A Measure of Exchange Rate Volatility: Scenario Analysis of the Effect of RBI's Intervention in the Indian Forex Market

G. Nagaraju

Quantitative Approaches to Public Policy –
Conference in Honour of Professor T. Krishna Kumar

Held in conjunction with the
Fourth Annual International Conference on Public Policy and Management
Indian Institute of Management Bangalore (IIMB)

9-12 August 2009

A Measure of Exchange Rate Volatility

Scenario Analysis of the Effect of RBI's Intervention in the Indian Forex Market

by

G Nagaraju

NIBM

March 2009

A Measure of Exchange Rate Volatility

Scenario Analysis of the Effect of RBI's Intervention in the Indian Forex Market

By G Nagaraju, NIBM

Introduction

It is a well known fact that forex market in India is moderated by RBIs intervention from time to time whenever it was warranted in the view of RBI. Intervention by Central Banks in foreign exchange markets is nothing new. Central banks intervene in the forex market in line with their policy to moderate the exchange rate whenever it wanders away from a comfortable level. objective. The stated objective in the Indian case is to reduce the volatility in the forex market[1]. The workmanship of RBI in moderating the exchange rate is well acclaimed world over.

Historically, the Indian forex market, which is basically the market for USDINR, has been within 1 to 4 percent monthly volatility. The exchange rate was broadly maintained between 39 to 45 in the last one year. Though there were some high volatile times, the exchange rate in India has shown a stable character. The exchange rate has shown some of those characters which are looked for in an ideal financial market such as unpredictability, two ways movement and moderate volatility. Critics have largely given credit to RBI for this well behaved exchange rate.

In this context, it is an interesting idea to measure the contribution of RBI in this objective of moderating volatility in the exchange rate. Has RBI really made a difference in the extent of volatility in the exchange rate? In case yes, is it possible to measure by how much? This is the basic quest of this study. Besides, the study also tries to concretise RBI's model of intervention in the forex market. Answer for such questions have many policy as well as business implications.

At the outset, the objective of this study looks like building an hypothetical scenario, like " in case RBI did not intervene, what could have been the volatility?" This is certainly hypothetical question. How do anybody know what kind of exchange rates could have been seen if RBI had not been there? It is hard, nay, impossible, to answer that question. Market could have gone anyway in the absence of RBI's intervention. Though it is true that one can not reconstruct the past, one can try to see the alternative path of history under certain safe assumptions. In such an exercise, the scenario constructed is conditional to the assumptions. The implications are only as

---

[1] Though the stated objective is 'reduction of volatility', there is also a measure of level of exchange rate, which RBI seems to be guiding. A case in point is when RBI defended the level of 39.30 in the early 2008. The timing and extend of intervention are difficult to read based on the stated objective.

strong as the assumptions are. Such a simulated study may throw light on a very important areas and enrich understanding of forex markets in India. The only concern in such an exercise is how close are the assumption to the reality? The study here makes a range of possible assumptions regarding the nature of forex market and arrives at some insightful conclusions regarding the nature of volatility in forex market in India.

Theoretical Framework

Under the IMF classification of exchange rate regimes, Indian exchange rate management is classified as "managed floating" regime. Under such regime, the exchange rate is closely watched and the movements are assessed against the fundamentals of the economy and the developments in the rest of the world. Based on its view, RBI resorts to moderate the exchange rate through intervention in the market. The intervention takes the form of either buy or sell of USD in spot or swap markets. It is unknown what level of exchange rate or volatility exactly trigger the intervention action by RBI and by how much of intervention. However, the basic model is said to be as follows.

The exchange rate in India under the current regime, is by and large market determined. Even while intervening, RBI takes care that through its operation, the basic market forces are not out of place. The market players, while always keeping an eye on what could be the possible move by RBI, broadly agree that the exchange rate moves based on the demand and supply forces. Therefore, the Indian forex market could perhaps be studied by the regular supply-demand models of price determination.

