Does Exchange Rate Intervention Trigger Volatility?

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A Vadivel is Junior Consultant, Institute of Economic Growth, New Delhi.

email: arjunavadivel@gmail.com

M Ramachandran is Professor and Head at the Department of Economics, Pondicherry University, Puducherry.

email: ramchn2003@yahoo.co.in

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ABSTRACT

This study aims at investigating two important issues concerning the exchange rate intervention policy of the Reserve Bank of India: (1) whether there is any asymmetry in intervention; and (2) whether intervention triggers volatility. The empirical evidence derived from a class of GARCH and A-PARCH models indicate the latter one fits the data much better than the conventional GARCH models. Further, intervention seems to have increased exchange rate volatility; the official sale of foreign exchange have had a relatively larger impact on exchange volatility than official purchase. This is consistent with the argument that secret intervention creates ambiguity in the market; hence, it results in larger volatility of exchange rate.

Key words: Exchange rate, foreign exchange reserve, ARCH, GARCH, A-PARCH

JEL codes: F31; G15; F41; C32; C52

1 INTRODUCTION

The study focusses on the factors of a large stockpile of reserves and on the changing nature of intervention policy depending on foreign exchange market conditions. Although this exercise is extremely useful in understanding the reason for the accumulation of reserves and the characteristics of intervention policy, they do not completely address the issues concerning the exchange rate management policy of the RBI. The intervention policy in India is specifically designed to ensure orderly conditions in the foreign exchange market, because it is not yet very deep and broad, and is characterised by uneven flows of demand and supply over different periods. The market is dominated by a few major players and characterised by lumpy public sector demands that largely reflect oil imports and servicing of external debt, etc. This can lead to adverse expectations, which tend to be self-fulfilling in nature, given their effect on 'leads and lags' in payments and receipts. Growing supply–demand mismatch and inter-bank activity to take advantage of such mismatch can trigger volatility, which may not be in tune with the fundamentals (Report on Currency and Finance 2003-04; para 4.64).

As far as foreign exchange rate management is concerned, the prime objective of the RBI has been to ensure realistic and credible external value of the rupee and foreign exchange reserves adequate for a stable exchange rate. While describing the characteristics of exchange rate intervention policy, former governor RBI Bimal Jalan said:

> [T]he Reserve Bank has been prepared to make sales and purchases of foreign currency in order to even out lumpy demand and supply in the relatively thin forex market and to smoothen jerky movements. However, such intervention is not governed by a predetermined target or band around the exchange rate (Jalan 1999). [T]he broad principles that have guided India after the Asian crisis of 1997 are: (i) careful monitoring and management of the exchange rate without a fixed or pre-announced target or a band; (ii) flexibility in the exchange rate together with ability to intervene, if and when necessary; (iii) a policy to build a higher level of foreign exchange reserves which takes into account not only anticipated current account deficits but also 'liquidity at risk' arising from unanticipated capital movements; and (iv) a judicious management of the capital account (Jalan 2002).

The official statements regarding the intervention policy exemplify that intervention is principally meant for managing volatility with no fixed rate target while allowing the market forces to determine the exchange rate. Therefore, this chapter deals with the crucial question: has intervention impacted exchange rate and its volatility in the desired direction? Although empirical studies of this issue have come out with mixed results, one important aspect of official intervention seems to indicate that the authority's response to appreciating and depreciating domestic currency is asymmetric.

Edison (1993) provides empirical evidence to show that a central bank's response to exchange rate changes is asymmetric in that appreciation is, often, penalised more severely than depreciation of the same magnitude. The central banks prefer such asymmetric intervention as they seem to believe that appreciation of domestic currency tends to affect export competitiveness (Dooley, Folkerts-Landau, & Garber 2003). In other words, exchange rate intervention policy is often triggered by concern about export growth. Such asymmetry has also been established in the Indian context by Ramachandran and Srinivasan (2007). This study further documents evidence to show that asymmetry has been the major cause for accumulation of foreign exchange reserves, i.e. the RBI has been relatively more aggressive in preventing rupee appreciation. Against this backdrop, this paper examines whether the RBI's intervention could reduce the volatility and also whether intervention has asymmetric impact on exchange rate and volatility (Vadivel 2011).

