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Does the currency regime shape unhedged currency exposure?

Ila Patnaik*, Ajay Shah

National Institute of Public Finance and Policy, 18/2 Satsang Vihar Marg, New Delhi 110067, India

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A B S T R A C T

This paper examines how unhedged currency exposure of firms varies with changes in currency flexibility. A sequence of four time periods with alternating high and low currency volatility in India provides a natural experiment in which changes in currency exposure of a panel of firms is measured, and the moral hazard versus incomplete markets hypotheses tested. We find that firms carried higher currency exposure in periods when the currency was less flexible. Our results support the moral hazard hypothesis: that low currency flexibility encourages firms to hold unhedged exposure in response to implicit government guarantees.

1. Introduction

The choice of exchange rate regime has seen renewed debate among policy makers and researchers in recent times (Ghosh et al., 2002; Ize and Yeyati, 2003; Fischer, 2006). One possible rationale for currency pegging or the "fear of floating" in emerging markets is the financial fragility of banks and firms. It is argued that incomplete financial markets in emerging economies limit the capacity of firms to hedge their currency exposure, and that the exposure of firms leads central banks to avoid currency flexibility (Calvo and Reinhart, 2002; Levy-Yeyati and Sturzenegger, 2003).

A second view identifies the moral hazard created by currency pegs as a *source* of balance sheet mismatches (Eichengreen and Hausmann, 1999). When the central bank pegs the exchange rate, low volatility against a target currency gives firms an implicit guarantee against short term movements of the exchange rate. Burnside et al. (2001) and Schneider and Tornell (2004) show that carrying unhedged currency exposure is an optimal response on the part of firms enjoying government guarantees.

* Corresponding author. Tel.: +91 9810517827; fax: +91 11 26852548.
E-mail address: ilapatnaik@gmail.com (I. Patnaik).

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A recent theoretical literature (e.g. Chang and Velasco (2005)) suggests that the relationship may hold both ways. A central bank chooses the exchange rate regime depending on the extent of currency mismatches. The fear of floating may give rise to a peg. In turn, the optimal response of firms to the implicit guarantee offered by the central bank is to carry unhedged currency exposure. These two processes could reinforce each other in an equilibrium with unhedged firms and pegged exchange rates.

Over the past decade, an extensive literature has used macroeconomic data to explore the relationship between exchange rate regimes and currency mismatches.[1] This literature is based on the argument that pegging the currency is more credible in the short run. If firms are taking higher risk in response to a peg, it should result in greater short term foreign currency denominated credit. However, few studies find strong empirical support for the hypothesis (Eichengreen and Hausmann, 1999).

Empirical studies using firm level data find some support for the moral hazard hypothesis for Latin America, Mexico and East Asia. Kamil (2006) and Martinez and Werner (2002) find that moving to more flexible regimes reduced currency mismatches on balance sheets of firms. Parsley and Popper (2006) find that firms in East Asia were less hedged under pegged exchange rates. However, with cross country evidence, it is difficult to distinguish between the incomplete markets and the moral hazard hypotheses. Another dimension which is linked to these questions is the premia that investors obtain when firms bear currency risk (Carrieri, 2001).

This paper complements the existing literature by explicitly examining the incomplete market versus the moral hazard view in the context of volatility changes under a pegged currency regime. India provides a unique natural experiment, where we can study the response of a set of firms placed under alternating high and low volatility phases of a pegged exchange rate regime. The rupee has been *de facto* pegged to the USD in the period 1993–2008, but four distinct periods of significantly different currency volatility can be identified. The first period, beginning in 1993, when the rupee moved away from an administered exchange rate was a period of low currency volatility. This was followed by a period of high volatility during the Asian crisis. The third period witnessed low volatility, followed by a fourth period of high volatility. The extent of market completeness, in terms of capital controls or access to currency derivatives, did not significantly change over the entire period 1993–2008. The empirical strategy of the paper derives strength from the fact that a stable set of firms, where a sound metric of currency exposure is obtained, are observed through three significant changes in currency flexibility.

