Núcleo de Conjuntura Econômico-Financeira
CAEN/UFC

NCF Researching Paper Series – 2016/03

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Agosto, 2016

CAEN
Universidade Federal do Ceará
PÓS-GRADUAÇÃO EM ECONOMIA

On the relationship between total reserves and contagion effects of BRIC financial markets ♣

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Abstract

We add to the literature on international reserves in emerging countries, by incorporating to the buffer stock framework developed by Frenkel and Jovanovic (1981) the evidence of contagion in BRIC. We take into account cross effects by means the joint estimation of this linear framework using an auto regression vector with error correction model. We are able to evidence that the contagion effects in BRIC do not seem to be relevant for Brazilian reserves, while reserves in China and Russia are very dependent on cross effects. According to our main findings, this innovation increases the explanatory power and allows us to highlight the role played by the volatility of Brazilian and Russian reserves. The excess of conservatism commonly observed in BRIC based on the benchmark buffer stock model does not remain when we incorporate cross effects to benchmark model.

Keywords: Sectorial analysis. Buffer stock model; Cross effects; Auto regression vector with error correction.

JEL Codes: G12, G15.

♣ First draft July 2015. The financial support from CNPQ-Brazil is gratefully acknowledged. We are thankful to two anonymous referees and the editor for their insightful comments. We thank Fabricio Linhares, João Mario and seminar participants at Federal University of Ceará for their comments and suggestions. The usual disclaimer applies.

1. Introduction

Robust evidences reported in Fidrmuc and Korhonend (2010) and Ozkan and Unsal (2012) on the strength and the intensity of the contagion effect, mainly among developing countries due to local or global crises, suggest the relevance of having a special concern for the protection mechanisms of developing economies financial systems by policy makers.

In this discussion, Feldstein (1999) argues that central banks in emerging economies have smaller and more limited access to external financing sources and even under worse conditions compared to developed economies. Therefore, emerging countries should increase international reserves, besides increasing the liquidity of international assets, reducing the short-term external liabilities and implementing measures for credit leverage.

The related literature concerning foreign reserves mentions that the monetary authority intervenes in the foreign exchange market aiming to practice a stock buffer, i.e., protecting of society from the demand or supply variations able to change significantly the prices of the asset in question.

We aim to aggregate to the debate regarding the puzzle: do emerging countries have excess reserves, even considering that emerging and developed countries have different optimal solutions against crisis?

More specifically, we analyze reserves in BRIC, a very heterogeneous bloc formed by: i) Brazil, a market economy with a high level of inequality, poverty, democracy and urbanization; ii) Russia, an ex-socialist superpower with high per capita income and human capital levels; iii) India, a predominantly rural country with strong cultural and religious divergences and iv) China, a communist dictatorship with a high degree of trade openness and high level of international reserves.

In terms of application, we follow Ford and Huang (1994), Ramachandran (2004), Jeanne (2007), Pina (2015) and Matos (2016). Methodologically, we are aligned to Ben–Bassat and Gottlieb (1992) and Chakravarty (2009), by proposing a simple but relevant extension of well-known buffer stock model of Frenkel and Jovanovic (1981).

Our main innovation is taking into account the cross effects due to the robust findings about contagion and integration between BRIC economies. According to Misra and Mahakud (2009), Chittedi (2010) and Matos et al. (2016), although these economies are heterogeneous, their financial markets and business transactions have strong relationships in the short and long terms.

This paper is divided into five sections. Section 2 analyzes the evolution of reserves in BRIC. The third section details the methodology, and the empirical exercise reported in section 4. The fifth section presents the final considerations.

2. Total Reserves in BRIC

BRIC is a very interesting bloc. First, due to the size of this bloc, which occupies 26% of the world's land coverage, where 45% of the world's population live in. BRIC used to share 14% and 25% of total trade and GDP in the world in 2010.

Second, although they are heterogeneous, their financial markets and business transactions have strong relationships in the short and long terms.

This heterogeneity remains when one observes historical evidences reported in Heller (1966) regarding reserves. According to him, in 1963, while Brazil had a level of reserves classified only as "satisfactory", based on a ratio of 0.56 between the actual level and the great rating reached out 0.56, China ratio reached out 1.67.

Some studies use to weight the volume of reserves by the respective GDP aiming to establish a comparison. There are several evidences suggesting that during the period from 1960s to the 1990s, emerging and developed seemed to converge in the conduct of policy of accumulation of reserves characterized by trajectories without growth trends and with mild fluctuations.