2 WHY A-PARCH MODEL?

Many empirical studies apply some version of ARCH and GARCH models to examine the impact of intervention on exchange rate volatility because high frequency data exhibit unconditional leptokurtosis. In this respect, studies by Westerfield (1997) and Hsieh (1988) found the presence of temporal clustering in variance of exchange rate changes. Hence, several empirical studies apply autoregressive conditional hetroskedasticity models (ARCH) of Engle (1982) and generalised autoregressive conditional hetroskedasticity models (GARCH) of Bollerslev (1986) and provide evidence to show that prediction errors of exchange rate change exhibit clusters.

In addition, the response of financial market volatility to positive and negative shocks is rarely found symmetric. Nelson (1991) argues that if the frequency at which data are sampled becomes very high, persistence should become larger. Both unexpected positive and negative excess returns on stocks change the next period's conditional volatility of the excess return on stocks. Unexpected positive returns result in a downward revision while unexpected negative returns result in an upward revision. Indeed, Nelson (1991) and Engle and Ng (1993) found different effects for positive and negative unexpected returns, but both led to variance increases.

However, the Engle (1982) type ARCH model and the Bollerslev (1986) type GARCH model define the variance of a variable as conditional on its past prediction errors. Such an approach imposes the restriction on the power of explanatory variable in the variance equation to be 2, which may not be appropriate under certain circumstances. For instance, if the correlation between absolute returns on holding foreign exchange is substantially more than the correlation between return themselves or between the square of the return, then the usual ARCH/GARCH modeling of exchange rate return is not appropriate. In this context, Taylor (1986) and Schwert (1990) define conditional standard deviation as a function of lagged absolute returns (residuals). Taylor (1986) found that the absolute stock return has higher serial correlation over long lags, i.e. the absolute return has a longer memory than their squared terms.

Ding et al. (1993) investigated the autocorrelation structure on the return series of the S&P 500 stock market and found that absolute return has higher serial correlation than return. The evidence from this study indicates that one can characterise $|r_t|^d$ to be long memory, and this property of the return series is very strong when d = 1. Tse and Tsui (1997) found that the absolute return on Singapore dollar/US dollar exchange rate has higher correlation than the return. Therefore, we examine the long memory property of the return on exchange rate, its absolute value and square of it before modeling the exchange rate return and its volatility.

Nonetheless, Ding et al. (1993) asked 'why one should assume the conditional variance is a linear function of lagged squared returns (residuals) as in Bollerselev's GARCH, or the conditional standard deviation [is] a linear function of lagged absolute returns (residuals) as in [the] Taylor/Schwert model'. They provide a general class of model wherein five other ARCH/GARCH type models can be nested. The general structure is:

$$\varepsilon_t = s_t e_t \qquad e_t \sim N(0,1)$$

$$s_t^{\delta} = \alpha_0 + \sum_{i=1}^{p} \alpha_i (|\varepsilon_{t-i}| - \gamma_i \varepsilon_{t-i})^{\delta} + \sum_{j=1}^{q} \beta_j s_{t-j}^{\delta} \tag{1}$$

where

$$\alpha_0 \succ 0, \quad \delta \geq 0$$

$$\alpha_i \geq 0, \quad i = 1,..., p$$

$$-1 \prec \gamma_i \prec 1, \quad i = 1,..., p$$

$$\beta_j \geq 0, \quad j = 1,..., q$$

The asymmetric response of volatility to positive and negative shocks in return is measured by $\sum\alpha_i$. If the coefficient is positive and significant, then the response of standard deviation of return to the appreciating rupee is much stronger than to the depreciating rupee. This is well known in the finance literature as leverage effect, in that the stock market tends to becomes more volatile in response to bad news and less volatile in response to good news. For the purpose of the present study, we use equation (1) as a benchmark to examine the response of exchange rate volatility to official intervention in the foreign exchange market.