Under this set of natural experiments, the incomplete markets and moral hazard hypotheses make divergent predictions. If firms are unable to hedge their foreign exchange exposure risk, owing to incomplete markets, higher currency volatility should not affect the currency exposure of firms. But if the incomplete market hypothesis is true, we would find that whether currency volatility is high or low, the unhedged currency exposure of firms is unchanged. If the moral hazard hypothesis is true, and firms carry currency risk in response to the flexibility of the currency, we will find that periods of low volatility have high unhedged currency risk, and vice versa.

Our results strongly support the moral hazard hypothesis. We find that in Period 1, when there was negligible currency volatility, firms had large exposures. This gave way to the high currency volatility of Period 2: we find that currency exposure of firms became very low. In Period 3, currency volatility was low and firms responded with increased unhedged exposure. Period 4 witnessed an increase in volatility and a reduction in unhedged currency exposure.

In summary, our results suggest that in a sequence of natural experiments where market completeness was unchanged, the currency exposure of firms responded powerfully to the implicit guarantees made by the government in the currency regime. When the government tightly managed the exchange rate, firms carried substantial currency exposure. When there was greater currency flexibility, firms reduced their exposure.

The remainder of this paper is divided into three sections. Section 2 describes the methodology for the identification of structural breaks in currency flexibility, the firm level dataset and measurement of currency exposure of firms. Section 3 discusses the impact of changes in currency flexibility on the magnitude of currency exposure of firms. Section 4 concludes.

[1] For a review of this literature see Luca and Zhang (2006).

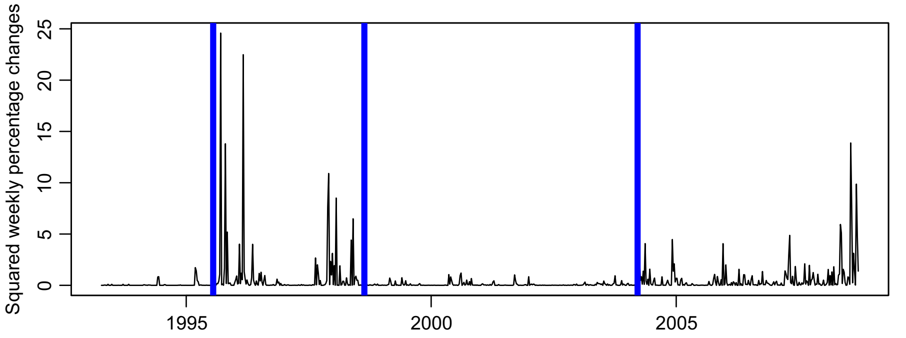

Fig. 1. Squared weekly returns on the INR/USD exchange rate and structural break dates.

2. Data and methodology

This section describes the data and methodology used in this study. The first part explains the structural breaks methodology for the identification of the fine structure of India's *de facto* pegged exchange rate. The second part describes the firm level dataset. The third outlines the methodology used for measuring currency exposure.

2.1. Structural breaks in the exchange rate regime

The INR currency regime has been *de facto* pegged to the USD over the full period. The *extent* of pegging has varied significantly through this period. There have been multi-month periods where the INR/USD exchange rate was fixed, and there have been periods where the volatility of the INR/USD was much higher.

The Reserve Bank of India has not announced any change in the currency regime since the move to a "market determined rate" in 1993. The rupee has been classified as a managed float by the IMF AREARS (Annual Report on Exchange Agreements and Exchange Restrictions). Calvo and Reinhart (2002), Reinhart and Rogoff (2004) and Patnaik (2007) present evidence that the rupee was a *de facto* peg to the USD.