During this period, 10% worked as an upper bound for reserves to GDP ratio for most economies. The divergence reported in this literature is recent. For details of such data, see Lane and Milesi–Ferretti (2007), and Pina (2015).

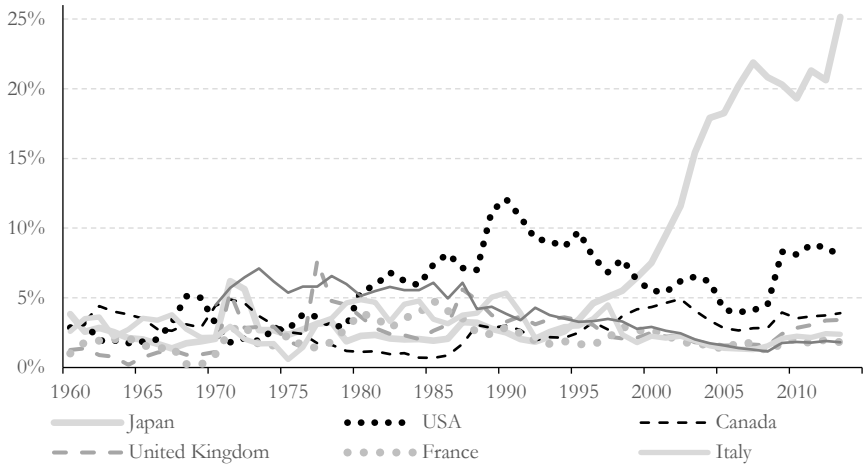
Taking into account a representative sample of developed and emerging economies, Figure 1 shows the annual series from 1960 to 2014 of reserves in G7 economies (Figure 1.a) and in BRIC economies (Figure 1.b).

3. Methodology

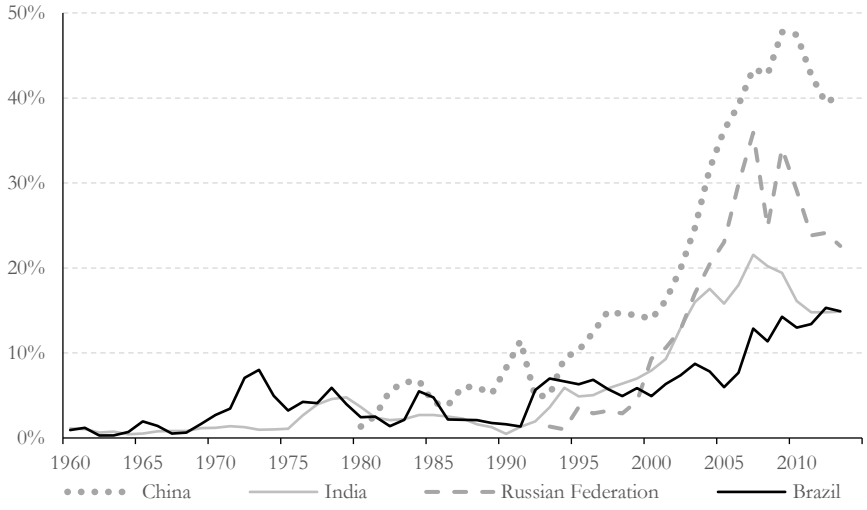
We suggest a linear pricing approach to model risk premiums of Brazilian sectorial indices, which incorporates weekly series of expectations of exogenous macroeconomic variables to the conditional volatility framework. This procedure accommodates the conditional heteroscedasticity and clustering of volatility, a fairly common evidence, according to Bollerslev, Chou and Kroner (1992). More specifically, regarding the average equation, we assume as satisfactory the ability of CAPM to model the returns. Thus, we use this simple framework developed by Sharpe (1964), Lintner (1965) and Mossin (1966), whose main assumptions are investors with short-term strategies, users of portfolio selection model a la Markowitz, with homogeneous expectations and absence of transaction costs. To summarize, in the mean equation the risk premium of each index depends linearly on the intercept and on the market risk premium.