3 DATA AND EMPIRICAL RESULTS

The exchange rate equation is estimated using weekly data for the sample period—from 6 December 1996 to 19 April 2013. We begin with presenting the autocorrelation structure for weekly return on Re/US$ exchange rate ($\hat{e}_t$), $|\hat{e}_t|$ and for $\hat{e}^2_t$ in Table 1 and plot the same in Figure 1. The serial correlation is calculated for all three variables under consideration up to 100 lags. It is very clear from the table that the absolute return ($|\hat{e}_t|$) has high correlation than the other two measures, which is consistent with the findings of earlier studies (Karanasos and Kim 2006; French et al. 1986; Poterba & Summers 1988; Ding 2011). Thus, the estimates of serial correlation provide ample support to use A-PARCH specification to model return on foreign exchange and its volatility.

Table 1 Autocorrelation of $\hat{e}_t$, $|\hat{e}_t|$ and $\hat{e}^2_t$

Lags Data	1	2	3	4	5	10	20	40	70	100
$\hat{e}_t$	0.032	0.090	0.033	0.018	0.052	-0.071	0.048	-0.004	0.033	0.040
$\|\hat{e}_t\|$	0.356	0.300	0.254	0.299	0.266	0.245	0.233	0.154	0.138	0.108
$\hat{e}^2_t$	0.222	0.183	0.116	0.157	0.157	0.161	0.137	0.076	0.087	0.018

For the sake of comparison, we present the empirical estimates of both GARCH and A-PARCH models. The RBI intervention is measured as a percentage change in foreign currency assets. The other components of foreign reserves such as gold, SDR, and IMF tranche positions are not considered as they constitute a negligible proportion of foreign reserves and are not used for intervention purposes. Before estimating equation (1), the stationary properties of both percentage change in foreign currency assets and in exchange rate are examined using the Augmented Dickey-Fuller test (ADF) and Phillips-Perron unit root test. The results of unit root tests produced in Table 2 show that the null hypothesis of unit root can be rejected at conventional significance level, suggesting that they are stationary stochastic process.

Figure 1 Autocorrelation of $|\hat{e}_t|$, $\hat{e}_t^2$ and $\hat{e}_t$

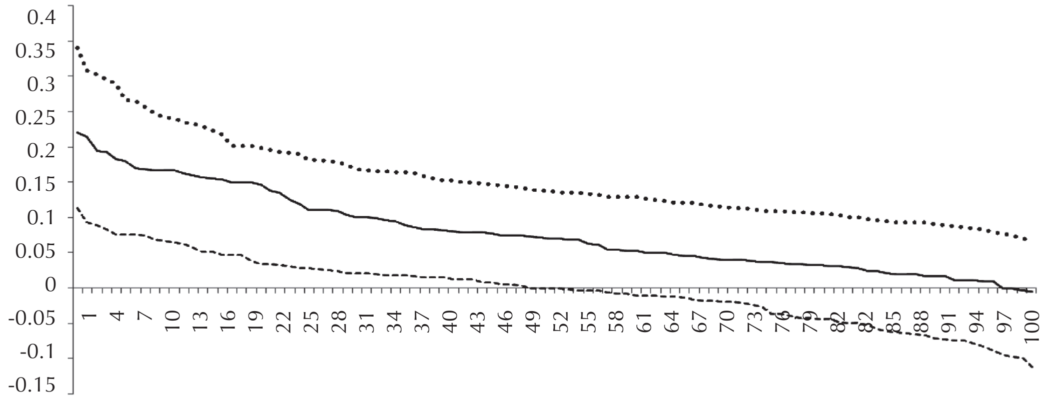

Table 2 Unit root test

Variable	ADF	PP
$\tilde{e}_t$	-28.204 (0.00)	-28.468 (0.00)
$\tilde{R}_t$	-6.565 (0.00)	-59.754 (0.00)

