

Operational Currency Mismatch and Firm Level Performance

Abstract

This paper looks at the determinants and effects of exchange rate exposure using data on 500 Indian firms over the period 1995-2011. Unlike the existing papers in the literature, we use a measure of `operational` currency exposure based on foreign currency revenues and costs of firms. Among other factors, exchange rate volatility appears as a significant determinant of average firm level exposure with the direction of relationship supporting the presence of `Moral Hazard` in firm's risk taking behavior. Further large `operational` exposure is associated with significantly lower output growth, profitability and capital expenditure during episodes of large currency depreciation at the firm level. Together this indicates that the policy makers must take into account the incentive effects of their intervention in foreign exchange markets.

Key Words: Operational Currency Exposure, Moral Hazard, Exchange Rate Volatility

Introduction

Impact of exchange rate movements on economic performance is one of the key questions in international economics. Exchange rates were one of the channels through which the recent global crisis affected many emerging market and developing economies across the world. In this regard, economies with balance sheet mismatches were particularly worse off (see Ranciere, Tornell and Vamvakidis (2010)).

Existing literature on currency mismatch and exchange rate exposure largely focuses on the balance sheet mismatches arising out of differences in currency denomination of assets and liabilities of the firms. Little attention has been paid, however, to the costs and revenue side of the currency mismatch. Firms with the same level of mismatch in their assets and liabilities can have very different level of vulnerability to exchange rate changes depending upon the structure of their costs and revenues. If a firm has a large share of its costs going in to buying imported inputs while its output is largely non-traded and sold domestically, it will be much more vulnerable to large currency depreciations when compared to a firm that produces traded goods. Further, these firm level mismatches can have spillover effects on the rest of the economy through demand as well as supply sides. It is therefore important to focus on the operational currency mismatches at the firm level and its impact.

Our paper looks at the firm level exchange rate exposure and its impact on firms' performance using data on 500 Indian firms for the period 1995 to 2011. We use the measure of currency exposure suggested by Bodnar and Marston (2000)¹ who present a measure of exchange rate exposure elasticity based on differences in revenues and costs of emerging market firms².

Two key results emerge out of our analysis. First, exchange rate volatility is inversely associated with operational exposure elasticity. In other words, periods of low exchange rate volatility are associated with higher average absolute exposure amongst the Indian firms and *vice versa*. This supports the 'Moral Hazard' hypothesis of risk taking behavior amongst Indian firms. Periods of low exchange rate volatility (associated with greater central bank intervention to support the value of rupee or manage rupee volatility) encourage firms to take on more risk through higher operational exposure to exchange rate changes as measured by the absolute level of exposure elasticity. One would not expect to see such an association where un-hedged exchange rate exposure is a result of incomplete markets.

Second, 'high' exposure elasticity has a significant adverse impact on firm level performance during episodes of 'large' currency depreciations (both 'high' exposure elasticity and 'large' currency depreciations are defined in detail below). Using alternative measures of firm level performance such as output growth, earnings per share and capital expenditure, we find that the firms with 'high' exposure elasticity perform much more poorly compared to the rest during

¹Unpublished manuscript available at <http://finance.wharton.upenn.edu/weiss/wpapers/2000/00-3.pdf>

² Details of this measure are presented in the next section.

episodes of large Rupee depreciations even though overall the Indian firms seem to benefit from a weaker rupee. Together these results suggest that Indian policy makers should be careful regarding the incentive effects of their intervention in foreign exchange markets. Further, there is need to focus on `operational` mismatches arising out of mismatches in cost and revenue streams of firms apart from the usually discussed asset-liability mismatches .

Our paper relates to a large body micro economic literature looking at the impact of exchange rate fluctuations on firm level performance. A section of this literature looks at the impact of exchange rate changes on firm's value measured by stock returns. Examples of this literature include Adler and Dumas (1984), Jorion (1990), Bodnar and Wong (2000), Dominguez and Tesar (2006), Parsley and Popper (2006). Another strand of the same literature looks at the issue of pricing policies in response to currency fluctuations (for e.g. Goldeberg and Knetter (1997)). Finally a small section of this literature looks at the impact of currency fluctuations on firm level investment (e.g. Goldberg (1993), Campa and Goldberg (1995), Campa and Goldberg (1999), Nucci and Pozzollo (2001)). While this paper is most closely related to the last strand of literature, most of the existing papers in this literature look at developing countries with little attention being paid to the emerging markets such as India. One of the reasons for this gap is the lack of good quality firm level data. In that respect our paper contributes to the existing literature by putting together a large firm level panel dataset for an emerging economy that can be used to answer questions regarding firm level performance macroeconomic variables such as exchange rates.

At the same time this paper is also related to the large macroeconomic literature on currency mismatch and its impact on growth in emerging markets. Key contributions in this literature include Goldstein and Turner (2004), Eichengreen, Hausmann and Pannizza (2007) and Ranciere, Tornell and Vamkvakidis (2010). In most of these papers the focus is on the mismatch between the currency denomination of assets and liabilities. Little attention has been paid to the currency mismatch between costs and revenues of the firms. Such `operational` mismatches are potentially equally important and deserve attention of policy makers and academics alike. Firms with same degree of mismatch in their assets and liabilities can have very different level of vulnerability to exchange rate shocks depending upon whether they produce tradable or non-tradable goods or the extent to which they depend upon imported inputs. This paper fills an important gap in the literature on currency mismatch by focusing on the `operational` mismatch between firm's costs and revenues.

Finally our paper is also linked to the literature on cost of sharp currency devaluations. While theory has been ambivalent regarding the impact of currency devaluations on real activity, empirical literature has also provided mixed evidence regarding the economic impact of sharp currency devaluations (see for example Hutchison and Noy (2005), Hong and Tornell (2005) and Gupta et al (2007)). Unlike most papers in this literature however, we use firm-level longitudinal data set for an emerging market that allows us to take in to account firm level characteristics. Next section describes our dataset in detail.

Our paper is organized as follows: Section 2 describes the data and our measure of currency exposure. Section 3 looks at the determinants of currency exposure while section 4 looks at the impact of exchange rate exposure on firm level performance. Section 5 discusses the policy implications of our results and concludes.

Data

Our data covers 500 Indian firms listed under the BSE 500 Index. Most of the data comes from their Annual Financial Statements and covers the period 1995 to 2011. Firms included under the index represent roughly 93 percent of the total market capitalization on the BSE and cover all the major industries in the Indian economy including construction, infrastructure, iron and steel, textiles, oil refining and marketing as well as non-traditional services such as software and ITeS. The time period covered by our data includes three important economic crisis of the twentieth century – the East Asian crisis; the 2001 dotcom bubble and the 2007 Global financial meltdown. Key variables of interest in our model are growth in output and earnings per share. We use them along with the level of capital expenditure as indicators of firm performance. Our objective is to study the impact of currency exposure on firm level performance as measured by output growth and earnings per share. The key explanatory variable for our analysis is therefore the measure of currency exposure.

Studies trying to measure currency exposure of firms often rely on stock returns data. They estimate exposure of individual firms in `excess` to the overall market exposure to exchange rate changes by regressing firm level stock returns on market level returns and exchange rate returns (see Adler and Dumas, 1984). However, since we need a measure of `absolute` exchange rate exposure at the firm level and not `excess` exposure we use the measure suggested by Bodnar and Marston (2000) instead. We describe the construction of this measure in detail below.

Measuring `Operational` Currency Exposure

Emerging market firms are exposed to exchange rate risks that are often not hedged fully. Ranciere, Tornell and Vamvakidis (2010) in a recent paper show that currency mismatches in emerging markets can be an important source of much needed credit for the emerging markets and can promote their growth by removing credit constraints during good times. At the same time, such currency mismatches can exacerbate the adverse impact of large exchange rate depreciations in these economies.

