [0.89167]
D_CPI(-1)	1.735746 [1.09739]	-1.530835 [-1.51916]	0.308867 [2.43163]	-0.089977 [-0.65982]	-0.024820 [-0.05621]
D_CPI(-2)	-1.048004 [-0.68407]	0.186128 [0.19070]	-0.036598 [-0.29747]	-0.051797 [-0.39216]	0.107448 [0.25124]
D_GDP(-1)	0.849375 [0.60177]	1.272272 [1.41484]	0.008469 [0.07472]	-0.139577 [-1.14700]	0.108789 [0.27610]
D_GDP(-2)	1.379609 [1.04678]	0.314967 [0.37512]	0.251897 [2.38000]	-0.072180 [-0.63524]	0.618581 [1.68133]
IR(-1)	0.908936 [1.96948]	0.257043 [0.87423]	0.055230 [1.49020]	-0.100845 [-2.53452]	1.046415 [8.12232]
IR(-2)	-0.832721 [-2.04508]	-0.053296 [-0.20545]	-0.031715 [-0.96990]	0.082776 [2.35797]	-0.206592 [-1.81753]
C	-3.503009 [-0.91094]	1.667444 [0.68061]	0.305607 [0.98960]	0.975421 [2.94212]	2.152966 [2.00558]
D_US_GDP	2.427864 [1.06997]	-4.417290 [-3.05566]	0.192563 [1.05675]	0.756134 [3.86516]	-0.180960 [-0.28569]
R-squared	0.167893	0.370619	0.415913	0.373208	0.864328
Adj. R-squared	0.020261	0.258954	0.312285	0.262003	0.840257
Sum sq. resids	7937.567	3221.706	51.18983	58.99915	618.5483
S.E. equation	11.31483	7.208537	0.908649	0.975499	3.158573
F-statistic	1.137238	3.319041	4.013513	3.356033	35.90775
Log likelihood	-277.9874	-244.6247	-91.36605	-96.61939	-183.5639
Akaike AIC	7.837498	6.935803	2.793677	2.935659	5.285512
Schwarz SC	8.211131	7.309435	3.167309	3.309291	5.659144
Mean dependent	2.712980	1.244937	1.595563	0.719614	17.43721
S.D. dependent	11.43122	8.373840	1.095700	1.135533	7.902793
Determinant resid covariance (dof adj.)	28019.93				
Determinant resid covariance	11568.23				
Log likelihood	-871.1799				
Akaike information criterion	25.16702				
Schwarz criterion	27.03519				

Figure 2 shows the impulse responses of the variables to a shock in foreign exchange reserves in Brazil, where the black solid lines represent the confidence interval of two standard deviations. We see that after the initial shock of foreign exchange reserves (upper left graph), the exchange rate appreciates (upper right graph). This can be explained by the fact that a higher level of foreign exchange reserves provides a signal to investors and rating agencies to lower country risk, which consequently may lead to an appreciation of the exchange rate. In this way, the price reaction (left graph in the middle row) was neutralized, and we see that this response was not statistically different from zero. Consequently, the growth of foreign exchange reserves leads to the growth of economic activity as measured by GDP growth (right graph in the middle row). Finally we note that there is a significant drop in interest rates, which can be explained by favourable macroeconomic conditions that allow relaxation of monetary policy.

Figure 2: Brazil



Source: Author

Table 3 presents the results of the estimated VAR models for India. In this case, the model is used in which the rate of change in foreign exchange reserves is not a statistically satisfactory result and is used as an alternative measure of coverage of imports by foreign exchange reserves. Since in the case of an exogenous variable the growth rate of GDP in the United States was not statistically significant for the explanation of any of the variables in the final model, it has been omitted. Other variables in the model are the same as in the model for Brazil.