(#) are p-values

First, we apply GARCH specification to model percentage change in foreign exchange since it is more parsimonious. After an extensive search with the help of relevant diagnostic statistics we arrive at the estimates of the following GARCH (1, 2) model for exchange rate return.

$$\hat{e}_t = 0.027 - 0.027\hat{R}_t + \varepsilon_t$$

(0.14) (0.00)

$$\sigma_t^2 = -4.592 + 0.207\,\varepsilon_{t-1}^2 + 0.625\,\sigma_{t-1}^2 + 0.178\,\sigma_{t-2}^2 + 0.056\,|\,\hat{R}_t\,|$$

(0.00) (0.00) (0.00) (0.24) (0.04)

ARCH-LM (4) 2.472 (0.65) LOG LIKELIHOOD-843.72

$$\hat{e}_t = 0.032 - 0.023\,\hat{R}_t^s - 0.034\,\hat{R}_t^b + \varepsilon_t$$

(0.10) (0.10) (0.01)

$$\sigma_t^2 = -4.607 + 0.205\,\varepsilon_{1-1}^2 + 0.629\,\sigma_{t-1}^2 + 0.176\,\sigma_{t-2}^2 + 0.02\,|\,\hat{R}_t^s\,| + 0.642\,|\,\hat{R}_t^b\,|$$

(0.00) (0.00) (0.00) (0.25) (0.95) (0.03)

ARCH-LM (4) 2.644 (0.61) LOG LIKELIHOOD-843.47

(#) are p-values

where $\hat{e}_t$ is percentage change in Re/US$ exchange rate;
$\hat{R}_t$ is percentage change in foreign currency assets;
$\hat{R}^s_t$ measures percentage change in official sale of foreign exchange in the market; $\hat{R}^b_t$ measures percentage change in official purchase of foreign exchange in the market; and v_t is a white noise process. The ARCH–LM test that follows x^2 distribution suggests that there is no remaining ARCH effect in the standardised residuals; hence, the variance equation adequately captures the ARCH effect in the errors of mean equation.

In the mean equation, the coefficients with respect to selling and buying operation of the RBI are statistically significant having negative sign, which is very hard to interpret. This is also consistent with the findings of most of the earlier empirical studies. Nonetheless, the magnitude of coefficient with respect to selling operation is thrice as large as that with respect to buying operation. This indicates that the RBI does not treat undue appreciation and depreciation of rupee similarly, and confirms the presence of asymmetry in the exchange rate intervention policy.

As far as the focus of this paper is concerned, the estimates of variance equation are very crucial. The sum of the ARCH and GARCH terms is found to be less than unity, indicating that variance is a stationary process. The coefficients with respect to the absolute selling and buying operation of the RBI are statistically significant and have a positive sign, suggesting that intervention in the foreign exchange market triggers volatility. This is consistent with the argument that secret intervention (or, in other words, intervention without official announcement, which has been the practice of the RBI) tends to create ambiguity in the market, which in turn triggers volatility in the exchange rate rather than moderating it.

As is evident from Table 1, the absolute exchange rates return exhibit high serial correlation than the square of the return. Therefore, we present the estimates of A-PARCH model for exchange rate:

$$\hat{e}_t = 0.043 - 0.030\hat{R}_t + \varepsilon_t$$
$$\quad (0.03) \quad (0.00)$$

$$\sigma_t^{1.47} = -4.064 + 0.212\left(|\varepsilon_{t-1}| + 0.143\,\varepsilon_{t-1}\right)^{1.47} + 0.603\,\sigma_{t-1}^{1.47} + 0.211\,\sigma_{t-2}^{1.47} + 0.045\,|\hat{R}_t|$$
$$(0.00) \quad (0.00) \quad (0.00) \quad (0.00) \quad (0.10) \quad (0.04)$$