Figure 1. Total reserves excluding gold (% of GDP). Data source: FRED

1.a. Annually total reserves excluding gold (% of GDP) for G7 economies



1.b. Annually total reserves excluding gold (% of GDP) for BRIC economies



The comparison with the G7 countries suggests that BRIC, except for China, had reserves to GDP ratio with an order of magnitude close to other countries, with a visually sharper oscillation, until the 1990s. Thenceforth, China has emerged as an outlier, with a stock reaching out almost 50% of GDP in 2010, while Russian and Indian paths take off the other G7 paths, breaking the barrier of 10% and situating below only the reserves to GDP of Italy. Brazil seems to have been the last one of BRIC to adopt a more conservative policy of reserve accumulation, beating the level of 10% of GDP only in 2007.

3. Methodology

Assuming that the balance of payments of economy i is in equilibrium and that reserves follow a stochastic Wiener process, one can derive the optimal path, $R^*_{i,t}$, in order to minimize the macroeconomic adjustment costs and opportunity costs. Assuming that $R^*_{i,t}$ follows an approach of second order Taylor, this optimal level can be described as

$$ln(R^*_{i,t}) = \beta_0 + \beta_1\, ln(\sigma_{i,t}) + \beta_2\, ln(r_{i,t}) + \epsilon_{i,t} \qquad (1)$$

Regression (1) suggests that the optimal level of reserves held by economy i in time t (in log) depends linearly on standard deviation of change in reserves (in log), given by $ln(\sigma_{i,t})$, and on opportunity cost of holding reserves (in log), given by $ln(r_{i,t})$. In this relation, $\epsilon_{i,t}$ means the residual.

Although simple, the implementation and possible extensions are not consensual, motivating some routes in this literature. Frenkel and Jovanovic (1981) had the estimated elasticities close to the theoretical predictions of the model, $\beta_1 = 0.5$ and $\beta_2 = -0.25$, but many studies, as Flood and Marion (2002) and Ramachandran (2004), for instance, have obtained different values of the elasticities. Chakravarty (2009) argues that the reason is these estimates are highly sensitive to the proxy used to represent opportunity cost, model specification, estimation methods and additional variables included in the original equation.

The most promising route following Frenkel and Jovanovic (1981) suggests extensions to their benchmark framework in the sense of incorporating some idiosyncratic additional variables, which are important in the determination of the level of reserves for specific emerging economies. Chakravarty (2009), for instance, takes into account the positive correlation between reserve holdings and the size of international transactions, while Matos (2016) adds expectations of most relevant macroeconomic variables in Brazil.

We follow them by proposing an extension that incorporates contagion effects on reserves in BRIC by estimating a joint buffer stock benchmark model for these economies. To summarize, we propose a joint estimation model for reserves in BRIC that can be described as follows:

$$ln(R^*_{i,t}) = \varphi_0 + \gamma_{i,i}\, ln(\sigma_{i,t}) + \delta_{i,i}\, ln(r_{i,t}) + \sum_{j\neq i} \gamma_{i,j}\, ln(\sigma_{j,t}) + \sum_j\ \delta_{i,j}\, ln(r_{j,t}) + \varepsilon_{i,t}, i, j \qquad (2)$$

Regression (2) suggests that the optimal level of reserves held by economy i in time t depends not only on respective standard deviation of change in reserves and opportunity cost of holding reserves, but also depends on standard deviation and opportunity cost of all other BRIC, given by $ln(\sigma_{j,t})$ and $ln(r_{j,t})$.

More specifically, we follow a method commonly used in the literature, namely the fiscal cost of sterilizing reserves, by computing this opportunity cost of reserves the spread given by the differential between the each BRIC government policy rate and the yield on short term U.S. government bonds (1-year Treasury bill). Concerning the adoption of a framework for modeling the volatility, we follow West and Cho (1995), who show that for short time horizons, exercises following the Bollerslev's Generalized Autoregressive Conditional Heteroscedasticity (GARCH) family of frameworks are more accurate and appropriate to predict volatility, than a constant standard deviation or even compared to other frameworks of conditional volatility.

4. The Model and Main Findings

In principle, whenever econometric tests are performed, it is preferable to employ a large data set either in the time-series or in the cross-sectional dimension. Here, our main limitation regards the time-series available for BRIC in a monthly frequency for total reserves and government bonds rates.

Regarding the sources used, interest series for the US economy are from the Federal Reserve Economic Data (FRED), while the Immediate Interest Rate - rates set by central banks that have very short term - was extracted from the Organisation for Economic Co-Operation and Development (OECD Statistics). The series of reserves have been extracted from FRED. The required uniformity in terms of time, due to the availability in the data OECD to Brazil only from October 1996, restricted the sample that was comprised of February 1997 to December 2013, 204 monthly observations.

