The exchange rate exposure of Indian firms

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2014-3-28

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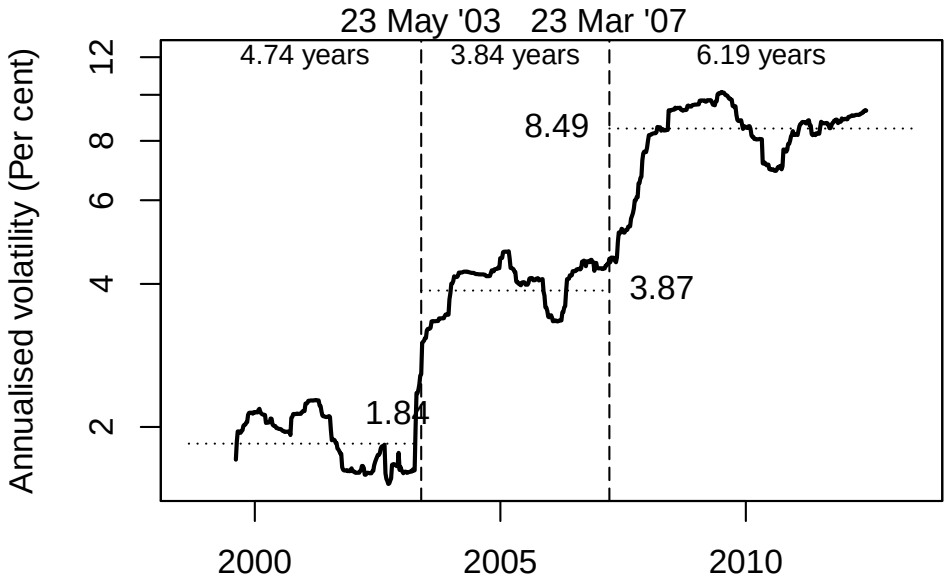
Contents

1 The economic exposure in India to currency risk

Over the last two decades, currency volatility has seen a structural shift to higher levels of volatility (Figure 1). Since 2007, volatility has been at an average of 8.6% annualised, and during some periods, it has reached as high as 15% annualised (July 2013).

Figure 1 Structural changes in USD/INR volatility, 1998-2013



During the same period, the size of the economic participation related to foreign exchange flows has more than doubled: from USD 600 billion in 2007 to around USD 2 trillion in 2013. Together, these show that the need for economic agents all over the world to hedge their exposure to currency risk in Rupee assets has never been higher.

In this note, we ask:

> What is the size of the economic exposure to currency volatility in India?

We attempt an answer by estimating the Value-at-Risk of the equity of Indian firms to fluctuations in the USD/INR exchange rates.

1.1 VaR as a measure of economic exposure

The Value-at-Risk (VaR) is a concept in risk measurement that asks *what is the loss in the value of a portfolio when there is a large change in the value of a component asset.*

In our case, the component asset is currency, and the portfolio is the equity capital of every agent in India who has exposure to the currency. If we approximate the economy

as a portfolio of listed manufacturing firms, then the economic exposure that the country has due to a large change in the currency may be approximated as the VaR of the portfolio of those firms due to the change in currency.

In recent times, the use of the VaR as a measure of risk has come under much dispute because it does not capture the full complexity of the risks to a portfolio. Nevertheless, the VaR remains a useful first step in measuring the loss due to an extreme change in the underlying asset or factor value. Further, this is one approach that can be consistently operationalised for different sectors of the economy (manufacturing vs. financial firms), and across different periods of time (pre-July 2013 vs. after). Thus, we proceed to use the VaR as a measure of economic exposure, with the caveat that that the VaR is almost certainly an under-estimate of the full exposure of the economy to currency volatility.

2 Our approach

In order to calculate the VaR, we first estimate the sensitivity of the risk of an individual firm to currency risk. This is called the "beta" from the market model estimation with the currency as the underlying factor, and is denoted as β_c. Next, we use β_c for an individual firm to estimate the VaR of the firm. Lastly, we aggregate the firm level VaR to arrive at the estimate of the economic VaR due to currency risk.