The basic principle of price determination is that at any point of time, at the market clearing exchange rate, the amount of forex purchased is exactly equal to the amount of forex sold.

$$TP = TS$$

TP represents the Total Purchase, ie., the amount of forex demanded in the market. It constitutes the total of interbank and merchant demand. TS represent the Total Supply of forex in the market. There are three sources of supply, viz., interbank, merchant and the autonomous supply by RBI by the way of intervention. Separating RBI's intervention, the total supply can be written as sum of market supply (MS which is from both interbank and merchant sections), and autonomous supply (AS which is the autonomous supply from RBI)

$$TP = MS \pm AS$$

Autonomous Supply plays a crucial role in equating the total purchase with market supply. It is important to understand the analytics of the AS very clearly. There are two kinds of intervention, 1) Net Buy (+AS) and 2) Net Sell (-AS).

Net Buy situation

RBI's intervention as a net buyer in the market usually comes when the perception is that exchange rate is falling below acceptable level. In the market, there seem to be excess supply than what market is willing to absorb at the given price level. In order to dry out the excess supply and to protect the exchange rate from falling further, RBI intervenes and sucks the excess supply. In this situation, the market supply is more than what the market is purchasing, and the difference between them is the autonomous supply of –AS by RBI.

TP = MS – AS

Therefore we have:

MS = TP + AS

Net Sell situation

This situation is a corollary situation to the earlier one. The perceived price level is higher than acceptable because of shortage of foreing exchange in the market. Therefore, to stabilise the rate from further rising, RBI intervenes in the market by Net selling, augmenting the market supply by +AS. The total purchase in the market is not only what is supplied by the market, but also supplied by RBI. Therefore, market supply will be smaller than market purchase by AS
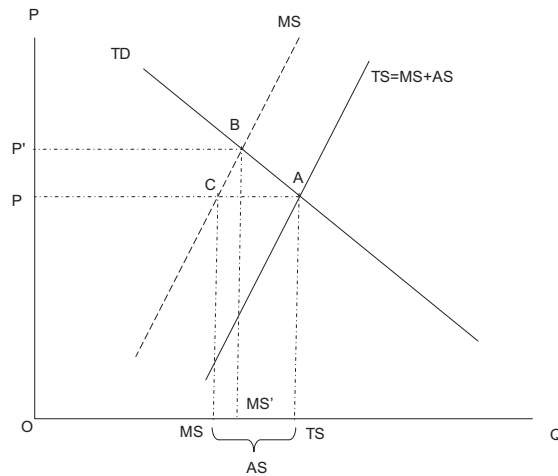
TP = MS + AS

Therefore we have:

MS = TP – AS

In order to understand the effect of RBI in the exchange rate determination, the model should assess the effect of absence of the autonomous supply AS in the price determination. In a regular supply-demand framework, the new price would be as shown in the figure 1

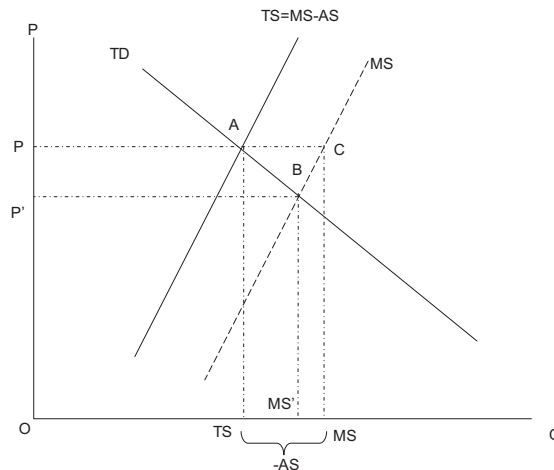Figure I

Effect of Net Selling by RBI

The figure 1 presents the case when RBI is net seller in the forex market. The downward sloping demand curve is depicted by TD, the total supply curve is being represent by TS=MS+AS. This is a supply curve which includes the market supply and also the autonomous supply by RBI intervention AS. The market clearing price is represented by P where TD and TS cross.

In the total supply, AS amount of forex was supplied by RBI as a matter of intervention in the form of net sell in the market. Accounting for this autonomous supply, the real supply in the market was only MS. Thus, on the X axis O-MS represents the market supply and O-TS represents the total supply, which is over and above the MS by RS. In the absence of RS, the market supply curve is given by dotted supply curve named MS. This supply curve intersects the TD curve at B. This analysis shows that in the absence of supply by RBI as intervention in the forex market, the market clearing supply and demand would have been at B, where quantity traded would have been somewhere in between MS and TS, and the , new price would have been P' a slightly higher price than P. The exact amount of forex traded and the market clearing price would be depending upon the slopes of TD and TS curves.