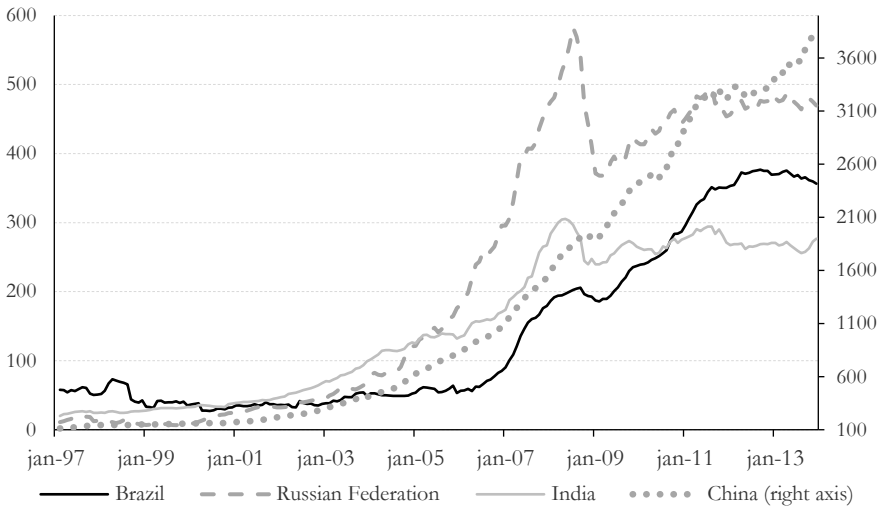
Figure 2 reports the monthly evolution of the absolute volume of reserves (US$) in BRIC from February 1997 to December 2013. During this period, one can note a seemingly joint upward moving, with growth rates ranging 1.12% in Brazil to 2.15 % in Russia. The discrepancies are due to the magnitude of China's reserves, more than 12 times Indian volume – an expected evidence because of the difference of size of both economies – and Russian decline in during financial crisis in 2008. One can also highlight policy of stagnation in India from 2008 to 2013.

Table 1 reports our main results based on estimation of buffer stock model taking into account cross effects. First, regarding equation of variance, we estimated all specifications of GARCH up to two lags of residuals and variance. For all economies, most of the parameters is significant to 5 %. We do not have problems with explosive trajectories of the conditional risk, or negativity.

The most relevant results are in the second stage of estimation: the joint buffer stock model applied to BRIC. First, a basic condition for the application of an Auto Regressive Vector Method is the stationary of reserves in log. According to the results obtained using extended version of test originally proposed in Dickey -Fuller (1979), entitled ADF, reserves of in BRIC are non-stationary even in logarithm. In first difference, the series are stationary. This result is robust to changes of stationarity technique. Because of this result, we proceed to the estimation of a vector error correction (VEC) model.

According to maximum eigenvalue test, we cannot reject the null hypothesis of two cointegrating vectors. [1]

Figure 2. Total reserves excluding gold (US$ billion). Data source: FRED



[1] We do not report the series of spread and conditional volatility, but they are available upon request.

Regards the explanatory variables that composes the benchmark version, as one could expect, the spread seems to be significant and negative only for Russia, while volatility is positive and significant for Brazil and China, at least at 10% level. Some counterintuitive findings are the positive impact of spread on reserves in China.

Concerning the relevance of cross effects, one can evidence the role played by Brazilian conditional volatility on reserves in China and in Russia. Chinese and Indian reserves seem to be dependent of Russian volatility. One may also emphasize the complex dependence of Russian reserves to spreads of all BRIC.

Table 1. Estimation of buffer stock model considering cross effects [a, b, c]