ARCH-LM (4) 2.598 (0.63) LOG LIKELIHOOD-839.43

$$\hat{e}_t = 0.455 - 0.267\,\hat{R}_t^s - 0.034\,\hat{R}_t^b + \varepsilon_t$$
$$(0.04) \quad (0.04) \quad (0.06)$$

$$\sigma_t^{1.48} = -4.091 + 0.211\left(|\varepsilon_{t-1}| + 0.143\,\varepsilon_{t-1}\right)^{1.48} + 0.605\,\sigma_{t-1}^{1.48} + 0.209\,\sigma_{t-2}^{1.48} + 0.020\,|\hat{R}_t^s| + 0.053\,|\hat{R}_t^b$$
$$(0.00) \quad (0.00) \quad (0.00) \quad (0.00) \quad (0.10) \quad (0.95) \quad (0.00)$$

ARCH-LM (4) 2.600 (0.62) LOG LIKELIHOOD = -839.25

(#) are p-values

The evidence obtained from the A-PARCH model is not qualitatively different from that obtained from the GARCH model. The estimated power of the model is close to 1; hence, the Taylor/Schwert type model seems to fit the data better. Nonetheless, the log likelihood values indicate that the A-PARCH specification is better one than the GARCH specification. The best way to understand the significant different between these two models is to test the null hypothesis that the true model is GARCH against the alternative that the true model is A-PARCH. This hypothesis can be tested using the following statistics:

$2(l\text{-}l_{\circ}) = x^2$

where l is the log likelihood from GARCH model and $l_{\circ}$ is log likelihood from A-PARCH model with two degrees of freedom. Therefore, the x^2 is 2(843.47 - 839.25) = 8.44 which is, for two degrees of freedom, significant at 1 per cent level. This indicates that the A-PARCH model fits the data much better than the GARCH model. Overall, the empirical evidence shows that every official selling operation seems to have less impact as compared to every buying operation of foreign exchange on exchange rate. Although intervention seems to trigger volatility, selling impact on exchange rate volatility is relatively larger. More importantly, the asymmetry coefficient in the A-PARCH mode (0.181) turned out to be positive and statistically significant, suggesting that volatility response is relative larger to appreciating rupee than to depreciating rupee.

Figure 2 Conditional variance of percentage change in exchange rate (GARCH)

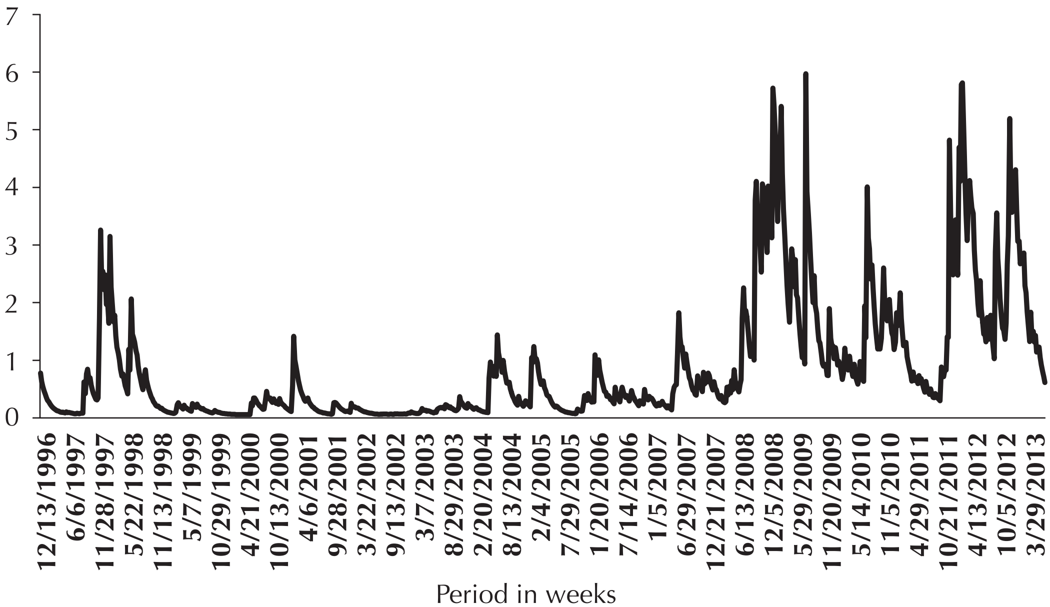

Figure 3 Conditional variance of percentage change in exchange rate (A-PARCH)