This sets the following order of estimations to arrive at the economic exposure due to currency for India:

1. Identify a sample of firms for which we estimate currency sensitivity, or β_c.
2. Estimate the β_c for an individual firm using the *Augmented Market Model* where returns on the firm is regressed against the market and the currency. This estimation will yield the sensitivity of the firm to market volatility (called β_m) and the sensitivity of the firm to currency volatility, or β_c.
3. Use the estimate of β_c, along with the variance-covariance matrix of the market and currency returns, to calculate the Value at Risk (VaR) of the firm against currency volatility.
4. Repeat the above Steps 2. and 3. for all the firms identified in Step 1. When the VaR of all firms is summed, we will arrive at the estimate of the possible loss (in Rs. terms) that can arise due to possible changes in the USD/INR for the sample.

The possible loss that can be attributed to changes in the currency is one measure of the exposure that India has to currency risk.

2.1 Identify a sample of firms for which to estimate currency sensitivity

We focus on the subset of listed manufacturing firms in India out of all the possible agents with exposure to currency risk. The reason we do this is because data for these firms is readily available to be used in the estimation exercise that follows. In reality, this will be a under-estimate of the true economic exposure in India, because this analysis does not include: (a) Individuals, and (b) Unlisted firms.

We use the following criteria to select a sample of manufacturing firms from the CMIE Prowess database for the analysis:

1. Select a set of firms that have foreign currency exposure in 2012-2013. This is available in the stand-alone annual financial statement of a firm, and is measured as the sum of:

   - foreign exchange income;
   - foreign exchange expenses; and
   - foreign exchange borrowings.

   This criteria yields 2549 firms.

2. Select the firms listed on the Bombay Stock Exchange (BSE) as of March 2013.[1] This criteria yields 1840 firms, out of which 767 are **large**, 572 **medium**, and 501 **small** firms.

3. This number reduced further because of data adequacy issues associated with certain firms in the BSE list. We filter out firms with less than 50 trading days in the period between April 2011 and August 2013.

At the end of applying these filters, the sample contained 1703 firms. We categorise these firms by size, so as to analyse the VaR separately for each as well as for the full sample. The categories are chosen as follows:

- Small: Total assets $<$ Rs.1 billion.
- Medium: Total assets between Rs.1 billion and Rs.5 billion.
- Large: Total assets $>$ Rs.5 billion.

Then, out of the 1703 firms, we have 746 **large**, 556 **medium** and 401 **small** firms.

[1] The BSE has a larger coverage of firms compared to the National Stock Exchange which has around 1700 listed firms only.

2.2 Estimating β_c using the augmented market model

The unhedged currency risk exposure of a firm can be estimated as the sensitivity of the changes in stock price of a firm to the changes in the exchange rate (Patnaik and Shah, 2010; Dominguez and Tesar, 2006; Adler and Dumas, 1984). This can be estimated using the "augmented market model" (AMM) as follows:

$$r_{i,t} = \alpha_i + \beta_{m,i} r_{m,t} + \beta_{c,i} r_{c,t} + \epsilon_{i,t}$$

where $r_{i,t}$ is the return on firm i at time t, $r_{m,t}$ is the contemporaneous return on the market index, m, and $r_{c,t}$ is the contemporaneous change in the exchange rate, c.[2]

Here, $\beta_{c,i}$ measures the sensitivity of the value of firm i to currency changes. A firm that has zero exposure to the currency is expected to have a $\beta_{c,i} = 0$. To the extent that the firm has exposure to the currency, β_c will be significantly different from zero.

For example, an importing firm that has taken no hedge against currency volatility, will suffer losses if the currency depreciates. β_c for such a firm would be both negative and significant. An unhedged exporting firm, on the other hand, will benefit from currency depreciation, and whose β_c will be positive and significant.