	Endogenous variables: Reserves (in log)			
Exogenous	Brazil	China	India	Russia
First step: estimations				
Variance equation based on parsimonious GARCH model				
Constant	1.49e+19** (0.000)	7.98e+20** (0.000)	1.67e+19** (0.000)	7.96e+19** (0.000)
ε_{t-1}^2	0.396** (0.018)	0.959*** (0.000)	0.585*** (0.000)	0.841*** (0.000)
ε_{t-2}^2		1.029*** (0.018)		0.822*** (0.000)
σ_{t-1}^2		-0.876*** (0.000)		0.991*** (0.000)
σ_{t-2}^2		0.131** (0.019)		
Second step: estimations and complementary results				
Joint buffer stock model: cointegration vector				
Constant	-0.652 [-1.047]	-0.127 [-1.027]	0.011 [0.040]	-0.461 [-0.694]
Coint. #1	-0.018* [-1.447]	-0.016*** [-6.338]	-0.011** [-2.095]	-0.041*** [-3.070]
Coint. #2	-0.019* [-1.389]	-0.013*** [-4.866]	-0.008* [-1.401]	0.043*** [2.876]
Joint buffer stock model: conditional volatility				
Brazil	0.033* [1.431]	0.008** [1.850]	0.005 [0.541]	0.033* [1.338]
China	0.006 [0.509]	0.004* [1.581]	0.003 [0.482]	-0.006 [-0.430]
India	0.002 [0.092]	-0.001 [-0.268]	0.010 [1.158]	-0.001 [-0.043]
Russia	-0.011 [-0.893]	-0.008** [-1.991]	-0.018*** [-3.453]	0.002 [0.180]
Joint buffer stock model: spread				
Brazil	-0.083 [-0.606]	-0.033 [-1.205]	0.019 [0.326]	-0.615*** [-4.214]
China	-0.069 [-0.106]	0.358*** [2.738]	-0.318 [-1.144]	1.245** [1.780]
India	0.104 [0.184]	-0.088 [-0.787]	0.224 [0.939]	-0.846* [-1.411]
Russia	-0.058 [-0.699]	0.006 [0.368]	-0.026 [-0.729]	-0.245*** [-2.785]
Complementary results of mean equation				
R^2	0.085	0.346	0.145	0.212
Gap of R^2	0.051	0.343	0.110	0.204
F statistic	1.772	1.009	3.244	5.123

[a] *Estimation results based on estimation over the period from February 1997 to December 2013, 2015.* [b] *GARCH models estimated through ARCH with normal distribution errors, using the Bollerslev-Wooldridge robust covariance coefficient heteroscedasticity of the residuals. Respective p-values are in the parenthesis, while t statistics are in the box brackets.* [c] *We specify the Newey and West (1987) covariance coefficients method, in order to get robustness to heteroskedasticity in mean equation estimations based on OLS method. * Indicates significance at 10% level. ** Indicates significance at 5% level. *** Indicates significance at 1% level.*

When we compare these result to those obtained in the estimation of the benchmark model, there are significant changes: only spread in India seem to be significant to explain Indian reserves and there is no other significance even at 10% level. Our final analysis is based on the complementary results. For all economies, there is a gain of explanatory power in relation to the benchmark buffer stock model, especially for China and Russia.

Figure 3 shows the time trajectory of the monthly realized and predicted reserves in BRIC. One can compare and infer about the better performance when we use a joint estimation of buffer stock model. When we take into account cross effects the order of magnitude of mean square errors are lower.

An interesting application of this figure is to support an increasing policy (or decreasing) of reserves based on a persistence able to characterize lack of protection (or excessive conservatism). It is possible to understand the reason of argument about excess conservatism: except for Brazil from 1999 to 2003, there are long periods characterized by a sequence without interruptions of total reserves in a level above the theoretical optimum level based benchmark buffer stock model. This same does not apply when we consider the effects of contagion between these economies.

The estimation based on a VEC method also enables us to infer about impulse-response of reserves in BRIC. Observing Figure 4, one can corroborate some of the results reported in Table 1: the contagion effects in BRIC do not seem to be relevant for Brazilian reserves, while reserves in China and Russia are very dependent on cross effects.

Given the fact that the main variations of the stock market can not be predicted and they depend on news, Blanchard (2011) suggests two possible actions to market participants: at the beginning of the week, one defines the strategy based on what happened in the past, or another possibility is to formulate questions such as " what... if... ", reacting to expectations.

Aligned to the second action, we analyze which series of macroeconomic variables expectations are relevant in order to soften or accentuate the turbulence in each of the main sectors of Brazilian economy. We add to the limited literature on these indices, by proposing an innovative framework aiming to accommodate the dependence of each to different sets of expectations, taking into account the heteroscedasticity of excess returns on indices and the role of CAPM, as a reasonable specification for modeling the mean equation. Based on our results, except for real estate sector, all other Brazilian sectors analyzed here react significantly to changes in macroeconomic expectations. In other words, some of these macroeconomic variables have significant power to influence the volatility of most sectorial indices. Some highlights are the price indices that influence five sectors, trade balance, able to influence three sectors and the basic interest rates shown significant in predicting the volatility of two sectors.