In a similar manner, figure 2 shows the case of price discovery in the case of net buy of forex by RBI as intervention in the market.

Figure II

Effect of Net Buying by RBI

The Figure 2 shows the analysis of price discovery in the net buy situation. The market clearing price is obtained at point A where TD is met by TS, which is sum of market supply and the RBI's net supply. The dotted supply curve MS is the market supply curve in the absence of intervention amount –AS. The new equilibrium price is obtained at point B. This indicates that in the absence of RBI's net buying, the market clearing volume would have been somewhere in between TS and MS and the market clearing price would have been P'. Again, the exact level of quantity traded and the price would depend upon the slopes of the demand and supply curves.

Slopes of Demand and Supply curves

In the analysis of understanding the forex markets in the absence of RBI's intervention, it is clear that the slopes of the demand and supply curves are very important.

$Qd = a - b\ P$ ....demand function

$Qs = \alpha + \beta\ P$ ....supply function

One way of getting the slope coefficients is to empirically estimate the demand and supply curves. However, in a market where autonomous supply is present, estimating the characteristic market demand and supply curves is difficult. In the heavy presence of RBI in the forex market, the price and quantity data available on the market would not be sufficient to estimate the true demand and supply curves. Therefore, obtaining slope coefficients empirically is a challenging job, which we would not attempt in this paper. Instead, we adopt an alternative methodology where we maker assumptions on the slopes and nature of supply and demand curves of the forex.

Given a certain nature of the demand and supply curves, the analysis tries to get at what could have been the alternative path of the exchange rate in the absence of RBI's intervention. We would postulate a range of assumptions about the supply and demand curves and build several alternative paths for exchange rates. The exchange rates thus rebuilt reflect the scenario in the absence of RBI's intervention under the assumptions of demand and supply conditions. The alternative exchange rates could be studied for volatility measures which would reflect the volatility in the absence of RBI's intervention. The implications arrived at, however, would be strictly subjected to the assumptions made regarding the nature of demand and supply curves. Though the exercise is thus a purely hypothetical analysis, the results throw very useful insights into the nature of forex market of India.

Methodology and Assumptions

The main pursuit of analysis is to derive alternative series of exchange rates if the RBI interventions was absent in the forex market. This alternative series is used to arrive at the volatility estimate, which is then compared with that of the original exchange rate to make inferences on the effect of the RBI's intervention. As said earlier, the variables required for this purpose are a) the original exchange rate (S), b) total volume of purchases in the forex market (TD), and c) the volume of net intervention of RBI. Apart from these variables, two very important functional relations are required, viz., demand functional and the supply function. The two parameters, that are most important in the demand and supply functions are the slope coefficients, viz., -b and β, which makes it possible to arrive at the effect of RBI's intervention. While the data series are available from RBI's source, the parameters, as mentioned earlier, are not available. We make assumptions about the elasticity coefficients and build different scenarios as mentioned below

Assumptions	Price Elasticity of Demand η_d	Price Elasticity of Supply η_s
Scenario I	-1	+1
Scenario II	-1	0
Scenario III	0	+1
Scenario IV	-1	∞
Scenario V	$-\infty$	+1

Under each of these assumptions we arrive at the alternative exchange rate that could have prevailed in the absence of RBI's intervention. Note that while the true elasticities are unknown, the range of assumptions perhaps give us broader corner scenarios, within which true elasticieis lie. After analysing exchange rates under each of these assumptions, we can perhaps arrive at a judgemental assessment of RBI's intervention on the volatility dampening.

Scenario I

Price Elasticity of Demand for forex $\eta_d = -1$
Price Elasticity of Supply or forex $\eta_s = +1$

The demand and supply conditions under the above assumptions is depicted in Figure III. Both the x axis and y axis are in logarithmic scales. TD is the demand curve which slopes negatively with a constant slope -1, indicating constant elasticity of -1. TS curve, which includes both market supply (MS) and the net sell of RBI (AS) has a positive slope coefficient of +1, indicating constant elasticity of +1.