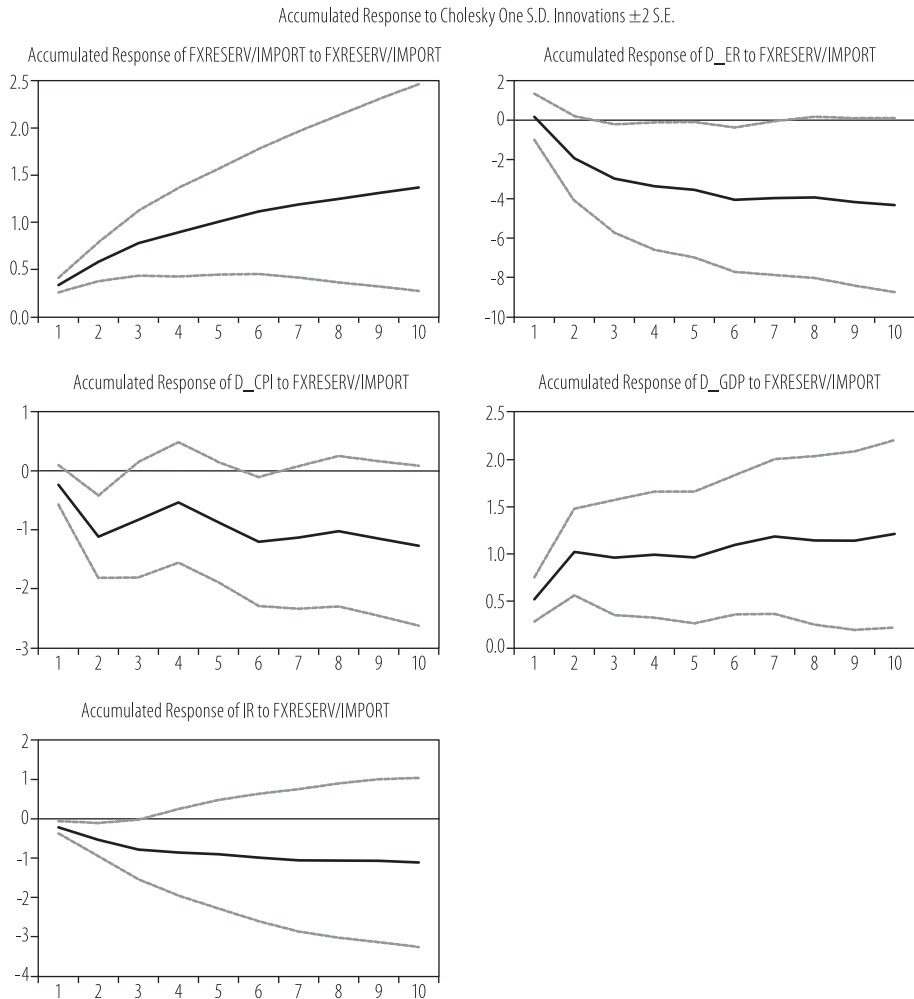
Table 3: VAR model evaluation for India for the period 2004 – 2013