Due to domestic and external compulsions, rupee volatility varied sharply during this period.[2] Hence, within the broad framework of a INR/USD pegged exchange rate, there was important variation of INR/USD volatility in sub-periods. We obtain dates of the structural breaks of the exchange rate regime using Zeileis et al. (forthcoming) which extends the econometrics of structural change to address the unique needs of this setting.

Fig. 1 shows the time-series of squared weekly returns on the INR/USD exchange rate, with the break dates superposed. The three break dates identify four distinct periods:

Period 1, 2 April 1993–17 February 1995: This was a period of low volatility. For most of this period, the exchange rate stood at Rs.31.37 per dollar.
Period 2, 18 February 1995–21 August 1998: This period included the Asian crisis, and there was a sharp increase in currency volatility.
Period 3, 22 August 1998–19 March 2004: This was a period of tight pegging, with low volatility and some appreciation.
Period 4, 20 March 2004–31 March 2008: In this period, there was greater currency flexibility. However, currency flexibility was lower than that seen in Period 2.

[2] The evolution of the currency regime reflected compulsions rooted in monetary policy and the evolution of capital controls (Patnaik, 2005; Shah and Patnaik, 2007). These influenced the Reserve Bank's decision to permit higher currency volatility in certain periods.

Table 1
The four periods of varying exchange rate flexibility.

	Dates	INR/USD	Reserves addition (Bln. USD)	
		Weekly vol.	Overall	Per year
1	1993-04–01 to 1995-02-17	0.16	13.03	6.93
2	1995-02-17 to 1998-08-21	0.93	4.86	1.39
3	1998-08-21 to 2004-03-19	0.29	82.64	14.81
4	2004-03-19 to 2008-03-31	0.64	186.22	46.55

Table 1 shows the volatility of the INR/USD exchange rate across these four periods. Currency volatility was highly heterogeneous across the four periods. It moved from 0.16% per week in Period 1 to a nearly six-times higher level of 0.93% per week in Period 2. In Period 3 it dropped to one-third (to 0.29) and then roughly doubled (to 0.64) in Period 4. These were large changes in currency volatility.

Over the full period, India had restrictions on the capital account. Financial derivatives were not well developed and there were restrictions on participation in these markets. Financial markets evolved over this period without major setbacks, policy reversals or structural breaks.[3] From the viewpoint of experimental design, there was a stable policy environment.

2.2. The data

A substantial system of capital controls was in place in India in this period (Shah and Patnaik, 2007). Firms were prohibited from accessing currency derivatives offshore. The onshore currency futures market was banned. Only OTC trading in currency derivatives was permitted onshore. Firms were required to demonstrate currency exposure owing to international trade or offshore borrowing in order to use this market. With these constraints, India might have exhibited an incomplete markets problem, where firms were unable to hedge currency exposure.

In such an environment, firms face constraints in modifying their currency exposure when the incentives associated with the exchange rate regime change. There are two key levers available to firms. The first is the extent to which offshore borrowing is done. The second is the extent to which the hedging that is permitted owing to the demonstrable currency exposure associated with international trade or offshore borrowing is actually undertaken. A firm that is an importer or exporter has the choice of hedging (e.g. by transacting in the onshore rupee-dollar forward market) or not hedging.

However, in their annual reports, companies do not report their hedging activities. For example, a key tool through which firms adopt currency risk is unhedged foreign currency borrowing. While there is some data on the foreign borrowing of firms, there is no disclosure of currency composition, derivatives and underlying trade exposures.

Hence, we focus on stock prices as the summary statistic that reflects changes in the value of the firm when there are currency movements. Compared with many developing countries, India has the advantage of high participation in financial markets and active speculative price discovery on the stock market. As an example, the 3rd and 5th biggest exchanges of the world, measured by the number of transactions per year, are found in India. This makes an exposure metric derived from stock prices relatively informative.