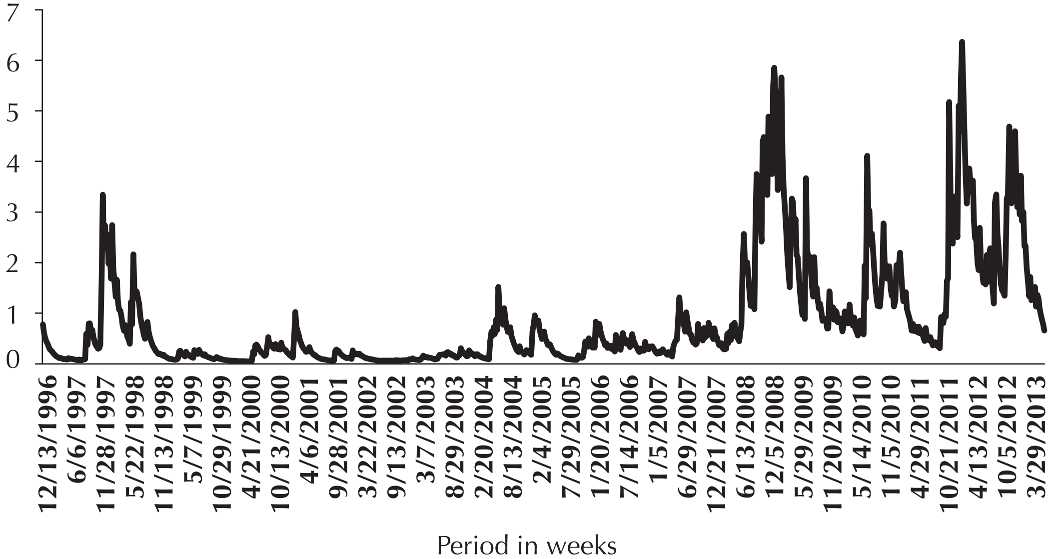

Figure 2 presents the plot of conditional variance obtained from the GARCH model, and Figure 3 presents the plot of conditional variance obtained from A-PARCH model. The variance measures from both models appear to have a symmetric trend, and also aptly reflect higher volatility in exchange rate during the Asian crises and the recent financial turmoil of the US.

4 CONCLUSION

The RBI has been focussing only on minimising undue fluctuations in the exchange rate through exchange rate intervention. This paper examines whether such official intervention during the sample has been successful in containing volatility in the exchange rate. To this end, we estimated the exchange rate equation using ARCH-type models wherein the absolute amount of intervention is incorporated as an explanatory variable in the variance equation. In addition, instead of using the usual GARCH models in which the power of variables in the variance equation is determined a priori, we adopted the approach of Ding et al. (1993), which is popularly known as the asymmetric power autoregressive conditional heteroscedastic model, and allows the data to determine the power of explanatory variables in the variance equation.

The empirical estimation of the model was carried out using the percentage change in the exchange rate as the dependent variable and the size of intervention as the explanatory variable in the mean equation. In addition to GARCH terms, the variance equation includes the absolute size of intervention as an explanatory variable to capture the impact of intervention on variance of exchange rate return. The results of the simple GARCH model and the A-PARCH model indicated that the RBI intervention triggers volatility and selling operation causes relatively larger volatility in exchange market. The evidence derived from the A-PARCH model further indicated that the impact of intervention seemed to have been asymmetric in that official selling of foreign exchange has a larger impact on volatility than buying operations.

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सत्यमेव परमो धर्मः
Institute of Economic Growth
University Enclave, University of Delhi
Delhi 110007, India
Tel: 27667101/288/424; Fax: 27667410
Website: www.iegindia.org