Important as it is for the firms and policy makers alike, measuring exchange rate exposure is fraught with various difficulties starting from the lack of data to need for proper theoretical framework. The literature has estimated currency mismatch based on two main, straightforward measures. The first is based on the net national debt or debt service requirements to the net exports of a country. The second is based on the ratio of foreign currency denominated liabilities to foreign currency denominated assets of the banking sector. Goldstein and Turner (2004) and Eichengreen, Hausmann and Panizza (2007) provide a review of the first strand of this literature while Lane and Ferretti (2007) and Ranciere et.al. (2010) are the latest example of the second

strand. These measures have the virtue of being simple but they suffer from two important drawbacks. First they lack an underlying theoretical foundation. Second, they ignore the fact that in many cases firms might use off balance sheet transactions to hedge or take on risks. These measures are not able to capture such off balance sheet risks and hedges. Equally important can be the operational `hedges` arising out of firm's decisions regarding location of production, sourcing of inputs etc.

Bodnar and Marston (2000) develop a model of foreign exchange exposure dependent on only three variables, the percentage of the firm's revenues and expenses denominated in foreign currency and its profit rate. `Exposure elasticity` is defined as the percentage change in the firm's profit in response to a one percent change in exchange rate defined as domestic currency per unit of foreign currency. The basic idea of their model is that firms with large differences in foreign currency revenues and costs see much larger changes in their value in response to exchange rate changes and hence have large `exposure elasticity`. In contrast, firms that develop operational hedges, in which they offset foreign currency revenues and costs, can shield themselves from the large-scale effects of exchange rate changes and consequently have, lower `exposure elasticity`. Using the model of a profit maximizing monopoly firm producing and selling goods at home and abroad, they derive the expression of exposure elasticity as follows:

$$\delta = h_1 + (h_1 - h_2)((1/r) - 1) \quad (1)$$

where

δ is the exposure elasticity or percentage change in firm's cash flow in response to a change in exchange rate.

h_1 is the foreign currency-denominated revenue as a percentage of total revenue

h_2 is the foreign currency-denominated costs as a percentage of total costs

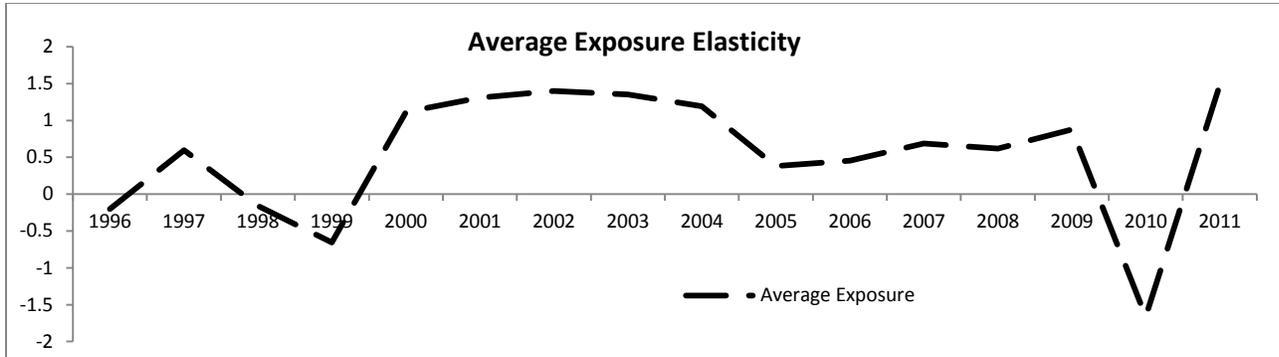
And r is the profit rate (i.e., profits as a percent of total revenues)

The equation above shows that greater foreign currency revenues lead to a greater increase in firm value in response to a depreciation of the home currency and greater foreign currency costs lead to a greater decrease in firm value in response to a depreciation of the home currency. Further, higher profit after tax would lower the exposure elasticity in `absolute` term.

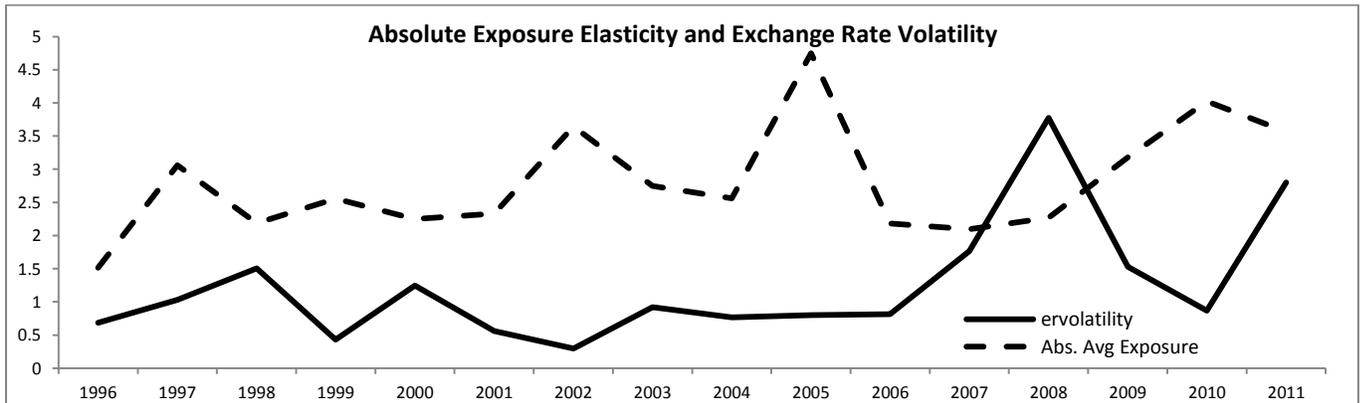
We use data on foreign currency costs, foreign currency revenues and profits from CMIE's PROWESS database to calculate exposure elasticity of the firms in our sample for the period 1995-2011. Top panel of Text Figure [1] plots the cross-sectional average of exposure elasticity between 1995 and 2011. As we can see, average exposure elasticity for Indian firms has been positive for most years between 1995 and 2011 indicating that, overall, the Indian firms benefitted from exchange rate depreciation during this period. Bottom panel of the same figure plots the average absolute exposure elasticity across Indian firms along with annual volatility of weekly Rupee-USD log returns. Key point that emerges from this plot is that periods of low exchange rate volatility are associated with higher absolute exposure elasticity. This indicates the presence of `moral hazard` type behavior amongst Indian firms whereby lower exchange rate

volatility prompts firms to take on higher exchange rate risk. We try to explore this hypothesis further in the next section.

Text Figure [1]