Vector Autoregression Estimates					
Sample (adjusted): 2004Q4 2013Q4					
Included observations: 37 after adjustments					
Standard errors in () & t-statistics in []					
	FXRESERV/IMPORT	D_ER	D_CPI	D_GDP	IR
FXRESERV(-1)/IMPORT(-1)	0.764073 [2.83883]	-5.743697 [-1.98403]	-3.280765 [-3.94588]	1.771221 [2.73701]	-0.396516 [-0.98306]
FXRESERV(-2)/IMPORT(-2)	0.168815 [0.61644]	4.193153 [1.42356]	2.213069 [2.61602]	-1.123628 [-1.70649]	0.042481 [0.10351]
D_ER(-1)	0.019194 [1.06874]	0.079591 [0.41203]	-0.097542 [-1.75821]	0.004789 [0.11091]	0.014546 [0.54047]
D_ER(-2)	0.007391 [0.40641]	0.038866 [0.19868]	0.068445 [1.21827]	-0.013467 [-0.30796]	-0.025757 [-0.94503]
D_CPI(-1)	-0.004330 [-0.09452]	-0.049353 [-0.10017]	0.140828 [0.99523]	-0.120483 [-1.09394]	-0.013934 [-0.20298]
D_CPI(-2)	0.038795 [0.84042]	-0.908705 [-1.83017]	-0.452936 [-3.17627]	0.009387 [0.08458]	-0.101434 [-1.46627]
D_GDP(-1)	0.009149 [0.10442]	-0.282218 [-0.29947]	-0.115662 [-0.42734]	-0.425761 [-2.02109]	0.141223 [1.07557]
D_GDP(-2)	0.021783 [0.25962]	-1.538196 [-1.70443]	0.148300 [0.57217]	-0.245132 [-1.21511]	0.118456 [0.94208]
IR(-1)	0.068300 [0.54773]	0.410002 [0.30569]	-1.462363 [-3.79631]	-0.464896 [-1.55059]	1.205668 [6.45183]
IR(-2)	-0.004936 [-0.04040]	0.193343 [0.14713]	1.443977 [3.82602]	0.116456 [0.39645]	-0.379783 [-2.07430]
C	-0.452633 [-0.62392]	5.100871 [0.65370]	5.093620 [2.27286]	4.329797 [2.48226]	1.769919 [1.62797]
R-squared	0.720376	0.437209	0.618015	0.480671	0.869587
Adj. R-squared	0.612828	0.220751	0.471098	0.280928	0.819429
Sum sq. resids	2.878147	332.9716	27.46529	16.63850	6.463794
S.E. equation	0.332713	3.578631	1.027793	0.799964	0.498606
F-statistic	6.698188	2.019833	4.206549	2.406456	17.33673
Log likelihood	-5.255955	-93.14780	-46.98782	-37.71555	-20.22375
Akaike AIC	0.878700	5.629611	3.134477	2.633273	1.687770
Schwarz SC	1.357622	6.108532	3.613398	3.112195	2.166692
Mean dependent	2.187680	0.797333	2.028805	1.864103	6.873874
S.D. dependent	0.534709	4.053954	1.413246	0.943375	1.173364
Determinant resid covariance (dof adj.)		0.075959			
Determinant resid covariance		0.013015			
Log likelihood		-182.1829			
Akaike information criterion		12.82070			
Schwarz criterion		15.21530			

Source: Author

Figure 3 below shows the impulse responses to a shock in relation of foreign exchange reserves and quarterly imports in India. We see that, as in the case of Brazil, the first reaction in a model of mild appreciation of the exchange rate and a slight drop in price, while GDP growth was recorded in the entire simulation period. Unlike Brazil, a statistically significant response rate was not obtained in the case of India.

Figure 3: India



Source: Author

When evaluating the VAR model for China not one combination has been found to show a statistically significant relationship between foreign exchange reserves and economic growth. However, if we reduce the model to a single equation where the dependent variable was the rate of growth of GDP and the results confirm the initial hypothesis. The independent variables (regressors) are: the rate of GDP growth lagged ($d_gdp(-1)$); interannual changes in the level of foreign exchange reserves ($d4_fxreserv$); growth rate of GDP in the US in the current (d_us_gdp) and the previous period ($d_us_gdp(-1)$); as well as a dummy variable ($dummy$) that throughout the period has the value 0, except in the second quarter of 2009 in order to explain the break in the series of GDP (Table 4)?.

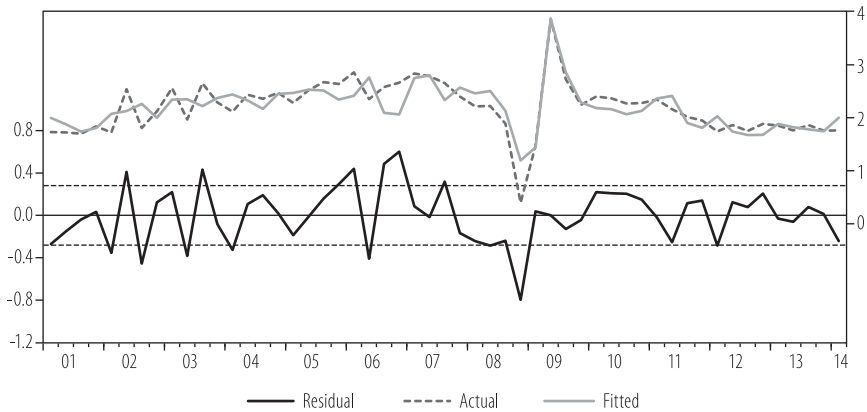
We see that the coefficient on the rate of change in foreign exchange reserves of 0.01 and it was statistically significant (t statistic is 2.535), which means that the growth of foreign exchange reserves by 1% led to the initial GDP growth of 0.01%. However, as the GDP growth influences with positive sign and GDP with a delay, it would mean that, by inertia, this effect extended to more periods.

