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Does Full Sterilization Feasible in Era of Excess Volatility: Evidence from India

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Abstract

India has accumulated a huge pile of international reserves, which is certainly more than the country's precautionary requirements. In this study, I test the extent and impact of the sterilization in India by using Toda and Yamamoto version of Granger Causality and Impulse Response function. The results of the analysis reveal that in India, the central bank (RBI) has been pursuing the sterilization policy, however, not able to fully insulate the domestic market from the external shocks.

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1. Introduction

The existing literature assigns precautionary and mercantile motives of central banks as reasons of holding international reserves (Aizenman and Marion, 2003 and Bird and Rajan, 2003, Kim et al., 2005; Aizenman and Lee, 2005). However, the stockpile of reserves in India has crossed all standard benchmarks (Sehgal and Sharma, 2008), which apparently suggest that there are some other motive(s) as well, apart from self-protection against any possible future sudden shocks in the external sector. Recently, Ouyang, Rajan and Willett (2007) found that China has been practicing sterilization very successfully. In this context, I intend to investigate whether Reserve Bank of India (RBI) has also been pursuing the sterilization policy and changing the money supply while bearing in mind the requirements of the country's external sector stability.

India had a mild crisis in the external sector in 1990-91, when the country's reserves dried up. Since then RBI has been busy in accumulating reserves, however, this led to a growth in the monetary base. To prevent this growth, RBI has been possibly pursuing sterilization policy. However, foreign capital inflows in India have increased substantially over the last decade, which has made the sterilization practice very complicated and difficult for the central bank. Consequently, RBI ran out of government bonds for the purpose of sterilization in late 2003. To avoid the impact on monetary system, a scheme which is called Market Stabilization Scheme (MSS) was introduced by RBI in early 2004. This scheme has not only minimized the monetary risk but also made the cost of sterilized intervention more transparent. Nonetheless, interest payments for MSS have risen significantly, and these expenses are inspected in the budgetary process. In this scenario, it would be interesting and relevant to analyze the extent of sterilization undertaken by RBI.

The remainder of this paper is organized as follows: Section 2 explains the theoretical model, while section 3 discusses the methodology and data related issues. The empirical results are discussed in section 4. Main conclusion of the paper is presented in the final section.

2. The Theoretical Model

The level of sterilization can be observed from the degree to which the central bank takes action to offset the effects of increase in international reserves on the domestic monetary base or other monetary aggregates. However, this can offer a misleading picture of the effectiveness of sterilization since, if the central bank wants the base to increase anyway, it would decide not to neutralize the reserve increases; this would not imply that it had lost control of the domestic monetary process (Ouyang, Rajan and Willett, 2007).

Since the external sector and the domestic money markets are interconnected, I try to find the effects of change in international reserves on domestic credit. In an alternative model, I test the effect of reserves change on the money supply of the country. Both of these models would reveal the sterilization practice in the country. Furthermore, the study investigates changes in reserves accumulation in response to a change in domestic credit, which is called offset test. Alternatively, this offset test is also tried to be captured by testing the response of reserves due to shift in money supply.

3. Empirical Methodologies and Data

To establish the direction of causal relationship among the variables, I apply Toda and Yamamoto version of Granger Causality. Toda and Yamamoto (1995) suggested an alternative approach to test causality, which has the advantage over other causality test as it does not require pre-testing of the cointegration rank, and still produces valid statistical inference. This is the technique we use below for the empirical analysis. The basic idea is to artificially augment the correct order, K, of the VAR by the maximal order of integration, say T_{max}. The augmented

($K+T_{max}$) is then estimated, and Wald tests for linear or non-linear restrictions are carried out on the first K coefficient matrix.

Toda and Yamamoto's (1995) has proved that the Wald statistics converges in distribution to a χ^2 random variable with m degrees of freedom, regardless of whether the process is I(0), I(1), I(2) possibly around a linear trend, or whether it is cointegrated. This method also requires some pre-testing in order to determine the lag length of the process. Sims *et al* (1990) show that lag selection procedures, commonly employed for stationary VARs, which are based on testing the significance of lagged vectors by means of Wald (or LM or LR) tests, are also valid for VARs with I(1) processes which might exhibit cointegration. Toda and Yamamoto (1995) extended their analysis and proved that the asymptotic distribution of a Wald likelihood ratio test for the hypothesis that the lagged vector of order p is equal to zero, unless the process is Markovian and I(2).