Panel 1

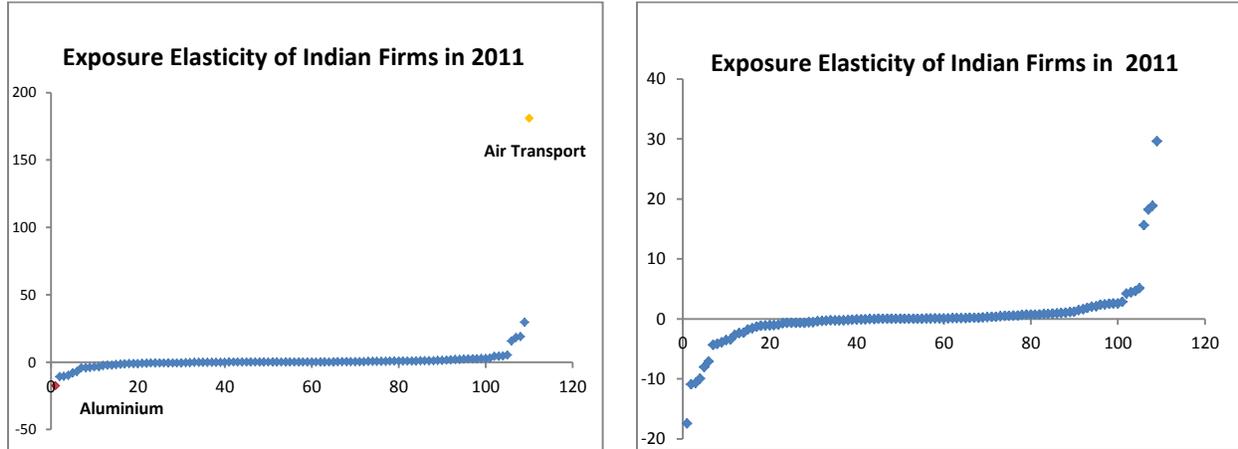


Panel 2

Industry-wise Exposure Elasticity

Average exposure elasticity can hide significant variation across industries. We therefore look at the industry-wise decomposition of exchange rate exposure in Text Figure [2] and [3]. We rely on the industry classification provided by the CMIE in what follows (see appendix for a list of all the industries). Text Figure 2 plots the industry wise average exposure elasticity in year 2011 for the firms in our sample. While the left panel shows all the industries in the sample, the right panel excludes Air Transport industry, which appears to be an outlier, to give a better picture for the rest. For most industries exposure elasticity is small (below 1) but there are a few industries with very large positive / negative operational exposures. Mean exposure elasticity of Indian industries was 1.9 in 2011 with the lowest quartile being -0.64 and the highest quartile being 181. Overall, a majority of Indian industries had positive exposure elasticity in 2011 indicating that at the industry level, more Indian industries were likely to gain from an exchange rate depreciation compared to the number of industries that would lose from such an event.

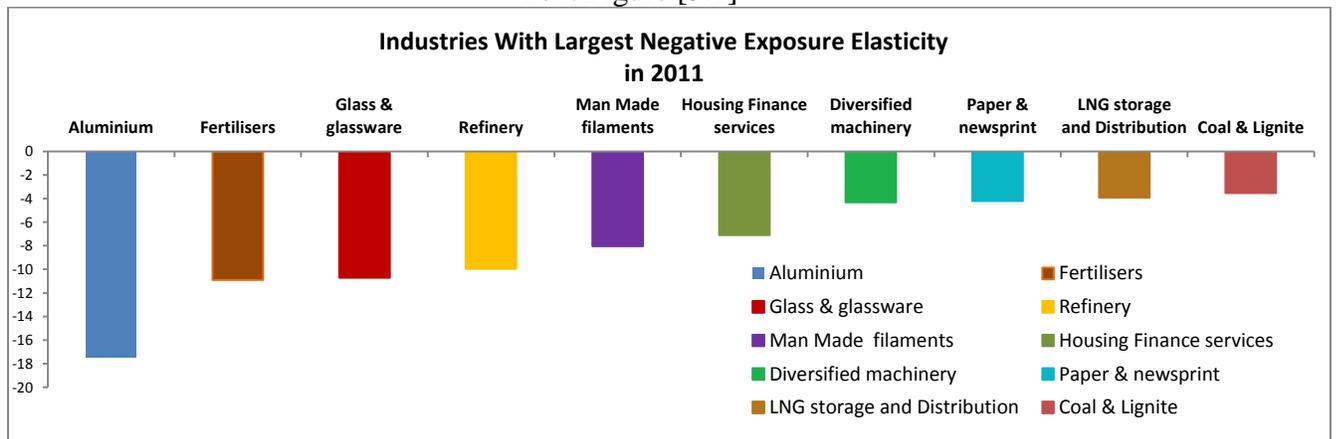
Text Figure [2]



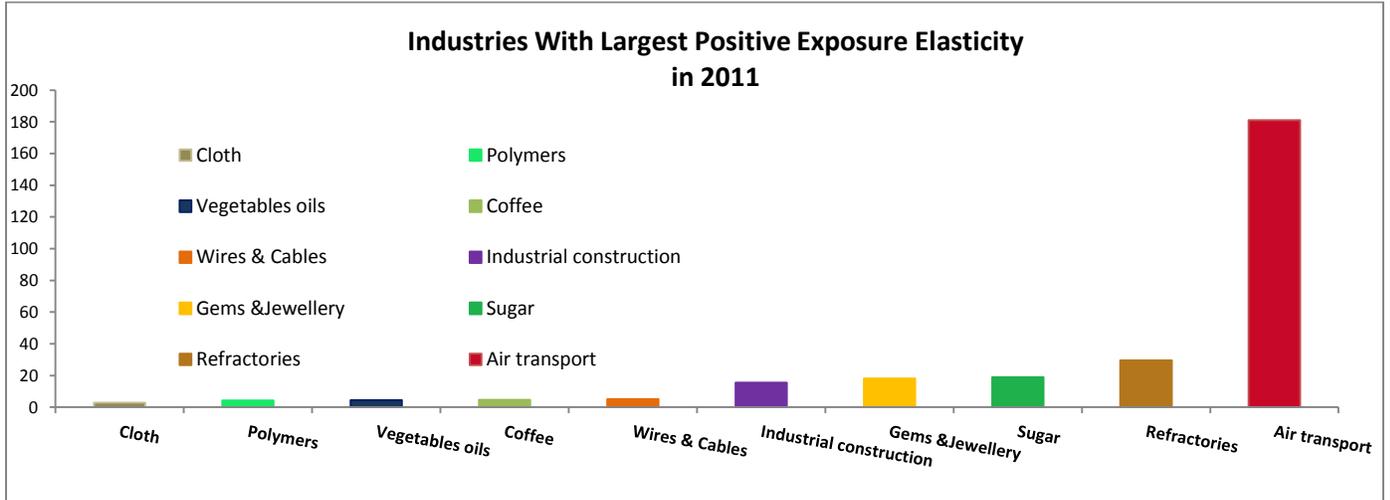
Text figure 3 presents top 10 industries with largest negative and positive exposure in 2011. From the top panel we can see that Aluminum industry had the largest `negative` exposure elasticity followed by fertilizers, glass and glass ware and refining industry. As explained above, a negative exposure elasticity implies that these industries would be hurt by a Rupee depreciation given their cost and revenue profiles. Bottom panel of the same figure shows the industries with largest positive exposure elasticity or industries likely to benefit the most from Rupee depreciation. These include Air transport which has the largest positive exchange rate exposure followed by refractories, sugar, gems and jewellery and industrial construction.

Overall, industries with large negative exposure are the ones with a very high share of imported inputs in their total cost relative to the share of foreign income in their total income. (e.g. imports comprised about 40 percent of the total cost in Aluminum industry while its share of foreign exchange earnings was only 30 percent of its total income in 2011). Opposite is true for firms with large positive exposure elasticity. Air transport services, for example, had 1.5 percent of its total costs going towards imports even though its share of foreign income in the total income was 18.5 percent. What matters for the exposure elasticity (both its size and direction), therefore, is the relative difference between the foreign currency costs and revenues.