Figure III

Estimating Exchange Rate Under
Assumption $\eta_d = -1$, $\eta_s = 1$
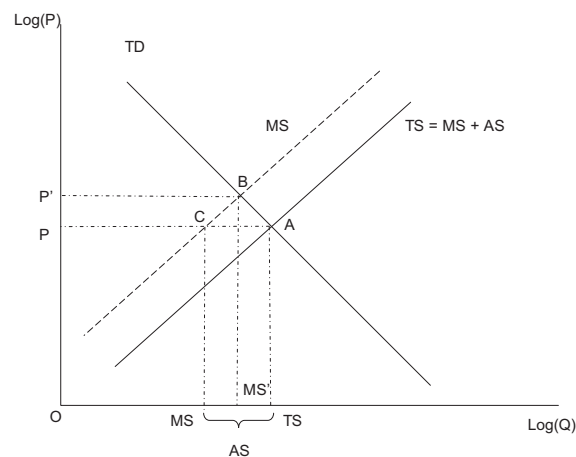
The total supply curve (TS) and the total demand curve (TD) are intersecting at point A, giving the price level as P. Important point to be born in mind is that P is the price level arrived at after the market supply is been supplemented by RBI's intervention. Our intention is to find out what could have been the price in case there was no such intervention by RBI.

In the absence of RBI's intervention, the supply curve could have been the one dotted line denoted by MS. The MS curve would be on to the left side of TS curve and the difference between the two curves would be AS. Since the MS curve is a parallel shift, the slope remains the same as that of TS, which is +1. The new intersection of demand and supply is given by the point B and the new price level is indicated by P', which is higher than P. The quantity transacted at the new equilibrium point is given by MS'.

In this whole exercise, what is known to us by the way of data is the equilibrium price P, the quantity transacted TS and AS, the amount of net intervention by RBI. The point of interest is to know how much would be the new equilibrium price, P' and what would be the new equilibrium quantity MS' in the absence of intervention.

Consider the triangle ABC in the figure III. The length of CA is equal to the percentage of RBI intervention in the market. Both the demand and supply curves being at 45 degrees to the x axis, the triangle ABC forms a right angle equilateral triangle with 90 degrees at B and both sides CB and AB being equal. Given the nature of the triangle, the line B-MS' bisects CA. The implication of this is that the price level that would have prevailed in the absence of RBI's intervention is exactly half of the percentage change of supply induced by RBI. If the RBI intervention AS forms say 1% of the market supply (MS), the impact on the price would be half percentage of the market clearing equilibrium point. Thus, one can quantify the exchange rate that would have prevailed in the market if there were no intervention of RBI in the market.

The market supply in the absence of RBI's intervention is MS

MS = TS – AS

Percentage change in the supply commissioned by RBI = x = ln(TS) – ln(MS)

(P - P')/ P' denotes the percentage change in the price achieved by RBI's intervention

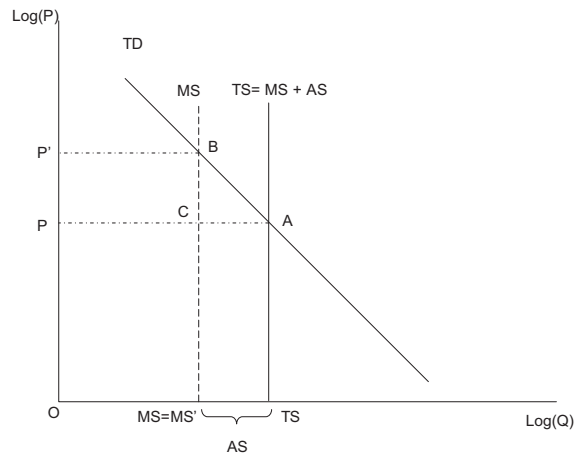According to the analysis shown earlier, $\dfrac{(P - P')}{P'} = -\dfrac{x}{2}$

Solving for P' we get, $P' = \dfrac{P}{1 - x/2}$

Scenario II

Price Elasticity of Demand for forex $\eta_d = -1$
Price Elasticity of Supply or forex $\eta_s = 0$

Figure IV

Estimating Exchange Rate Under
Assumption $\eta_d = -1$, $\eta_s = 0$

Log(P)

TD

MS   TS= MS + AS

P'   B

C   A

P

O   MS=MS'   TS   Log(Q)