We also apply VAR methodology, because it allows tracing out the time path of the various shocks on the variables contained in the VAR system by using the impulse response function.

Data: in order to estimate the above mentioned relationship, data are retrieved from Handbook of Statistics on the Indian Economy, 2008-09, published by RBI. For the domestic assets, we use domestic credit in the economy, while for money supply we utilize data of broad money (M3).[2] For the international reserves, we take liquid part of the reserves, which is reserves minus gold holding of RBI. Our data is quarterly and it covers the sample period 1990:1 to 2007:4.

4. Empirical Results

As it is explained in section 2, our final empirical models to test for causality in Granger's sense by means of the following VAR models:

$$\mathrm{LDCRDT_t} = a_0 + \sum_{i=1}^{k} a_i LRES_t + \sum_{i=1}^{k} b_i \mathrm{LDCRDT_{t-1}} + e_{1t} \quad \ldots\ldots\ldots\ldots\ldots 1$$

$$\mathrm{LRES_t} = c_0 + \sum_{i=1}^{k} c_i LDCRDT_t + \sum_{i=1}^{k} d_i \mathrm{LRES_{t-1}} + e_{2t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Alternatively:

$$\mathrm{LRES_t} = \alpha_0 + \sum_{i=1}^{k} \beta_i LMS_t + \sum_{i=1}^{k} \delta_i \mathrm{LRES_{t-1}} + e_{1t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

$$\mathrm{LMS_t} = \eta_0 + \sum_{i=1}^{k} \eta_i LRES_t + \sum_{i=1}^{k} \kappa_i \mathrm{LMS_{t-1}} + e_{2t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

where LDCRDT , LRES and LMS are logged value of domestic credit, international reserves and money supply of India respectively. e_{1t} and e_{2t} are innovations and are assumed to be white noise with mean zero. The number of lags, k, has been decided to be equal to four by using the Schwarz Information Criteria (SBC) criteria.

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[2] In India, M3 includes currency with public and deposits (demand and time). We prefer M3 over M1 and M2 as measure a money supply in our analysis, because since the mid-1980s, the RBI's monetary targeting was mainly focused on the medium-term growth rate of M3. Though this policy was changed in 1998, but M3 is continued to be considered as an important reference indicator for policy formulations (for details, see Inoue and Hamori, 2008).

As expected, these variables are non-stationary. Augmented Dickey–Fuller (ADF) unit root tests indicate that LDCRDT, LRES and LMS are integrated of order one (see Table-1A, Appendix). The results of Johansen and Juselius (1990) cointegration suggest for two cointegration vectors in the both frameworks (see Table 2.A. of Appendix). This means that the variables in the models have a common trend and that there are possible linear combinations of these variables which are stationary, or I (0). We also implement a test of weak exogeneity, in which the null hypothesis of weak exogeneity can be rejected for all variables (see Table 2.A. of Appendix).

The causality test provides interesting results, which is reported in Table-1. The study finds bidirectional causality between reserves and domestic credit, which suggest that the RBI has involved in active sterilization. However, I also find bidirectional causality between money supply and reserves, which implies that the central bank has not been able to sterilize fully. As per the standard argument if the central bank is able to fully insulate the supply of money in the economy from the shocks of international reserves, one can conclude that the sterilization is full. However, in the present case the evidence suggest that the central bank has failed to do so. Therefore, domestic assets are affected by external shocks and vice versa.[3] The impulse-response test results also endorse the results of causality and exhibit that external (reserves) shocks do affect domestic assets, however, not fully. On the other hand, I find a partial effect of change in domestic assets on reserves (see Figure 1 and 2). These results indicate that although the RBI has been pursuing the sterilization policy actively, but not able to insulate the domestic money market from the effect of external shocks and vice versa. Probably huge inflows and outflows of capital are making the task difficult as well as cumbersome for the central bank.