The 'Prowess' database of Indian listed companies from the Centre for Monitoring Indian Economy (CMIE) contains daily stock price data. We construct a dataset of weekly returns on the 100 most liquid stocks on Indian stock exchanges. These are the firms that belong to the 'NSE-50' (Nifty) and 'Nifty Junior' stock market indexes. The prime rationale for choosing these 100 firms lies in the *informativeness* of their stock price processes, given the high level of stock market liquidity. In terms of market turnover, these 100 firms account for 58% of the turnover of the spot market. Index

[3] See Thomas (2006) for the evolution of financial markets in this period.

Table 2
Market value of firms in the dataset.

					(Million USD)
	1993-04-09	1995-02-17	1998-08-21	2004-03-19	2008-03-31
Minimum	1	12	7	116	210
25th Percentile	72	203	158	494	1038
Median	204	425	302	868	2791
Mean	433	787	641	2065	7685
75th Percentile	643	931	684	2353	7385
Maximum	2775	4701	6014	27060	86010

derivatives and individual-stock derivatives on these 100 stocks account for 92% of total equity derivatives turnover.[4]

Table 2 shows the distribution of market capitalisation of these 100 firms on the five dates which bracket the four periods under examination. At each date, the market capitalisation in rupees is converted into million USD using the exchange rate then prevalent. The median market capitalisation has risen dramatically from $204 million to $2791 million over this period. However, even in the earliest time period, the firms of this dataset are large enough to enjoy adequate stock market liquidity and hence an informative price process.

In addition, Table 3 shows that these 100 firms account for roughly two-thirds of the value added and market value of the broad set of listed firms in India (which are identified by CMIE Cospi index membership). The value added by these 100 firms amounts to roughly 10% of India's GDP. Hence, this dataset of 100 firms is simultaneously a set of firms where risk measurement based on stock price sensitivity is meaningful, and a set of firms which is representative of the currency exposure of Indian firms at large.

2.3. *Measuring currency exposure*

We measure unhedged currency exposure in the tradition of Adler and Dumas (1984). We build on the work of Dominguez and Tesar (2006); Parsley and Popper (2006); Dahlquist and Robertsson (2001); Jorion (1990); Bodnar and Wong (2000) and measure the change in the stock price of a company in response to a change in the exchange rate. To measure the unhedged currency exposure of firms we utilize an 'augmented market model':

$$r_j = \alpha_j + \beta_{1j} r_{M1} + \beta_{2j} r_{M2} + \varepsilon \quad (1)$$

The model relates firm returns r_j to market index movements r_{M1} and currency fluctuations r_{M2}. The coefficient β_{2j} measures the sensitivity of the valuation of firm j to changes in the exchange rate. If an exporting firm is unhedged and gains when there is a currency depreciation, it would have $\beta_{2j} > 0$.

In an efficient market, market model parameters reflect the efforts of speculative markets at discerning all aspects of currency exposure of the firm. If a firm sells a product which is priced through import parity, stock market speculators who form a judgment about future profits of the firm will embed currency fluctuations into the stock price process, even when it does not appear in balance sheet disclosures about currency exposure.[5]

[4] The methodology for construction of Nifty and Nifty Junior (Shah and Thomas, 1998) is based on computing the impact cost when placing program trades to buy or sell the entire index as a portfolio, into four 'snapshots' of the limit order book every day. The biggest firms of the country are selected into these two indexes, while ensuring that the overall impact cost of index program trades remains low. As an example, in 2006, the average impact cost for doing a Rs. 5 million program trade on Nifty was 0.08% and the impact cost for doing a Rs. 2.5 million program trade on Nifty Junior was 0.16%. These transactions costs are comparable with program trades on indexes in industrial countries, and underline the high quality of stock market liquidity and informativeness of the stock prices in the dataset.

[5] The analysis of firm-specific hedging data would have been an important corroboration of the statistical estimates, based on market prices. However, given the lack of disclosure about hedging by firms, this corroboration was not feasible.

Table 3
Weight of 100 sample firms in overall equity market and value added.