Table 4: VAR model for Chine for the period 2001 Q1 – Q12014

Dependent Variable: D_GDP				
Method: Least Squares				
Sample: 2001Q1 2014Q1				
Included observations: 53				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_GDP(-1)	0.478043	0.102272	4.674217	0.0000
D4_FXRESERV	0.010130	0.004012	2.525020	0.0150
D_US_GDP	0.215930	0.053931	4.003785	0.0002
D_US_GDP(-1)	-0.134540	0.060516	-2.223223	0.0310
DUMMY	1.879445	0.295077	6.369338	0.0000
C	0.821145	0.196113	4.187096	0.0001
R-squared	0.709218	Mean dependent var		2.194698
Adjusted R-squared	0.678284	S.D. dependent var		0.495894
S.E. of regression	0.281271	Akaike info criterion		0.407276
Sum squared resid	3.718335	Schwarz criterion		0.630328
Log likelihood	-4.792818	Hannan-Quinn criter.		0.493051
F-statistic	22.92662	Durbin-Watson stat		2.037019
Prob(F-statistic)	0.000000			

Figure 4 shows the actual value (gray dotted line) and estimated (gray solid line) obtained with the help of the model explained above for China.

Figure 4: China



Source: Author

In the case of Russia, VAR model of the first order (one lag) is estimated, and the on-year rate of change has been used as a measure of foreign exchange reserves. The unemployment rate was also used among other already described variables in the model. Although its effect is not statistically significant, the results do not change its omission. The growth rate of GDP in the United States also appears in this case as an exogenous variable which, as can be seen from Table 5 below, has a statistically significant impact on almost all variables in the model.