Since changes in both the market and the currency can be correlated, both contemporaneously and across time, the following three step approach is used to estimate the β_c for a firm i accurately (Patnaik and Shah, 2010):

1. Remove all time dependence within the currency returns series. This is done by estimating an autoregressive (AR) model on currency returns:

   $$r_{c,t} = \alpha_c + \Sigma_i^k \gamma_i r_{c_{t-i}} + e_{c,t}$$

   where k denotes the number of lags in the currency series, selected using the AIC criterion.

   From the above equation, we extract residuals $e_{c,t}$, which will have only unanticipated factors.

2. Remove dependencies between the market index and the currency by estimating the following:

   $$r_{m,t} = \alpha_m + \Sigma_i^k \omega_i e_{c_{t-i}} + e_{m,t}$$

   From the above estimation, we extract the residuals $e_{m,t}$ which is independent of $e_{c,t}$.

3. Finally, estimate a modified AMM as follows:

   $$r_{i,t} = \alpha_i + \beta_{m,i} e_{m,t} + \beta_{c,i} e_{c,t} + \epsilon_{i,t}$$

[2] Returns are calculated Logarithmic returns.

2.3 Estimating the Value-at-Risk (VaR) of a firm due to currency risk

The Value-at-Risk (VaR), at a given significance level X, of a firm due to the currency risk refers to the risk that a firm might loose an amount V (or more) over a certain horizon h due to the movements in the currency with a probability of $X\%$. This VaR can be computed as:[3]

$$VaR_{X,h} = Z_X \sigma_i - \mu_i$$

where Z_X is the X^{th} percentile of the standard normal density. From the standard normal tables, Z_X at $X = 0.01$ equals 2.33. σ_i is the standard deviation of the returns of asset i, and μ refers to the mean of the asset returns, which can be assumed to be zero at very short horizons.

From the AMM equation specified in Step 3 of Section 2.2, σ_i of the returns of a firm i is written as the square root of:

$$\sigma^2_{r_{i,t}} = \beta^2_{m,i}\sigma^2_{e_{m,t}} + \beta^2_{c,i}\sigma^2_{e_{c,t}} + 2\beta_{m,i}\beta_{c,i}\sigma_{e_{m,t},e_{c,t}} + \sigma^2_{\epsilon_{i,t}}$$

where $\sigma^2_{(\cdot)}$ refers to the variance of each variable, while $\sigma_{e_{m,t},e_{c,t}}$ refers to the covariance between the residual series of the market index (m) and the exchange rate (c). Since we filter out the dependencies between m and c (described in Step 2 of Section 2.2), $\sigma_{e_{m,t},e_{c,t}} = 0$.

The variance of $r_{i,t}$ *attributable to variance in currency* is equal to $\beta^2_{c,i}\sigma^2_{e_{c,t}}$. Hence, the $X = 0.01\%$ VaR of a firm due to currency risk over a one week horizon is written as:

$$VaR_{0.01,1} = 2.33 \cdot \sqrt{\beta^2_{c,i}\sigma^2_{e_{c,t}}}$$

3 An estimate of economic exposure to the currency

In this analysis, VaR is calculated at a 99% confidence level, over a one week horizon. This is calculated for two time points: March 2013 and December 2013. The sample of firms is described in Section 2.1, and the currency used is the USD/INR exchange rate. β_c is estimated using weekly returns data of the firms, the NSE-50 (Nifty) as the market index and USD/INR as the exchange rate. Data between April 1, 2011 to March 31, 2013 is used to estimate β_c for the VaR of March 2013. Data from April 1, 2011 to August 16, 2013 is used for VaR estimates for December 2013.

The value of the estimated β_c[4] averaged across the firms in the total sample and the three sub-samples are presented in Table 1. This tells us how sensitive returns on equity of Indian firms are to changes in the currency.