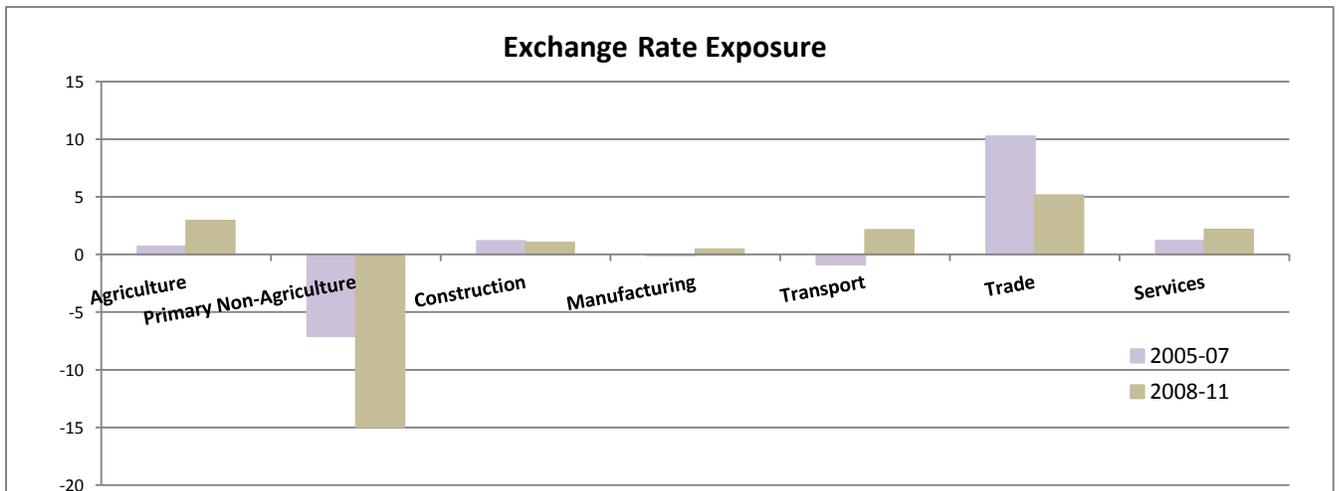
Text Figure [3.1]



Text Figure [3.2]



Text Figure [4]



To get a better picture of the industry-wise exposure we further club these industries in to seven broad categories and look at their average exchange rate exposure over time in Text Figure 4 which plots the average exposure elasticity of these seven industries during 2005-07 and 2008-2011. Looking at the 7 year period between 2005 and 2011, the average exposure elasticity increased for most of the Indian industries between 2005-07 and 2008-11 – construction and trade being the two exceptions. While agriculture, construction, trade and services (excluding banking) exhibit positive exposure elasticity during both periods; primary non-agricultural sector (which includes fossil fuels) has negative exposure elasticity in the two periods. Once again it appears that a majority of Indian industries are likely to benefit from exchange rate depreciation on account of their `operational` exposure. The large negative exposure of the primary non-agricultural sector is a cause for worry however especially since output from this sector includes crucial inputs for other sectors such as oil and Aluminum.

Operational Exposure Elasticity and Exchange Rate Regime

Theory gives different explanations for underinsurance in emerging markets which can be largely divided into two categories – ‘Moral Hazard’ and ‘Incomplete Markets’. While the former explanation looks at implicit or explicit government guarantees in the form of bank bailouts and fixed exchange rate regimes, the latter looks at market frictions resulting in inadequate provision of hedging. The former explanation implies that the degree of central bank intervention would have a direct impact on the risk taking behavior of individual firms. In the latter case, one would not expect to see any discernible relationship between exchange rate regime and currency exposure.

Based on this insight Shah and Patnaik (2010) test the ‘moral hazard’ hypothesis in the case of India. India presents a unique natural experiment that can be used to test the impact of differing exchange rate volatility on firm level exchange rate exposure. Shah and Patnaik (2010) use Bai and Perron (2003) algorithm to identify structural breaks in the volatility of weekly Rupee – Dollar returns. They use this to test the impact of exchange rate regime on un-hedged currency exposure amongst a set of 100 Indian firms and find evidence in support of the moral hazard hypothesis. In similar spirit, we try to test whether operational mismatches in costs and revenues are related to exchange rate regimes.

We divide the entire sample into four time periods for our analysis. Division of the sample is based loosely on the study by Shah and Patnaik (2010). Given that we have annual data unlike Shah and Patnaik (2010) that uses weekly data; we use their break points and match them with our annual series. This however leaves out the period since year 2007. For this period we use data between years 2009 and 2011 in order to avoid confounding our results due to the impact of global financial crisis.

Text Table [1]: Summary Statistics of Delta

Period	Variable	Mean	Variance	Volatility INR/USD	Reserve Accumulation as Percentage of Net Capital Inflows
1996-1998	$\bar{\delta}_1$	0.30	200.6	0.53	26.86
1999-2003	$\bar{\delta}_2$	0.87	50.82	0.046	84.3
2004-2006	$\bar{\delta}_3$	0.71	88.87	0.22	47.0
2009-2011	$\bar{\delta}_4$	0.21	271.1	1.01	0.09

Text Table [1] gives the average exposure elasticity ‘delta’ on Indian firms in the four periods along with the volatility in INR/USD weekly returns in those periods. The first thing to note is that the volatility of INR-USD weekly returns varies substantially across the four periods even

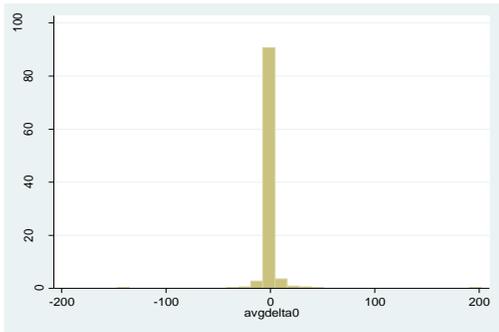
though India has had a *de jure* 'managed float' throughout this period. This result is in line with Shah and Patnaik (2010, 2011). Thus, even though India had a managed floating exchange rate regime throughout this period the extent to which the central bank authorities intervened in the foreign exchange market and tried to control rupee volatility varied. Again in line with the findings in Shah and Patnaik (2010), rupee volatility was higher in the first period that included the Asian financial crisis. It came down during the next five year period between 1999 and 2003 following which the volatility increased again. During the latest period (between years 2009-2011) volatility of Rupee has gone up even further (this holds true even if we exclude the year 2011).

Column 3 above shows the mean exposure elasticity of the firms in our sample during different periods. Average exposure elasticity of the firms in our sample is positive for all the four periods under consideration. This indicates that overall, Indian firms have tended to benefit from Rupee depreciation on account of their operational currency mismatch. At the same time, the average exposure elasticity has been higher in periods when the exchange rate volatility was lower. Average exposure elasticity increased from 0.3 in the first period (volatility 0.53) to 0.87 (volatility 0.046) in the second period. Subsequently, as the exchange rate volatility increased the average exposure elasticity came down.

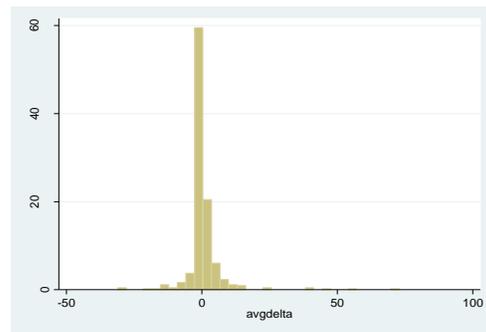
This indicates that on an average, Indian firms have tended to expose themselves more heavily to a Rupee appreciation risk during periods of low exchange rate volatility. This is most likely a reflection of the fact that periods of low exchange rate volatility in India have been associated with a higher net inflow of foreign capital that were sterilized by the authorities in order to prevent Rupee appreciation and used to build up reserves. The last column in Table 1 provides some evidence to this effect. It presents the ratio of average reserve accumulation to average net capital inflow for the four periods. As we can see, periods of low exchange rate volatility are associated with a higher ratio of reserve accumulation to net capital inflows which is reflective of monetary sterilization of foreign exchange inflow by the central bank.

Finally, column 4 of Table 1 presents the variance of exposure elasticity in the four periods. Looking at this column one finds that periods of high exchange rate volatility are associated with a higher degree of variance in exposure elasticity even though the average exposure elasticity is lower in these periods. This makes intuitive sense as the uncertainty associated with higher exchange rate volatility gets reflected in firms' decision regarding their exchange rate exposure. The kernel density and histogram plots of average delta for the four periods presented below show the same thing. While a large number of firms have exposure elasticity clustered around zero, there has been a significant increase in large sized exposures (both negative and positive) in recent years concomitant with the rise in exchange rate volatility. It is therefore important for policy analysts and firms alike to focus on the determinants and effects of such 'operational' currency mismatches in their costs and revenues. The next two sections of the paper attempt to do that.