AS

With the above assumptions, the demand and supply picture is drawn in Figure IV. As the elasticity of supply is assumed to be 0, the supply curve is vertical line to x axis. The market clearing equilibrium point at TS = TD is at A. In the absence of RBI's net selling intervention, the supply line would have met the demand line at point B, indicating a new price level P'. As the supply line is inelastic, there would not be any additional supply forthcoming, implying that entire effect of intervention would be absorbed by price. The intervention therefore, has pushed the price from P' to a lower level P. Measure of this reduction in price is indicated by BC in the figure IV. The triangle BCA is an right angle equilateral triangle with right angle at C. The side BC and CA are equal in length. The RBI's market intervention in is given by CA. Therefore, the price effect is exactly equal to the percentage of intervention.

Percentage change in the supply commissioned by RBI = $x = \ln(TS) - \ln(MS)$

(P - P')/ P' denotes the percentage change in the price achieved by RBI's intervention

According to the analysis shown earlier, $\dfrac{(P - P')}{P'} = -x$
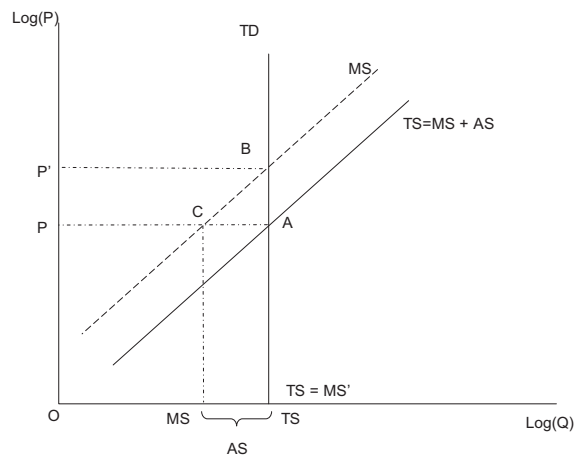
Solving for P' we get, $P' = \dfrac{P}{1 - x}$

Scenario III

Price Elasticity of Demand for forex $\eta_d = -0$
Price Elasticity of Supply or forex $\eta_s = 1$

Figure V depicts the conditions supply and demand under the above assumptions. The inelastic demand curve TD is drawn perpendicular line to x axis.

Figure V
Estimating Exchange Rate Under
Assumption $\eta_d = 0$ $\eta_s = 1$

In the absence of intervention by RBI, the equilibrium between demand and supply would have been at B indicating price level of P'. The extra supply of forex in the form of intervention causes a shift in the supply curve to the right and the new equilibrium point is at A. As the demand is inelastic, entire effect of extra supply would be only absorbed by price.

Similar to the Scenario II, the price effect would be $P' = \dfrac{P}{1-x}$, where x is the percentage change in the supply caused by RBI's intervention.

Scenario IV

Price Elasticity of Demand for forex $\eta_d = -1$
Price Elasticity of Supply or forex $\eta_s = \infty$

Figure VI

Estimating Exchange Rate Under
Assumption $\eta_d = -1$, $\eta_s = \infty$
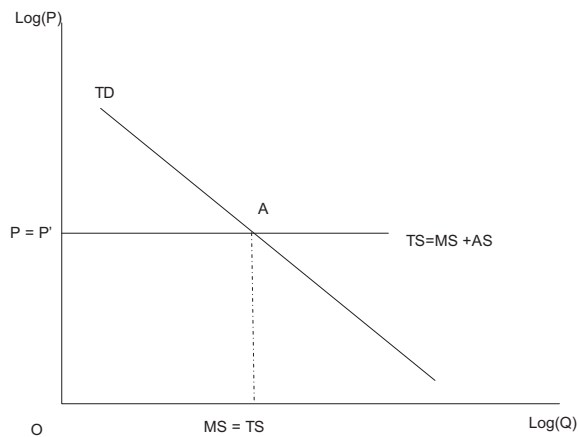
In the case of Scenario IV, the supply line is drawn parallel to the x axis. As the supply is assumed to be perfectly elastic, any amount of supply would be met at the same price. This implies that the intervention by RBI would not matter to the market as, at the market supply would adjust such a manner that the price would remain where it was.
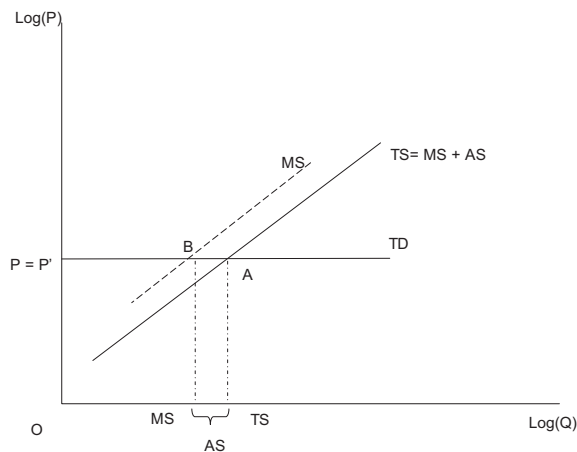
Scenario V