[3]This method assumes that returns of the asset are normally distributed, with a mean μ and standard deviation, σ.

[4]The implementation is done using the *eventstudies* package in **R** (Anand *et al.*, 2014).

Table 1 Sensitivity of the average firm returns to currency risk, March 2013

The table presents the number of firms in the full sample, as well as in each sub-samples – small, medium exporter/importer and large with foreign subsidiaries. It also shows the average values of estimated β_c for the full sample as well as the three sub-sample.
Estimated values are based on the period between April 1, 2011 to August 16, 2013.

	No. of firms	$\bar{\beta}_c$
Total	1703	-1.29
Large	746	-1.28
Medium	556	-1.26
Small	401	-1.41

Table 1 shows that, on average, equity returns have a negative correlation with currency returns. This means that there is a loss in firm value, on average, when the currency *depreciates*. Table 1 also show that for a 1% depreciation in the currency, there is a 1.26% drop in the firm's price. While the amount of the drop is slightly different for **Large, Medium** and **Small** firms, they all see a drop in price on average.[5]

The average β_c values are then used to estimate the Value-at-Risk for the full sample, as well as for each subset of firms. In each case, the exposure ($\text{VaR}_{0.01,\text{sample}}$) over a one week horizon ($h = 1$) is computed as:

$$VaR_{0.01,\text{sample}} = 2.33 \times \Sigma_i^N \text{mcap}_i \cdot \sqrt{\beta^2_{c,\text{sample}} \sigma^2_{e_{c,t}}}$$

where $\beta_{c,\text{SAMPLE}}$ refers to the average beta of each sample of firms, N refers to the number of firms, and **mcap**$_i$ is the fraction of the market capitalisation of firm i over the total market capitalisation summed over all the firms in the sample.

The estimated values of the 99% VaR for a one-week horizon is presented in Table 2. The table indicates that as of March 2013, a sharp depreciation in the currency could have resulted in reduction in the market cap of Rs.1.61 trillion. Of the Rs.1.61 trillion loss in market capitalisation, Rs.1.58 is the loss in the market capitalisation of large firms due to currency depreciation.

3.1 What happened to economic exposure after the currency volatility shock of July 2013?

The VaR values in Table 3 show that the economic exposure in India to the currency has increased by around Rs.120 billion compared to the levels in March 2013, most of

[5]Table 1 report the average of $\hat{\beta}_c$ that were significant in the estimation. There were 302 Small, 304 Medium and 246 Large firms for which the estimated $\hat{\beta}_c$ were insignificant. There were only four firms for which $\hat{\beta}_c$ turned out to be positive and significant. The rest had negative values of β_c estimates.

Table 2 An estimate of economic exposure to currency, March 2013

The table presents the value of total assets and the market cap of the sample of firms used in the analysis, as of end March 2013.
It also presents the 99% VaR as the 1% probable loss in market capitalisation (Mcap) over a one week horizon for the firms, due to movements in the USD/INR.

(Values in Rs. billion)

	No. of Firms	Total Assets	Total Mcap	VaR (based on Mcap)
Full sample	1,682	47,118.41	42,729.66	1,606.14
Large	743	45,570.78	41,924.51	1,575.94
Medium	553	1,352.90	718.16	26.60
Small	386	194.73	86.99	3.60

Table 3 An estimate of economic exposure to currency, December 2013

The table presents the value of total assets and the market cap of the sample of firms used in the analysis, as of end December 2013.
It also presents the 99% VaR as the probable 1% loss in the market capitalisation over a one week horizon for the firms, due to extreme movements in the USD/INR.

(Values in Rs. billion)

	No. of Firms	Average β_c	Total Assets	Total Mcap	VaR (based on Mcap)
Full sample	1,703	-1.26	47,188.82	46,622.38	1,772.39
Large	746	-1.28	45,628.47	45,738.32	1,740.30
Medium	556	-1.22	1,360.26	812.66	29.38
Small	401	-1.27	200.09	71.40	2.70

which is seen as increased VaR of the large firms. The rise in the VaR partly reflects the higher probable loss due to the depreciation of the currency, as well as the higher market capitalisation in the economy in December.