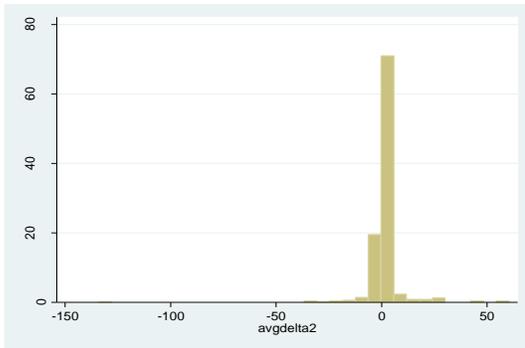
Figure 1: Histogram Plots



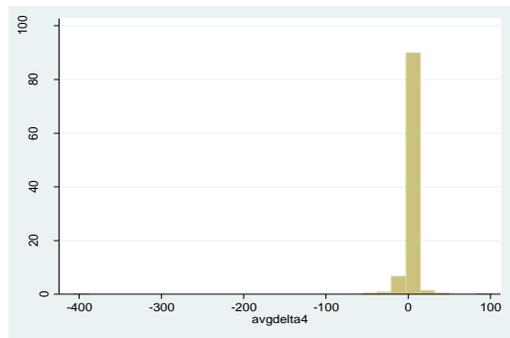
1996-1998



1999-2003

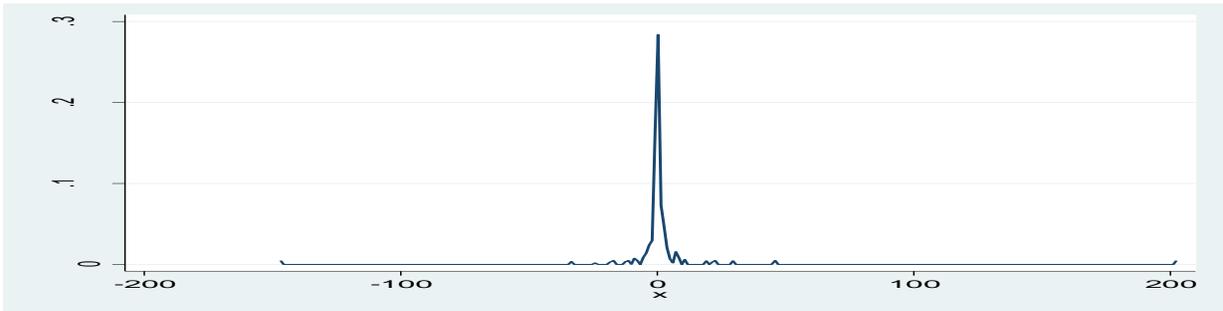


2004-2006

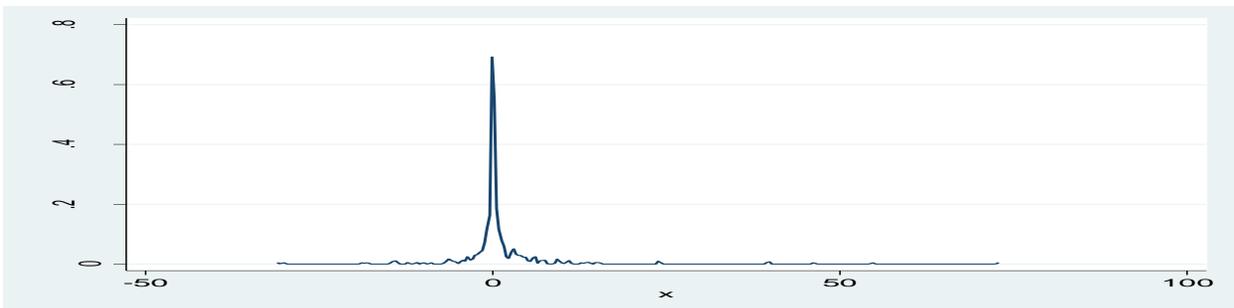


2009-2011

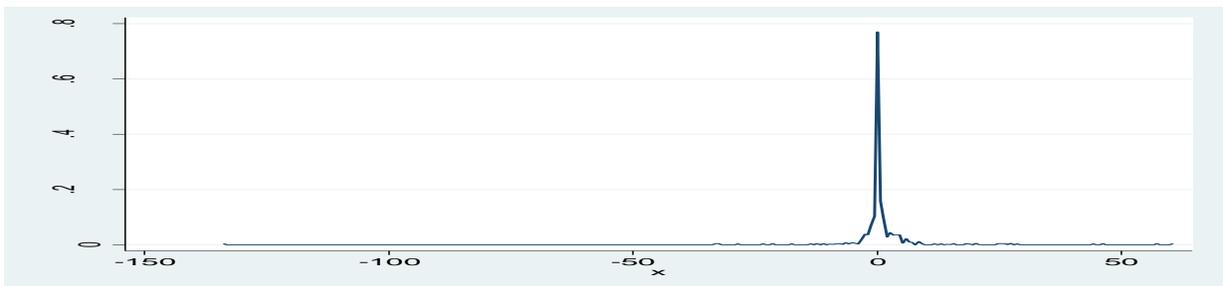
Figure 2: Kernel Density



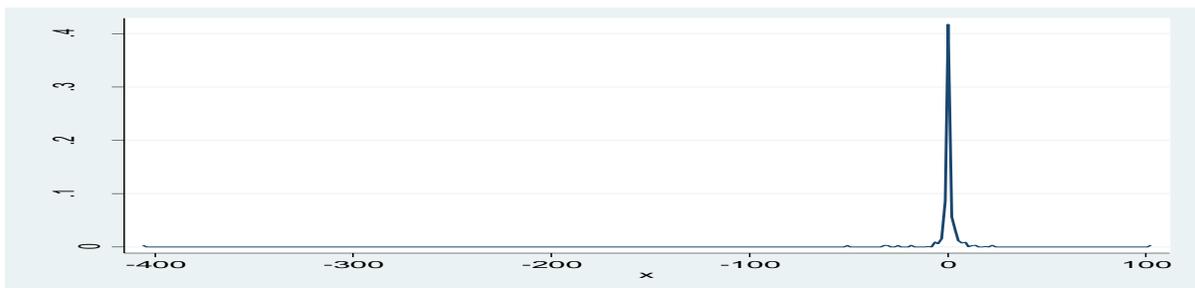
1996-1998



1999-2003



2004-2006



2009-11

Determinants of Firm Level Exposure

As discussed above, recent years have seen an increase in the size of currency mismatch between the costs and revenue sides of Indian firms. In this section we explore the determinants of firm level exposure elasticity in India. We would like to study the factors that are associated with higher absolute level of currency exposure at the firm level especially those directly or indirectly related to government policies. In this regard, the key variable for interest for us in this exercise is the volatility in exchange rate. Exchange rate in India has been market determined but subject to the Central Bank intervention that has tried to keep its volatility under check. The econometric model used for this exercise is given below:

$$|\delta_{i,t}| = \alpha_i + \beta_i X_{i,t} + \varepsilon_{i,t} \quad (2)$$

Our dependent variable is the absolute size of $|\delta_{i,t}|$ or the exchange rate exposure elasticity calculated above. The set of explanatory variables $X_{i,t}$ includes share of exports in sales, growth rate of sales, volatility in exchange rate and log of market capitalization. Our Hausman's specification test between random and fixed effects estimator selected the former hence we used it for estimating equation (1). Text Table (2) presents the results from this exercise. Column 1 presents the results from the entire sample while the remaining columns present the results of different sub-samples. We begin by discussing the results for exchange rate volatility which is the key variable of interest for us.