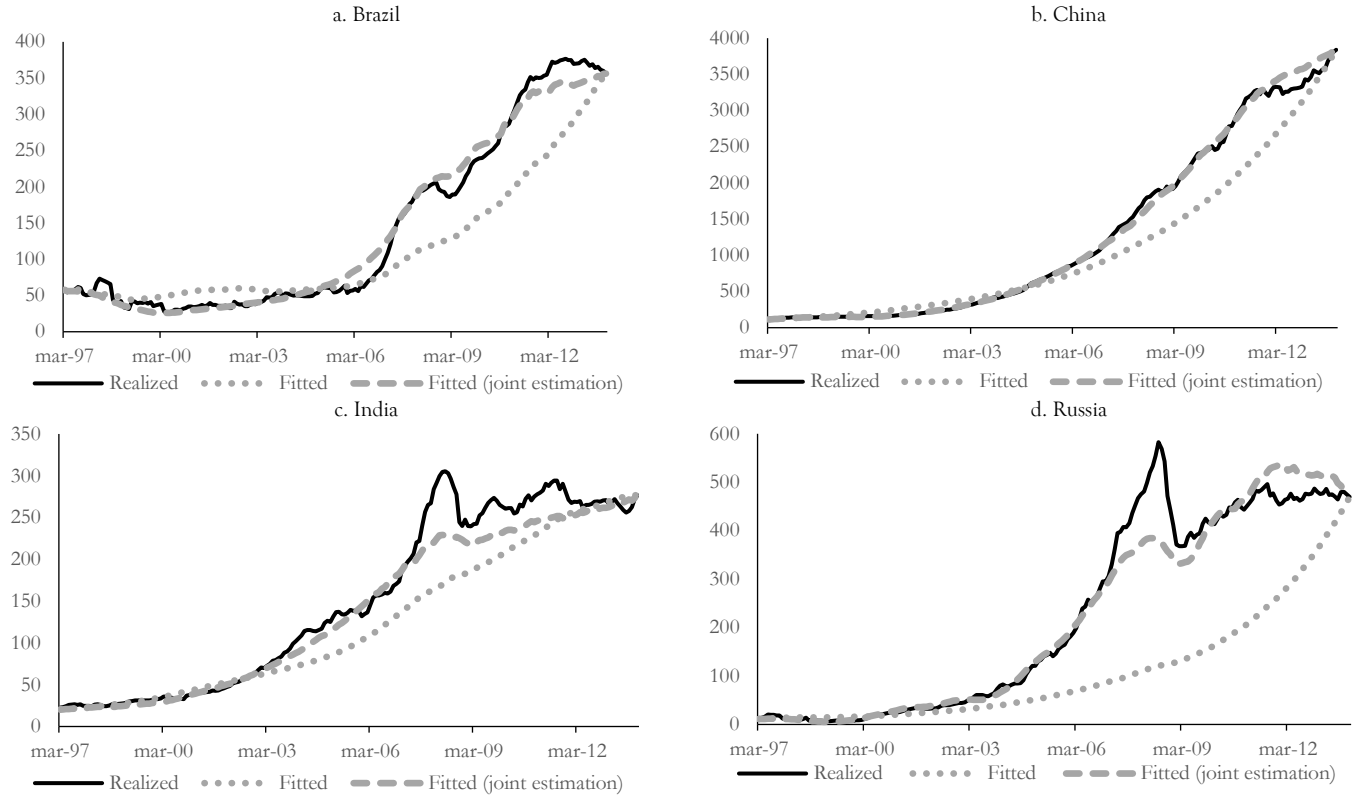
We do not intend to establish deterministic relationship between the short-term expectations for macroeconomic variables and the volatility of sectorial indices, as stylized facts, but shedding light on issues hitherto little explored in Brazil. Our findings suggest using most widely expectations of macroeconomic variables in empirical finance applications. More broadly, we hope that our paper motivates the maturation of a new research route modelling the impact of macroeconomic expectations on the behavior of financial assets of this economy.