If we assume that the universe of manufacturing firms, which had a market capitalisation of Rs.61.2 trillion in March 2013, had a similar VaR to currency of 3.79%, the value at risk in this universe was an estimated Rs.2.3 trillion. This had risen to Rs.2.6 trillion in December 2013.

3.2 What was the economic exposure of the financial firms?

The initial analysis focussed on the manufacturing sector alone. In this section, we include financial firms as well. In this case, we take all financial firms available in Prowess that are listed, and satisfy some threshold level of liquidity. This gives us a total of 492

firms, of which 40 are banks.

We calculate the 99% weekly VaR for the financial firms for both March 2013 and December 2013 as was done for the manufacturing firms. Table 4 presents the average sensitivity (β_c) of the sample of financial firms, along with the equity VaR.

Table 4 Estimates of VaR of the financial sector due to currency volatility

The table presents the value of total assets and the market cap of the sample of financial firms.
It also presents the 99% VaR as the probable 1% loss in the market capitalisation over a one week horizon for the firms, due to movements in the USD/INR.

					(Values in Rs. billion)
	No. of Firms	Average β_c	Total Assets	Total Mcap	VaR (based on Mcap)
March 2013					
Total	492	-1.35	97,641.52	13,644.75	527.00
Banks	40	-1.31	86,586.32	8,003.60	302.76
NonBanks	452	-1.38	11,055.20	5,641.14	224.24
December 2013					
Total	492	-1.35	97,641.52	12,963.13	514.42
Banks	40	-1.31	86,586.32	7,557.88	293.70
NonBanks	452	-1.38	11,055.20	5,405.26	220.73

We see that while the financial sector has a larger sensitivity to currency changes with an average $\beta_c = -1.35$, it is still the manufacturing sector with a significantly larger market capitalisation that dominates the economic exposure to the currency, being almost thrice as large as the financial sector. The economic exposure, including the financial firms, increases to Rs.2.13 trillion from Rs.1.61 trillion, in March 2013. In the financial sector, banks dominate with just 40 listed firms accounting for more than half the VaR. Among the non-bank firms, the risk is spread out over 452 firms.

4 Conclusion

In this note, we estimate the economic exposure of Indian firms to currency fluctuations using the Value at Risk (VaR) approach. We find that, in March 2013, there was a 1% chance that the market capitalisation of a sample of 1703 firms could drop by Rs.1.61 trillion or more in a week due to an extreme move in the currency. This was a potential loss in equity capital of 3.76% of a total market capitalisation of Rs.43 trillion. After the regulatory interventions of July 2013, the VaR increased to Rs.1.78 trillion in December 2013, when market capitalisation had risen to was Rs.46.6 trillion.

This sample only captures a small fraction of firms in the economy with currency exposure. The full market capitalisation of manufacturing firms in March 2013 was Rs.61.2 trillion and Rs.68.8 trillion in December 2013. If the sensitivity of the remaining firms in the economy to currency fluctuations is similar to the sample analysed, then the one week VaR due to currency can go upto Rs.2.6 trillion, 30% higher than for the sample analysed.

We find that the financial sector is more sensitive to currency fluctations, with a higher average β_c at -1.31. It contributes an additional Rs.0.5 trillion to the economic exposure only. This is because the market capitalisation of this sector is less than $5\times$ compared to the real economy manufacturing sector.

However, the small size of the financial sector is a disadvantage for the Indian economy, despite the lower fraction it contributes to the economic exposure from currency fluctuation. It emphasises the lack of capacity in the financial sector to provide services at the size that is required by the manufacturing sector. This should drive the impetus to either reform the Indian financial sector quickly, or open up the capital account in order for domestic economic agents to access financial services and products from the global financial sector.

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