Table 5: VAR model for Russia for the period 2003Q2 – 2013Q4

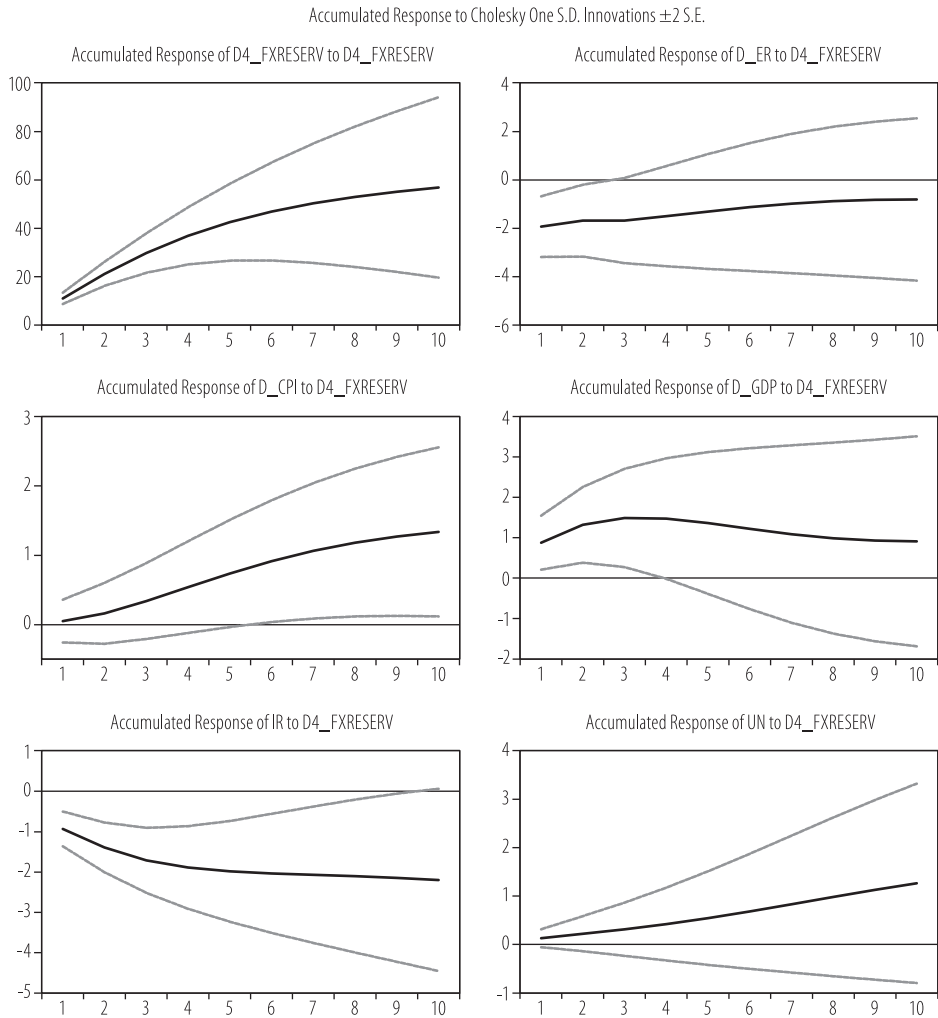
Vector Autoregression Estimates						
Sample (adjusted): 2003Q2 2013Q4						
Included observations: 43 after adjustments						
Standard errors in () & t-statistics in []						
	D4_FXRESERV	D_ER	D_CPI	D_GDP	IR	UN
D4_FXRESERV(-1)	0.868708 [9.19581]	0.010619 [0.28063]	0.021728 [2.45374]	0.020038 [1.00987]	-0.010104 [-0.74462]	0.006281 [1.16646]
D_ER(-1)	-0.293209 [-0.60843]	-0.163517 [-0.84708]	-0.008302 [-0.18379]	-0.016999 [-0.16794]	-0.052155 [-0.75346]	-0.006980 [-0.25411]
D_CPI(-1)	-2.568323 [-1.25991]	0.684451 [0.83822]	0.358226 [1.87474]	-1.630619 [-3.80835]	0.349692 [1.19428]	-0.000935 [-0.00805]
D_GDP(-1)	0.641731 [0.90355]	-0.659494 [-2.31814]	-0.050722 [-0.76188]	0.126454 [0.84767]	-0.225491 [-2.21035]	-0.049308 [-1.21795]
IR(-1)	0.530983 [0.41531]	-0.491002 [-0.95875]	0.108563 [0.90587]	-0.079669 [-0.29667]	0.226568 [1.23373]	0.053828 [0.73860]
UN(-1)	1.508788 [0.95445]	-0.811025 [-1.28082]	-0.075025 [-0.50632]	0.620387 [1.86845]	-0.446426 [-1.96610]	0.842927 [9.35456]
C	-9.460941 [-0.70831]	9.326479 [1.74315]	1.196967 [0.95602]	-1.244890 [-0.44373]	6.985728 [3.64110]	0.912033 [1.19787]
D_US_GDP	5.758342 [2.18757]	-3.412781 [-3.23670]	-0.244213 [-0.98975]	3.500541 [6.33134]	-0.848774 [-2.24486]	-0.323534 [-2.15623]
R-squared	0.855620	0.391284	0.325871	0.662571	0.535901	0.747690
Adj. R-squared	0.826744	0.269541	0.191045	0.595085	0.443082	0.697228
Sum sq. resids	4111.863	659.7513	36.12848	181.4044	84.83498	13.36044
S.E. equation	10.83890	4.341663	1.015993	2.276617	1.556874	0.617840
F-statistic	29.63087	3.214008	2.416980	9.817923	5.773575	14.81687
Log likelihood	-159.0636	-119.7236	-57.27081	-91.96422	-75.62377	-35.88296
Akaike AIC	7.770402	5.940633	3.035852	4.649499	3.889478	2.041068
Schwarz SC	8.098067	6.268298	3.363517	4.977164	4.217143	2.368733
Mean dependent	22.28058	0.073543	2.246166	1.719682	4.507752	6.995349
S.D. dependent	26.04002	5.079934	1.129611	3.577733	2.086209	1.122841
Determinant resid covariance (dof adj.)		1818.149				
Determinant resid covariance		528.7216				
Log likelihood		-500.9011				
Akaike information criterion		25.53028				
Schwarz criterion		27.49627				

Source: Author

In figure 5, in addition to the expected response variables, we can observe the growth of prices, which can be explained by the weak reaction of the exchange rate, which in most parts is not statistically significant. Here we also see that GDP in Russia grows in response to the initial shock of foreign exchange reserves,

while the reaction rates of unemployment (lower right graph), as already mentioned, gives no statistically significant response.