5. Conclusion

According to recent empirical literature, although BRIC are heterogeneous, their financial markets and business transactions have strong relationships in the short and long terms. In this complex and heterogeneous context, our empirical exercise based on a buffer stock model with cross effects is useful to suggest an optimal trajectory, which allows us to characterize whether there is an excess or lack of reserves, then supporting the decision of the respective central banks to adopt a policy more or less conservative.

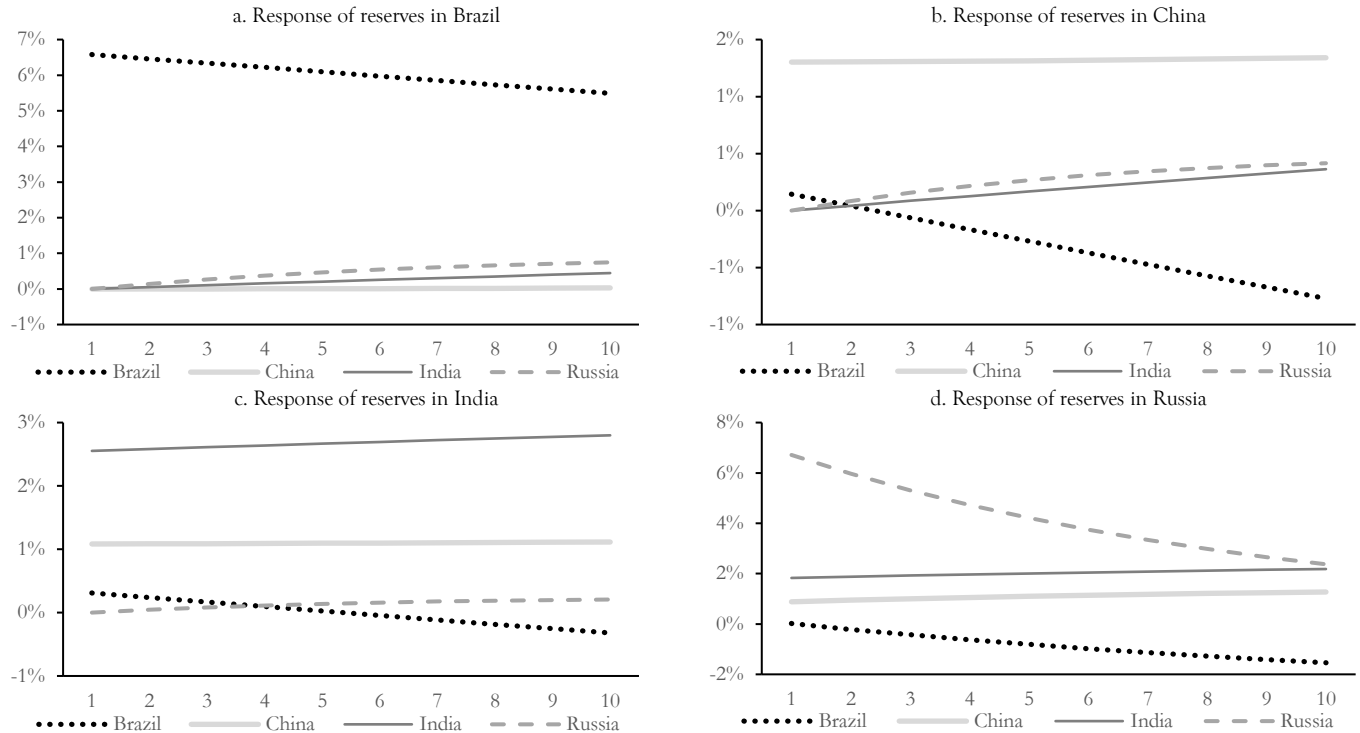
Our main finding is that, except for Brazil, other BRIC seem to depend on cross effects. As our main implications in practice, due to the performance of fitting, the assumptions of our extension and the results based on significance, we believe that have provided a methodological contribution, which is useful to support BRIC's policy makers decisions about driving the stock of international reserves.

Figure 3. Monthly realized and fitted total reserves (US$ billion) for BRIC economies [a]



[a] *This figure plots monthly realized reserves and its predictions based on original buffer stock model and its extended version with cross effects, during the period from March 1997 to December 2013.*

Figure 4. Impulse and responses of total reserves (US$ billion) for BRIC economies [a]



[a] *This figure plots the series of monthly impulse response based on extended version of buffer stock model taking into account cross effects, during the period from March 1997 to December 2013.*

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