Price Elasticity of Demand for forex $\eta_d = -\infty$
Price Elasticity of Supply or forex $\eta_s = 1$
In this scenario, the demand curve would be parallel to x axis indicating absorption of any amount of supply making the price stay at the same place.

Figure VII

Estimating Exchange Rate Under
Assumption $\eta_d = -\infty$, $\eta_s = 1$

In the Scenario V too, similar to the scenario V, the price would remain without change if there were to be no RBI's intervention in the forex market. In such a market, RBI's intervention would not make any difference. The Exchange rate would have been the same whether there was intervention or not.

Note that through there are five scenarios of analysis, the effect of intervention on exchange rate in scenario II and III are same. Similarly, under scenario IV and V, the intervention leaves with no effect on the price. Since no price effect on price is observable, no results for scenario IV and V need to be reported in the analysis. Therefore, effectively, there would be only two kinds of price effects i.e., under scenario I and under scenario II and III.

Volatility

As mentioned earlier in the objective of the study, the point is to examine the effect of RBI's intervention on the volatility of USDINR exchange rate. The volatility is measured usually by the standard deviation of the returns of the rate.

Data

The main data required for the study are a) volumes of transactions in the forex market, b) volume of intervention by RBI and c) the exchange rate. All this data is available from RBI source. The RBI monthly bulletin publishes daily volumes in forex transactions. The same source also publishes monthly data on RBI's intervention in the forex market. Therefore, the study is done on the monthly data. The monthly average exchange rate is also collected from the

RBI bulletin. The volumes are expressed in USD terms and are given for millions of denomination. The exchange rate is for USD/INR.

The nature and kind of data on turnover in forex market as published by RBI needs some understanding. The turnover data is separately reported as 'purchase volume' and 'sales volume'. Like in any commercial transaction, forex transactions also involve two legs, a buy a sell leg. Since the two legs represent the same transaction, they should be matching at the aggregate level. However, it may not be the case in the case of Indan forex market for the reasons explained in the paragraph below. Since volume of purchase and sale are not the same, RBI publishes two legs separately.

The volume of forex transaction published by RBI is obtained from the reporting Authorised Dealers. The Authorised dealers buy and sell foreign exchange not only among themselves, but also to other players in the market such as merchants, banks across border and importantly, the RBI, which do not report their transactions to RBI. In a transaction involving a reporting bank and a non-reporting counterparty, while one of the legs get reported to RBI, the other does not. Therefore, the buy and sell legs reported by the Authrosied Dealers need not match. For this reason, data is published for both purchase volume and sell volume.

The volume data is also further disaggregated as merchant turnover and interbank turnover. Within each such category, the data is given further segregated for USD/INR segment and FX/FX segment. Under each of these segments volume for spot transactions and forward / swap transactions are reported.

For the present study, we have a wide choice to choose from to represent total volume in the forex market. The first choice is to choose between 'purchase' side data or 'sales' side data as the relevant volume for the study. Then, within the side chose, we need to further chose variable of volume.

In the present study, the intervention of RBI is taken as a supply side variable. As RBI is not a commercial agent, its purchase or sales do not form part of total demand for foreign exchange in the market. However, the RBI's interventions alter the supply in the market. A net sell of forex by RBI augments the market supply by the amount of intervention. The total demand would equal to the total of net sell of RBI and the market supply. Similarly, when RBI is net buying in the market, the market supply is absorbed by RBI to that extent. In this case the total demand would equal to the market supply minus RBI's net buy. Given this approach, we would consider only 'Purchase' data as demand. The market supply is derived by adding / subtracting the net purchase / net sell of RBI's intervention volume.