Exchange rate volatility has a negative and significant coefficient in our model. This indicates that higher exchange rate volatility as measured by the annual standard deviation of weekly log returns on Rupee/ USD exchange rate is associated with lower `operational` exposure on average. This can be due to a greater mismatch between their foreign exchange revenues and costs or due to a lower profit rate or both. To check which of these is true, we regress growth in profits and absolute size of revenue-cost mismatch (absolute value of the difference between h_1 and h_2) on a set of time and firm specific fixed effects and exchange rate volatility. Results from this exercise are given in the Appendix 2. We find that exchange rate volatility does not have a statistically significant effect on the growth of firm's profits (in fact it has a positive coefficient), though it is significantly and positively associated with the `operational` foreign currency mismatch as measured by the absolute value of the difference between h_1 and h_2 .

Our result is therefore in line with the findings of Shah and Patnaik (2010) and supports the `Moral Hazard` hypothesis. Periods of high exchange rate volatility are associated with higher absolute level of exposure elasticity as compared to the periods with low exchange rate volatility indicating that whenever government tries to stabilize the exchange rate in order to keep its

volatility under check, the result is an increase in the risk taking behavior of the private sector as reflected in higher exposure elasticity as well as higher `operational` currency mismatch.

Share of exports in total sales is positively related with the size of exposure elasticity indicating that more export oriented firms tend to see much higher levels of exposure elasticity. On an average, a one percent increase in the share of exports in total sales is associated with a 2.8 basis points increase in the size of exposure elasticity. This result holds across different sub-samples as shown by the remaining columns. To check for the direction of exposure we replace absolute value of delta with the actual exposure elasticity delta in the same model as above and find that share of exports is positively related to delta indicating that firms with higher share of exports have more `positive` exposure elasticity or they tend to benefit from an exchange rate depreciation on an average, *ceteris paribus*³.

Growth rate of sales is positively associated with the size of exposure elasticity. Firms with better growth prospects as reflected in higher sales growth exhibit higher exposure elasticity. At the same time, exposure elasticity is negatively related to the firm size as measured by their market capitalization. Larger firms tend to have smaller exchange rate exposure elasticity.

One possible explanation of the last result might be that market capitalization is positively correlated with the profit rate indicating that smaller exposure elasticity of `large` firms reflects their higher profitability. `Smaller` firms are more vulnerable to exchange rate changes due to lower profit margins. There is some evidence to support this view. However, since our main focus is on the relationship between exchange rate volatility and firm level exposure, we leave this hypothesis for future research.

Text Table [2]

Dependent Variable: Absolute size of Delta	Entire Sample	Excluding Mining	Excluding Services	Manufacturing
Exports as a Percentage of Sales	0.028*** [0.005]	0.029*** [0.005]	0.028*** [0.005]	0.032*** [0.008]
Growth in Sales	0.16** [0.066]	0.17** [0.068]	0.18** [0.07]	0.21** [0.10]
Exchange Rate Volatility	-0.11*** [0.03]	-0.11*** [0.03]	-0.11*** [0.03]	-0.11*** [0.04]
Market Capitalization	-0.24*** [0.05]	-0.26*** [0.05]	-0.22*** [0.05]	-0.27*** [0.07]
Hausman's specification test:	Chi2(4) = 21.59 P val. 0.00			

³ Results for this exercise are available upon request from the authors.

Next section looks at the relationship between exposure elasticity and firm level performance measured by their output growth and earnings per share.

Aggregate Exchange Rate Exposure and Firm Level Performance

Objective of this exercise is to look at the impact of large currency exposure on firm level performance. We use the measure of exposure elasticity described above to do so. Details of the models and their estimation are provided below.

Output Growth And Exposure

$$(1) Y_{i,t} = \alpha_i + \beta X_{i,t} + \sum_{i=0}^p \gamma_i D_i + \sum_{i=0}^q \lambda \times D_i \times Exposure_{i,t} + \sum_{i=0}^s \theta \times Exposure_{i,t} + \varepsilon_{i,t}$$

Our first specification is given above. The dependent variable in the above equation is the growth rate of output. $X_{i,t}$ is a set of explanatory variables that vary across firms and time periods. These include the growth rates of *employment* (as measured by the number of workers) and *unit labor cost* (defined as Total Emoluments to Workers divided by the Total Value of Output) along with growth in *market capitalization* and *share of exports in total sales*.

As we saw in section 2, there has been a significant increase in large sized exposures (both negative and positive) in recent years concomitant with the rise in exchange rate volatility. We therefore try to capture the impact of large exposure elasticity on firm performance by using a dummy. $Exposure_{i,t}$ is the exposure elasticity dummy that takes a value 1 whenever the absolute value of exposure elasticity $\delta_{i,t}$ is greater than 2.5⁴ and zero otherwise. We also try to include absolute exposure elasticity in levels but it does not have a significant coefficient and our main results remain unchanged even after its inclusion. Hence we do not report those results separately.

Since our focus is on the impact of exchange rate exposure of firms which would be expected to have a greater impact during episodes of large currency changes we include a dummy for large nominal depreciation of Rupee and its interaction with the exposure dummy in our analysis. D_t is the dummy for large nominal depreciation of Rupee which takes a value of one whenever the annual rate of increase in the monthly Rupee/USD exchange rate is more than one standard deviation above the average annual rate of exchange rate change for this period and zero otherwise. With this criterion, currency devaluations are defined as sharp decline in Rupee / USD exchange rate exceeding 10 percent on an annual basis. The reason for using nominal Rupee USD exchange rate for defining depreciation episodes is that Indian Rupee has been de-facto pegged to USD (Ref. Patnaik and Shah (2010))¹. This definition helps us identify four episodes of large depreciations in Indian Rupee – 1995, 1998, 2008 and 2011.

⁴ The cut-off value of 2.5 represents the top 2.5 percentile of the distribution of $|\delta_{i,t}|$. Using alternative values of this cut-off does not change our results significantly.

The interaction term between the crisis dummy and firm level exposure dummy captures the impact of higher level of exchange rate exposure on firm's output growth during episodes of large exchange rate depreciations. An overall exposure elasticity of 1 increases the output growth of firms in our sample by θ during `normal` times. At the same time, an exposure elasticity of 1 changes the output growth of firms by $\theta + \lambda$ during currency depreciation episodes. $\varepsilon_{i,t}$ is the random error. In addition to the above variables we also try a number of industry and firm level fixed effects to capture the impact of omitted variables. They do not, however, affect our main results. The entire sample consists of 500 firms over a period of 17 years or 8500 firm-years of data.

Table [3] gives the results from this exercise (figures inside the brackets are robust standard errors corrected for intragroup correlation). We discuss the results in the following paragraphs.

Text Table [3]

Dependent Variable: Output Growth	Entire Sample	Manufacturing	Non-Manufacturing	Excluding Mining	Excluding Services
Exposure Dummy	0.02 [0.05]	0.02 [0.05]	0.07 [0.10]	0.05 [0.028]	0.00 [0.05]
Depreciation Dummy	-0.027 [0.05]	-0.037 [0.05]	-0.15 [0.15]	-0.02 [0.05]	-0.02 [0.05]
Lag Depreciation Dummy	-0.07 [0.05]	-0.09** [0.04]	-0.00 [0.14]	-0.07 [0.06]	-0.05 [0.05]
Deprecation Dummy * Exposure Dummy	-0.027*** [0.004]	-0.047** [0.02]	-0.027*** [0.006]	-0.04** [0.01]	-0.03*** [0.003]
Employment Growth	0.27** [0.13]	0.15** [0.07]	0.73*** [0.17]	0.015** [0.07]	0.26** [0.13]
Unit Labor Cost Growth	0.013 [0.04]	0.02 [0.04]	0.03 [0.05]	0.03 [0.03]	0.00 [0.04]
△ Market Capitalization	-0.02 [0.05]	0.03 [0.05]	-0.15 [0.09]	-0.05 [0.05]	-0.01 [0.05]
F-Statistic	7.5 [0.00]	2.47 [0.01]	6.6 [0.00]	2.3 [0.02]	7.39 [0.00]
R-sq Within	0.05	0.03	0.11	0.02	0.05

The second column of Table 3 gives the estimation results for the entire sample. The key variable of interest for our analysis is the exposure dummy which enters with a positive coefficient in the estimated equation indicating that a higher level of exposure elasticity is associated with a higher level of output growth. Though the coefficient on the exposure dummy is not significant, this none the less indicates that firms tend to take on currency exposure as a rational response to the higher output growth associated with it during normal times. This result holds across different sub-samples as seen from the remaining columns.