		(Trillion rupees)
Set	Market value	Value added
CMIE Cospi (2500 firms)	35.3	4.74
Nifty (50 firms)	19.6	2.33
Nifty Junior (50 firms)	3.3	0.71
Fraction accounted for by 100 firms	0.65	0.64

The CMIE Cospi is a set of roughly 2500 listed firms in India which trade on at least 66% of trading days. It constitutes the universe of Indian listed firms, for all practical purposes. The 100 firms in Nifty and Nifty Junior, which are used in this paper, account for an economically significant part of this universe.

We follow Parsley and Popper (2006) and Dahlquist and Robertsson (2001) in focusing on a bilateral exchange rate, the INR/USD, in contrast to other studies such as Dominguez and Tesar (2006) who have used trade-weighted exchange rates to measure currency exposure. A focus on the USD in gauging the currency exposure of firms in India is consistent with (a) the fact that the INR is a *de facto* peg to the USD; (b) key trade partners such as the US, China, Hong Kong and UAE are all pegged to the USD and (c) considerable trade invoicing takes place in USD.[6]

The stock price of a firm at any point of time takes into account all information available at that point. The stock market price is likely to respond only to unanticipated changes in the exchange rate (Doukas et al., 2001). To measure the response of the stock market to innovations, rather than raw changes in the exchange rate, we examine the time-series characteristics of the INR/USD exchange rate. We find that the time-series of the INR/USD exchange rate often has time-series structure. We choose the order of an AR model in each of the four periods based on the Akaike Information Criterion. Through this, we shift from raw currency market returns r_{M2} in each time period to innovations, that we call e_t.[7]

The full impact of a currency innovation takes place over several time periods, which requires introducing a set of lags into the estimating equation. This implies the model specification:

$$r_{jt} = \alpha + \beta_1 r_{M1,t} + \sum_{i=0}^{k} a_i e_{t-i} + \varepsilon_t \tag{2}$$

Under this specification, an innovation e_t on the currency market has an impact on the stock price at time t and the following k time periods. Under Model 2, currency exposure is embedded in the vector of a_i coefficients; it is no longer a simple scalar β_2 as was the case under Model 1.

We identify the k that yields the best value of the Schwartz Bayesian Criterion for each r_j series separately. This allows the lag structure to vary based on stock market liquidity.

Since the exchange rate series has been re-expressed as a series of innovations, the total impact of an unexpected change in the exchange rate on a stock price is the sum of a_i coefficients across all lags. Further to address the problem of heteroscedasticity in r_{M1} and r_{M2} we use a HAC estimator of the covariance matrix.[8]

The market index, r_{M1}, that plays an important role in the estimation of the market model, reflects the average stock market returns of firms in the market index. If one-way bets are present on the currency, and a large number of firms have a certain direction of exposure, this will result in currency exposure *of the market index*.

[6] In order to explore the significance of exposures other than the USD, augmented market models were estimated for the biggest 20 companies by market capitalisation, where Euro, Pound and Yen exposures were measured in addition to the USD. These were not significant.

[7] In Period 1, an AR(3) model is chosen; in Period 2, an AR(1) model is chosen; in Period 3, an AR(10) model is chosen and in Period 4, an AR(6) model is chosen.

[8] This is implemented using the methods of Zeileis (2006).

Table 4
Summary statistics about the cross-section of $|\overline{\beta}_{2j}|$ in 4 periods.

Period	Q1	Median	Mean	Q3
1	2.28	3.99	5.04	5.97
2	0.17	0.32	0.42	0.52
3	2.51	3.18	3.65	4.67
4	1.45	2.04	2.05	2.65

This table shows summary statistics about the $|\overline{\beta}_{2j}|$ values obtained across firms in the four periods.

Under these conditions, when the estimated $\beta_2 = 0$, this means that the stock has the same exposure as the market index. The exposure measured by β_2 is not the currency exposure of the firm: it is the exposure of a particular firm over and above the exposure of the market index or the average firm.