The second question is about the volume variable within the purchase side. One choice could be the total of merchant and interbank transactions of both spot and forward markets in both USD/INR and Fx/Fx. However, such choice could be too general to measure the intervention effect of RBI, which is generally in spot market and only in USD/INR market. May be we need

to consider only that market which is directly affected by RBI's intervention. In this case, the choice would be the total of spot market of USD/INR. But, then, whether to include merchant spot volume or not is another question. As the intervention is only in the interbank market, may be the effect directly falls on interbank USD/INR spot market. But then, such a selection assumes interbank market does not move with RBI's intervention, which may not be acceptable. Similarly, the question of Fx/Fx market, and forward market complicate the choice selection of volume variable. Though all segments of forex market may not directly affected by RBI's intervention, there would be very quick adjustment process spreading across all such markets. In the absence of any clear choice for a single volume variable, we take a range of the following variables

Table I

TP	Total Purchase	Total of Merchant and Interbank, both spot and forward and USD/INR and Fx/Fx market
TSP	Total Spot Purchase	Total of Merchant and Interbank only Spot volumes of both USD/INR and Fx/Fx market
MSP	Merchant Spot Purchase	Total of Merchant spot volumes of USD/INR and FX/FX market
IBSP	Interbank Spot Purchase	Total of Interbank spot volume of USD/INR and Fx/Fx market
INRSP	INR spot purchase	Total of merchant and interbank USD/INR market volumes
IBSP	Interbank INR spot	Interbank USD/INR spot market volume

Table II

|	Jul-08		July 96 to July 2008	
	Volume (mil)	% in total	Avg % in total	% of RS
TP	53921	100.0	100.0	1.41
TSP	249673	46.30	49.38	2.90
MSP	54169	10.05	11.97	11.94
IBSP	193499	35.88	37.51	3.88
INRP	140502	26.05	30.79	4.51
IBSP	98400	18.24	20.17	6.92

Exchange Rate Volatility

The average monthly rate of USD/INR is used as the relevant exchange rate in this study. Obviously, the data on exchange rate is inclusive of the effect of RBI's intervention in the market. The historical volatility of this rate as calculated for the period of April 1997 to July 2008 is 1.733.

Using the method mentioned in theoretical framework section, we can estimate alternative series of exchange rate based on market volume and elasticity coefficients of demand and supply of forex in the market. The alterative exchange rate thus arrived would be the hypothetical exchange rate in case there was no intervention by RBI in the market.