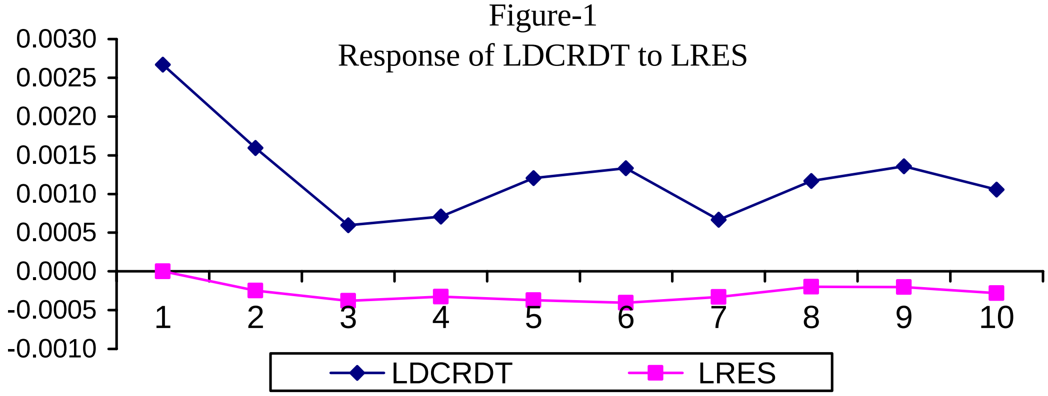
Table 1: Toda and Yamamoto test of Granger Causality for India

Null Hypothesis	Direction of Causality	χ^2	P-value
LDCRDT does not Granger cause LRES	LRES $\rightarrow$ LDCRDT	39.3203*	0.000
LRES does not Granger cause LDCRDT	LDCRDT $\rightarrow$ LRES	19.4055*	0.001
LMS does not Granger cause LRES	LRES $\rightarrow$ LMS	66.3651*	0.000
LRES does not Granger cause LMS	LMS $\rightarrow$ LRES	38.0685*	0.000

Notes: The underlying model for the two equation system is a SUR model; the lag order is 4 (rank of VAR is 2 + Cointegration vector is 2, based on SBC criterion) for all the variables. * denotes significant at 5% confidence

Figure-1

Response of LDCRDT to LRES



[3] To confirm the causality results, vector error correction (VEC) test is also conducted for the models and reported in Table 4.A of Appendix, and these results are broadly at the same of line as of the causality results.

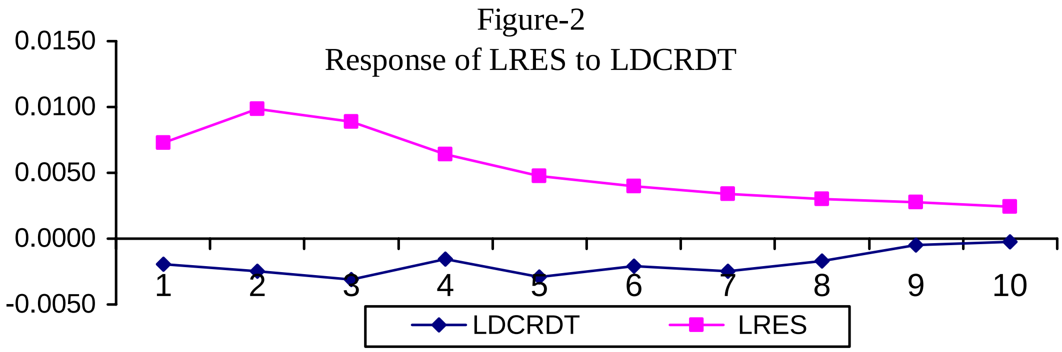


Figure-2
Response of LRES to LDCRDT

5. Conclusion

This study attempts to investigate the extent of sterilization and capital mobility in India. For this purpose, I apply Toda and Yamamoto version of Granger Causality along with Impulse Response Function on quarterly data for the sample period 1990:1-2007:4. Results of the tests apparently suggest for a partial sterilization in the Indian case, which infers that probably a large amount of capital flows in and out of the country has made a situation where full sterilization has not been possible. Therefore, on the basis of these results, it can be recommended that some efforts should be made to dampen the capital flows volatility such as some restraint on external commercial borrowing might prove the policy effective.