Figure 5: Russia



Source: Author

5. Conclusion

A rapid increase in foreign exchange reserves in emerging countries in recent years has been a part of the complex variables of global trends. Accumulation of foreign exchange reserves is closely associated with the process of financial globalization. Foreign exchange reserves are used mostly as insurance against foreign exchange crisis. Foreign exchange reserves have been on an increase due to growing financial and foreign exchange risks. The accumulation of foreign exchange reserves is an important macroeconomic mechanism for increasing the long-term rate of economic growth. It leads to exchange rate depreciation, increase in exports, investment and economic growth based on higher exports. Countries that have accumulated large stock of foreign exchange reserves had higher rates of economic growth.

In addition to the fundamentals of the economy, the level of foreign exchange reserves also affects the interest rate. If the interest rate is higher at home than abroad, there is a capital inflow and increase in foreign exchange reserves and vice versa. Therefore, the interest rate should be maintained competitive to stem capital flight and loss of foreign exchange reserves.

Foreign exchange reserves contribute to financial stability. Foreign exchange reserves can be considered as output stabilizers as they reduce the likelihood of falls in output caused by a sudden outflow of capital or the depth of the output collapse when a sudden stop of capital inflows materializes.

The accumulation of foreign exchange reserves mitigates the effects of trade shocks on the real exchange rate. Volatility of terms of trade leads to volatility of the real exchange rate, which increases the volatility of the economic cycle. Countries accumulate foreign exchange reserves to stabilize the real exchange rate in the presence of volatile terms of trade shocks and volatile short-term capital flows. Excessive accumulation of foreign exchange reserves mitigates exposure to volatile terms of trade since the volatility of the real exchange rate reduces economic growth at a relatively low level of financial development.

In a situation where an extreme shock impacts the foreign exchange market to such an extent that seriously endangers liquidity and leads to dysfunction of the foreign exchange market, foreign exchange reserves would be an important weapon of monetary policy. Foreign exchange reserves allow the central bank intervention in the foreign exchange market in order to maintain liquidity, support trade and limit the exchange rate cycle that occurs due to the dynamics based on the liquidity problems, rather than changing the equilibrium exchange

rate associated with the initial shock. Also, foreign reserves enable the central bank to achieve the function of lender of last resort which means that, in terms of widespread liquidity, the central bank through loans and other instruments of the injected liquid assets accelerates the recovery of the banking system.

Based on the above-conducted empirical research, significant implications for future research can be made. First, foreign exchange reserves allow the central bank to intervene in the foreign exchange market in order to maintain the exchange rate target or prevent the exchange rate cycle. Second, in a situation where an extreme shock would affect the foreign exchange market to such an extent that it seriously threatens liquidity and leads to foreign exchange market dysfunction, foreign exchange reserves would be an important monetary policy tools. Third, primary reason for the accumulation of large stock of foreign currency reserves in emerging countries is insurance against the expensive foreign exchange crisis. Fourth, although not a panacea, foreign exchange reserves are significant due to: (1) insurance against sudden stop of capital inflows; (2) mitigating the shocks of the exchange rate to the real exchange rate; (3) adjustments to current account shocks; 4) creating a more efficient foreign exchange market by providing liquidity when necessary; 5) limitation of foreign exchange rate volatility; 6) stimulating the growth of exports, de facto, by a fixed exchange rate; 7) limiting the vulnerability of the economy to external shocks. Finally, the foreign exchange reserves accumulation should enable the maintenance of a stable and competitive real exchange rate that is compatible with the short-term goals of macroeconomic policy. In other words, the macroeconomic policy of foreign exchange reserves accumulation should keep the real exchange rate stable and competitive while achieving full employment and low inflation (internal equilibrium) and current account sustainability (external equilibrium). Further empirical research is needed to point out the positive consequences of foreign exchange reserves accumulation and their importance in the absorption of internal and external shocks, as well as a positive influence on the movement of nominal and real macroeconomic variables, which are significantly analysed in this paper. Empirical results in this paper can be used as suggestions and recommendations for the implementation of macroeconomic (monetary) policy.

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