Next two rows give the coefficients on current and lagged dummy for large currency depreciations. While literature has found both positive and negative effects of currency depreciations on growth, theory is not clear regarding the direction of this relationship. Large currency depreciations can help growth by boosting exports. At the same time they can also have an adverse impact on growth through a rise in the cost of imported inputs, worsening of balance sheets and an increase in the financial fragility. Large currency depreciations are associated with a decline in output growth as seen from the negative coefficients on the current and lagged dummies. However, coefficients on these dummies are insignificant except for the case of manufacturing firms where the coefficient is large and significant. Episodes of large Rupee depreciation reduce the output growth of manufacturing firms by nine percent on average with a lag of one year. One possible explanation for this result can be greater reliance of manufacturing sector on imported inputs with few domestic substitutes. The other reason can be greater reliance of manufacturing firms on external finance due to relatively less own equity capital. However, further exploration of this result would require more detailed data than is currently available. We therefore leave it for future research.

Finally, we look at the interaction term between the depreciation dummy and the exposure size dummy. The coefficient on this interaction term is negative and significant for all the subsamples in our study. Thus, large currency depreciations reduce the output growth in firms with large exposure elasticity by a much higher percentage compared to the rest. For the entire sample, the average loss in output growth due to large currency depreciation is almost three percentage points higher in firms with high exposure elasticity as compared to the rest. Thus, policy makers and business managers alike should monitor their `operational` exposure to exchange rate fluctuations.

Of the other variables used in the model employment growth is the only one which has a significant coefficient. The rest do not appear to have a significant impact on output growth. Higher employment growth is associated with a faster output growth as expected. Employment elasticity of output growth is higher for non-manufacturing firms when compared to manufacturing firms.

It is quite possible that large negative and positive exposure elasticity has different impact on firm level performance. We therefore repeat our analysis with separate dummies for large negative and positive exposures. However, Wald test for coefficient restrictions showed that the coefficients on them were not significantly different from each other. We therefore continue with our original specification.

Profitability and Exposure

The key insight from the above exercise is that higher level of exchange rate exposure elasticity is associated with a greater loss in output growth during episodes of large Rupee depreciation even though it appears to affect output growth positively during `normal` times. We next try to do the same analysis for earnings per share which is used as a measure of firm's profitability.

Our model is the same as in equation 1 except that the dependent variable is now earnings per share⁵. Table [4] presents the results from this exercise.

The first row of Table [3] gives the coefficient on exposure dummy. Unlike the model for output growth, the sign of the coefficient on exposure dummy changes across different sub-samples in case of the model for earnings per share. The coefficients are insignificant in all the cases, though. Overall, there does not appear to be a strong relationship between the exposure elasticity and firm level profitability.

Looking at the depreciation dummy we find that the coefficient is positive but insignificant for all the sub-samples. Since the coefficient on depreciation dummy gives the average impact of large currency depreciations on earnings per share when the exposure dummy is zero, a positive coefficient indicates that large currency depreciations tend to raise earnings per share for firms with exposure elasticity below the threshold of 2.5. In other words, currency depreciation are beneficial for firms with 'low' exposure elasticity.

Third row of the table below gives the coefficient on the interaction term between the depreciation dummy and the exposure dummy. The coefficient on the interaction term is negative and significant for all the sub-samples except for non-manufacturing firms where the coefficient is insignificant though of correct sign.

Of the remaining variables, unit labor cost and growth in market capitalization are significantly correlated with earnings per share. While higher unit labor cost is associated with lower earnings per share as expected, the coefficient is significant for manufacturing firms only at 10 percent level of significance. Growth in market capitalization is positively related to earnings per share. In the last case, the direction of causality can actually run from earnings per share to the growth in market capitalization as high earnings per share increases the market price of share and hence the value of company's outstanding capital stock. We therefore try to use lagged growth in market capitalization as an instrument. Our results remain unchanged with lagged market capitalization as instrument. One possible explanation for this result is that higher market capitalization, by lowering the cost of raising capital increases earnings per share of firms.

Once again, as in the previous section, the key insight from the above exercise is that large exposure elasticity significantly raises the cost of currency depreciations in terms of lower earnings per share. While earnings per share increases slightly in response to currency depreciation for firms with 'low' exposure elasticity, it declines significantly in case of firms with 'high' exposure elasticity. The difference is especially noticeable for manufacturing firms.

In the next section we try to explore possible transmission channel from exposure elasticity to firm level output growth.

⁵ We tested for the presence of unit roots in all our series using Fisher's panel unit root test and were able to reject the null of unit root for all of them.

Text Table [4]

Dependent Variable: Earnings Per Share	Entire Sample	Manufacturing	Non-Manufacturing	Excluding Mining	Excluding Services
Exposure Dummy	-0.82 [1.5]	-2.2 [2.16]	1.2 [2.2]	-0.67 [1.6]	-2.8 [1.8]
Depreciation Dummy	0.59 [1.3]	0.62 [2.1]	0.51 [1.7]	0.70 [1.3]	0.49 [1.7]
Depreciation Dummy *Exposure Dummy	-4.2** [1.7]	-5.3** [2.4]	-2.5 [2.5]	-3.9** [1.7]	-4.4** [2.1]
Employment Growth	-0.32 [0.85]	1.9 [0.99]	-1.29 [1.1]	-0.31 [0.92]	1.8 [0.97]
Unit Labor Cost Growth	-1.17** [0.50]	-1.96 [1.1]	-1.16** [0.53]	-1.2** [0.54]	-1.6 [0.9]
△ Market Capitalization	4.49*** [0.75]	5.1*** [1.3]	4.3*** [0.94]	4.6*** [0.79]	5.7*** [0.97]
F-Statistic	128.1 [0.00]	16324.6 [0.00]	311.6 [0.00]	124.9 [0.00]	96.8 [0.00]
R-sq Within	0.14	0.17	0.13	0.16	0.13

Capital Expenditure and Exposure Elasticity

One of channels through which high exposure elasticity can lead to a reduction in output growth is through lower investment. We try to explore that channel in this section. Below we present the estimates of a model for firm level capital expenditure augmented with variables capturing firm level exposure. Unfortunately we do not have data on capital expenditure for the firms in our sample prior to year 2002 hence we have to restrict this part of our analysis to period after year 2002.

Text table 5 presents the results from this exercise. Our dependent variable is the log of capital expenditure⁶. We test for the presence of unit root in the series for capital expenditure using Fisher's panel unit root test and are able to reject the null hypothesis of unit root. The test however does point towards persistence in the series in the form of lagged dependent variable. We therefore use a log-linear specification with a single lag of the dependent variable for the benchmark model. Since there are well known problems of estimating dynamic panel models with lagged dependent variable, we use the system GMM estimator suggested by Arellano and Bover (1995) and fully developed by Blundell and Bond (1998) for our analysis. Key variables of interest for us are the dummies for exposure and currency depreciation along with their interaction term. However, we also use several firm specific variables that can potentially affect the level of capital expenditure by the firm. At the same time we also include industry specific

⁶ Figures in the parenthesis are the `robust` standard errors.

time effects to capture industry specific omitted variables that vary over time. These omitted variables could include industry specific shocks to demand and/or productivity along with industry specific policy shocks.