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APPENDIX

Table: 1. A. Results of test for unit root applying Augmented Dickey-Fuller (ADF)

Variables	Test statistics (levels) (Intercept only)	Optimal Lags (AIC)	Test statistics (1st difference) (Intercept only)	Optimal Lags (AIC)
LRES	-0.56951 (0.8698)	1	-8.05726* (0.0000)	0
LDCRDT	0.61612 (0.9892)	2	-9.01708* (0.0000)	1
LMS	-1.31865 (0.6163)	2	-7.57166* (0.0000)	1

Notes: 1. *denotes that the null hypothesis that the variable concerned is non-stationary can be rejected at 1% significance level. Asymptotic cut off values for 1% significance level -3.54. 2. MacKinnon (1996) one-sided p-values are in parentheses.

Table 2.A. Results of Johansen cointegration test (Max-Eigenvalue and Trace Statistics)

Null hypothesis	Model of LDCRD and LRES		Model of LMS and LRES	
	Test statistics (Max-Eigenvalue)	Test Statistics (Trace Statistics)	Test statistics (Max-Eigenvalue)	Test Statistics (Trace Statistics)
r = 0	15.64054* (0.0301)	19.97028* (0.0099)	17.14769* (0.0479)	18.74298* (0.0448)
r ≤ 1	4.329744* (0.0374)	4.329744* (0.0374)	5.832555* (0.0157)	5.832555* (0.0157)

Notes: 1. r is the number of cointegration vector under null hypothesis of no cointegration. 2. I am assuming a linear deterministic trend. Both the trace test and the max-eigenvalue test indicate two cointegration vectors at 5% level. The lag order in the VAR process is 1.3. p-values are in parentheses.

Table 3.A. Results of weak exogeneity tests

Weak exogeneity of:	Model of LDCRD and LRES	Model of LMS and LRES
	Test statistic	Test statistic
LDCRD	$\delta^2_{0.05}$ (1)=18.82*	
LRES	$\delta^2_{0.05}$ (1)= =18.61*	$\delta^2_{0.05}$ (1)= 17.29*
LMS		$\delta^2_{0.05}$ (1)= 18.47*
LDCRD and LRES	$\delta^2_{0.05}$ (1)= 18.76*	
LMS and LRES		$\delta^2_{0.05}$ (1)= 18.23*

Note:* denote significance at the 1% level.

Table 4. A. Results of Linear VEC Analysis

Independent Variables	Equation: 1 ΔLDCRD	Independent Variables	Equation: 2 ΔLRES	Independent Variables	Equation:3 ΔLMS	Independent Variables	Equation:4 ΔLRES
ECM	-0.012881 ((0.00296)	ECM	0.034109 (0.01695)	ECM	0.004660 (0.00963)	ECM	-0.180482 (0.07124)
ΔLRES (-2)	-0.019130 ((0.12447)	ΔLDCRD (-3)	0.186502 ((0.10292)	ΔLRES (-2)	0.020086 (0.01427)	ΔLRES (-3)	0.802366 (1.20636)
R^2	0.367321	R^2	0.172954	R^2	0.200745	R^2	0.241291
ARCH* (4)	0.5258	ARCH* (4)	0.3832	ARCH* (4)	0.7317	ARCH* (4)	0.3119

Notes: 1. the dependent variable is the quarterly change in the variables. 2. ECM is the equilibrium correction mechanism derived from Johansen cointegration analysis. 3. Standard errors in parentheses. 4. ARCH is the ARCH-LM test for residual heteroscedasticity, assuming one and four lags. 5. a range of diagnostics test of the model i.e. Standard tests for normality (Jarque–Bera), heteroscedasticity (White) and serial correlation (Q- statistic, LM) are conducted and they show that the residuals are well behaved. 6.* denotes p-value.