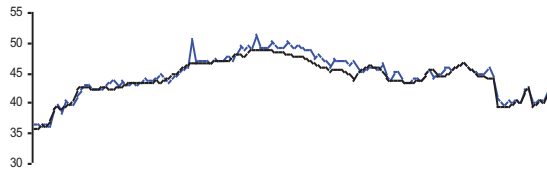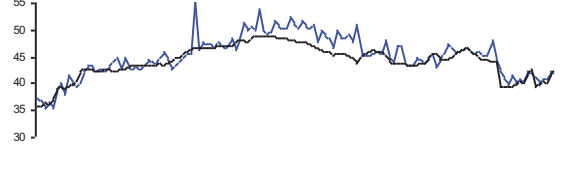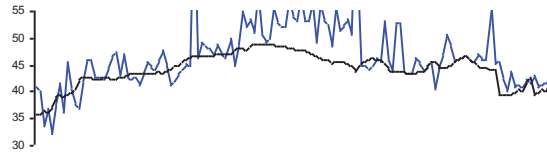Taking each of the variable mentioned in Table I as a proxy for volume, alternative exchange rate series are derived. Chat 1 gives a summary of such exchange rates.
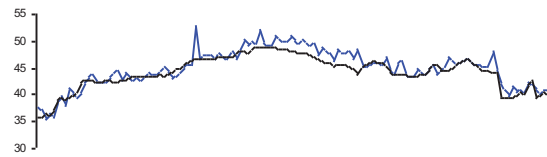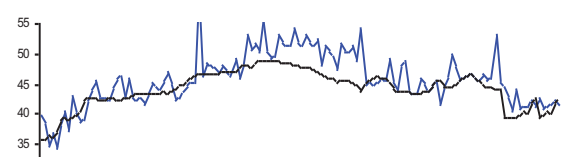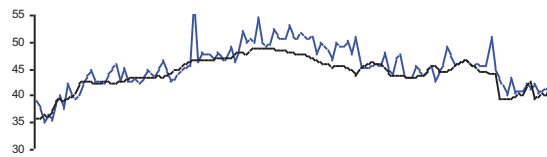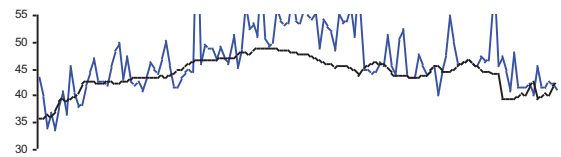
TP
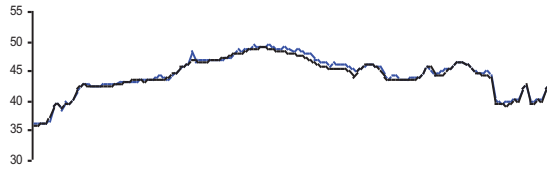
TP
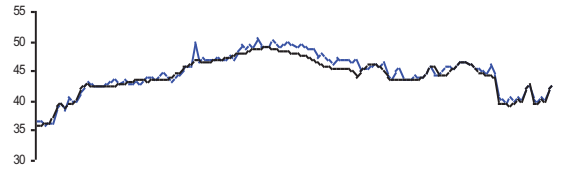
TSP

TSP

MSP

MSP
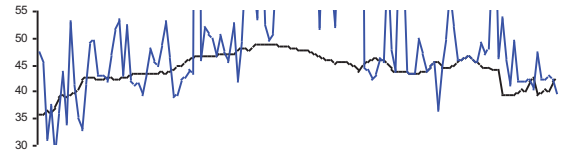
IBSP
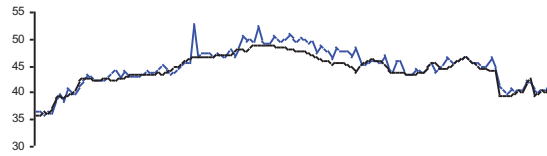
IBSP
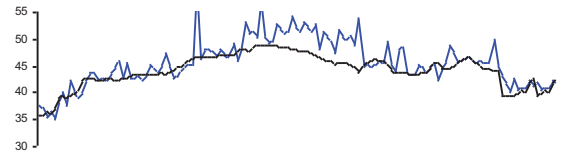
INRSP

INRSP

IBSP

IBSP

Each of these variables would be considered for analysing the effect of intervention. The results are separately obtained and presented in Table I

Table I Volatility Measures under conditions of Intervention and postulated non-intervention

	Scenario I		Scenario II and III	
Volume Variable	Volatility in the absence of Intervention	Difference from historical vol 1.733	Volatility in the absence of Intervention	Difference from historical vol 1.733
TP	2.98	1.25	2.96	1.23
TSP	2.94	1.21	3.01	1.28
MSP	3.67	1.94	6.31	4.5
IBSP	2.94	1.21	3.13	1.40
INRP	3.02	1.29	3.32	1.59
IBSP	3.14	1.41	3.83	2.1

Conclusion

The above result is a scenario analysis of volatility in the USDINR market on the assumptions of different corner values of demand and supply elasticities for the forex in India. Though the analysis is based on assumed or hypothetical demand and supply functions, it is quite instructive. The analysis presents that there is surely a contribution of RBI in terms of volatility reduction in the exchange rate. The net effect (as read by the 3 and 5 of Table I) is minimum of 1.21 % to maximum of 6.31% reduction in the volatility.

Further Research

The first important constraint of the study is that the results are obtained based on aummed values for demand and supply elasticity values for forex. The second one is the choice of volume variable for analysis. Depending upon different volume variables, the impact of RBI intervention is widely changing. The study needs to be furthered to get the best and realistic choices for these two assumptions. Deeper and wider survey of studies on the same filed need to be done in order to assess acceptable assumptions regarding elasticity values and the volume variable.