The first row in Table 5 gives the coefficient on the lagged dependent variable which is positive and significant for all the specifications. Capital expenditure does seem to exhibit strong persistence. Given that the decisions regarding capital expenditure are long-term, persistence in shocks to capital expenditure makes intuitive sense.

The second row shows the coefficient on the dummy for large currency depreciation. In combination with the interaction term in column 4, this coefficient can be interpreted as the impact of large currency depreciation on firms with `low`⁷ exposure elasticity. Large currency depreciation seems to boost the level of capital expenditure for firms with `low` exposure elasticity *ceteris paribus* (though the coefficient is not significant). On the other hand, firms with `high` exposure elasticity see a significant reduction in their capital expenditure during episodes of large currency depreciations as seen from the negative and significant coefficient on the interaction term between the depreciation and exposure dummies. To elaborate further, firms with `large` exchange rate exposure elasticity see a reduction in their capital expenditure by about 25 basis points relative to the rest during episodes of large currency depreciation. On the whole, firms with large exchange rate exposure see a reduction in their capital expenditure by around 15 to 18 basis point during episodes of large currency depreciation while `low` exposure firms see an increase in their capital expenditure by around 10 to 12 basis points.

Next we look at the dummy for large currency exposure (column 3 in Table 5). Firms with large exchange rate exposure tend to have a higher level of capital expenditure compared to the rest as seen from the positive and significant coefficient on the exposure dummy. Compared to the `low` exposure firm; firms with `large` exposure elasticity have a capital expenditure level that is 24 to 25 basis points higher on average. However, this gap is reversed during periods of large currency depreciations. Firms with large exchange rate exposure tend to see a capital expenditure level that is 2 to 3 basis points lower than the low exposure firms on average. Thus firms with large exposure elasticity perform better than the rest during `normal` periods but are worse off than the rest during periods of large currency depreciation when we look at the level of capital expenditure. It must be emphasized that these correlations do not necessarily imply a causal relationship between exposure elasticity and the level of capital expenditure. Establishing such a causal relationship would require further analysis beyond the scope of this study.

The remaining variables do not exhibit a significant relationship with the level of capital expenditure once we have taken in to account time varying industry level fixed effects.

⁷ Firms with `Low` exposure elasticity are those with an exposure elasticity below the threshold of 2.5. In similar vein, firms with `High` exposure elasticity are those that have an exposure elasticity above 2.5

The key insight of our analysis in this section is that, just like in the case of output growth and earnings per share, higher exchange rate exposure elasticity is associated with a lower level of capital expenditure during episodes of large currency depreciation even though it is associated with a higher level of capital expenditure during `normal` time. This provides one potential channel through which higher exposure elasticity leads to a lower output growth and lower earnings per share during periods of large currency depreciation.

Text Table [5]

Dependent Variable: Log(Capital Expenditure)	Model 1	Model 2	Model 3	Model 4
Log(Capital Expenditure[t-1])	0.50*** [0.16]	0.53*** [0.18]	0.46*** [0.16]	0.49*** [0.18]
Depreciation Dummy	0.12 [0.07]	0.09 [0.08]	0.11 [0.07]	0.11 [0.07]
Exposure Dummy	0.25** [0.1]	0.24** [0.10]	0.24** [0.09]	0.25** [0.10]
Depreciation Dummy* Exposure Dummy	-0.27** [0.12]	-0.27** [0.13]	-0.25** [0.12]	-0.25** [0.10]
Log(Market Capitalization)	0.16 [0.09]	0.12 [0.09]	0.17 [0.08]	0.16 [0.08]
Log(Income)		-0.22 [0.20]		-0.12 [0.14]
Exports as Percentage of Sales			-0.00 [0.00]	-0.00 [0.00]
Constant	9.7** [4.1]	11.2*** [4.2]	10.7** [4.2]	11.1*** [4.1]
Sargan's Test (P-Val.)	0.096	0.30	0.028	0.057
Total Number of Observations	2477	2465	2457	2456

Conclusion

This paper aims at exploring the causes and effects of large `operational` currency exposure in one of the key emerging markets of the world – India. We use a firm level panel data set covering the period between 1995 and 2011. The key findings of the paper can be summarized as follows – exchange rate volatility has a significant effect on the level of currency exposure of Indian firms apart from firm specific factors such as size growth. Further, large `operational` exposures have significant impact on the level of output growth, earnings per share and capital expenditures of the firms during episodes of large exchange rate depreciations even though they seem to encourage higher capital expenditure and output growth during `normal` times. The results have important implications for policy makers worried about mitigating the impact of exogenous shocks. Implicit and explicit guarantees with regards to the value of exchange rate

tend to raise the vulnerability of the economy to exchange rate shocks at same time that they encourage capital expenditures and possibly output growth during 'normal' times.

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Appendix I

List of Industries

Abrasives	Fertilisers	Electricity generation
Air transport	Films	Engines
Air-conditioners	Footwear	Other recreational services
Aluminium	Gems & Jewellery	Other storage & distribution
Auto-finance	General purpose machinery	Other textiles
Automobile Ancillaries	General transformers & switchgears	Other transports equipment
Bakery	Glass & glassware	Paints & Varnishes
Banking	Health services	Paper & newsprint
		Passenger cars & multi utility vehicles
Beer & Alcohol	Hotels & restaurants	Pesticides
Boilers & Turbines	Housing construction	Plastic films & flexible packaging
Books & Cards	Housing Finance services	Plastic furniture floorings & misc.
Business consultancy	Industrial construction	Plastic packaging
Castings & Forgings	Industrial machinery	Polymers
Caustic soda	Infrastructural construction	Shipping transport services
Cement	Infrastructure finance services	Sponge iron
Ceramics products	Investment services	Steel
Cloth	ITES	Steel pipes & Tubes
Coal & Lignite	LNG storage and Distribution	Storage batteries
Coffee	Lubricants	Sugar
Commercial complexes	Man Made filaments	Tea
Commercial vehicles	Media-broadcasting	Telecommunication services
Communication equipment	Media-print	Tobacco products
Computer software	Metal products	Tourism
Construction equipment	Minerals	Tractors
Consumer electronics	Misc. electrical machinery	Trading
Copper & copper products	Organic chemicals	Transport logistics services
Cosmetics	Other agricultural Products	Two & Three Wheelers
Cotton & Blended Yarn	Other asset financing services	Tyres & Tubes
Crude oil & Natural Gas	Other chemicals	Vegetables oils
Dairy products	Other construction	Wires & Cables
Diversified	Other electronics	Vegetables oils
Diversified Automobile	Other financial services	Wires & Cables
Diversified cotton textiles	Other industrial machinery	
Diversified machinery	Other misc services	
Drugs & Pharmaceuticals	Other non-ferrous metals	

Appendix 2

Table A

Dependent Variable: PAT Growth	Entire Sample	Manufacturing	Non-Manufacturing
Exchange Rate Volatility	3.2 [31.3]	-2.2 [34.0]	11.1 [50.5]
R-squared	0.002	0.004	0.006
F-statistic	1.45 [0.10]	1.96 [0.00]	0.98 [0.47]
Total Number of Observations	6328	3150	3178

Table B

Dependent Variable: <i>Abs. size of $h1-h2$</i>	Entire Sample	Manufacturing	Non-Manufacturing
Exchange Rate Volatility	-0.012*** [0.002]	-0.012*** [0.003]	-0.012*** [0.003]
R-squared	0.01	0.04	0.01
F-statistic	3.98 [0.00]	3.77 [0.00]	2.47 [0.00]
Total Number of Observations	6506	3214	3292