This issue can be addressed by orthogonalising the market index time-series by first estimating a regression model explaining r_{M1} as a function of past and present currency innovations, and extracting the residual from this regression (Griffin and Stulz, 2001).[9] We set up a regression of r_{M1} on currency innovations with lags and extract residuals from this.[10] These residuals represent equity index returns, uncontaminated by exchange rate effects (if any). These residuals are then used in the estimation of exchange rate exposure for each firm.

Through this process, for each firm *j*, estimates for currency exposure $\overline{\beta}_{2j}$ and the standard deviation of the estimate σ_{2j} are obtained.

The direction of unhedged currency exposure may differ across firms. Some firms may benefit from an appreciation ($\overline{\beta}_{2j} < 0$), while others may benefit from a depreciation ($\overline{\beta}_{2j} > 0$). To focus on currency *exposure*, regardless of the sign, we use $|\overline{\beta}_{2j}|$ as the metric of unhedged currency exposure.

The inference procedure for the average, $\overline{|\beta_2|} = E(|\overline{\beta}_{2j}|)$, uses a simulation-based strategy. In each simulation, one draw is made from the distribution of $\overline{\beta}_{2j}$ for each firm, and $\overline{|\beta_2|}$ is computed using these values. This is repeated 5000 times, which yields 5000 draws from the distribution of $\overline{|\beta_2|}$. Summary statistics and kernel density plots are reported using these draws.

3. Results

This section describes our results. Table 4 shows summary statistics about the cross-sectional dispersion of $|\overline{\beta}_{2j}|$ in each period.

In Period 1, where currency flexibility was very limited, the exposure of firms was considerable. The 25th percentile was 2.28 and the 75th percentile was 5.97, with a median value of 3.99.

In Period 2, when the highest currency volatility was observed, the exposure of firms fell dramatically. The 25th percentile dropped to 0.17 and the 75th percentile dropped to 0.52. The median dropped to 0.32.

In Period 3, where currency flexibility once again dropped, though not all the way to the levels of Period 1, the 25th percentile rose to 2.51 and the 75th percentile climbed to 4.67. The median rose to 3.18.

Finally, in Period 4, where greater currency volatility came about (though not up to the levels of Period 2), currency risk dropped sharply, with a 25th percentile of 1.45 and a 75th percentile of 2.65. The median dropped to 2.04.

Currency volatility in the four periods took the values of : 0.16, 0.93, 0.29, 0.64. The median exposure of firms responded in ways which are consistent with a moral hazard hypothesis, with values of: 3.99, 0.32, 3.18, 2.04.

[9] Priestley and Odegaard (2007) orthogonalise the market index return with respect to a number of macroeconomic variables which also affect the exchange rate. This requires high-frequency macroeconomic time-series data, which is not available for India.

[10] The lag order that minimizes the AIC is 5 weeks.

Table 5
$\overline{|\beta_2|}$ estimates, along with simulation-based inference.

Period	$\overline{|\beta_2|}$	Std. Devn.
1	5.899	0.592
2	0.540	0.052
3	3.753	0.168
4	2.066	0.061

The simulation-based inference strategy described in Section 2 gives us $\overline{|\beta_2|}$, the mean of $|\overline{\beta}_{2j}|$ across firms along with an estimate of its sampling variation. These results are shown in Table 5.

For all the transitions from one period to the next, the change in the mean exposure is highly significant. As an example, the 95% confidence interval in Period 3 runs from 3.42 to 4.08, while the 95% confidence interval in Period 4 runs from 1.95 to 2.19. We infer that at a high level of significance, $\overline{|\beta_2|}$ was lower in Period 4 when compared with Period 3.

Fig. 2 visually compares kernel density plots for the distribution of $\overline{|\beta_2|}$ in the four periods. The lack of overlap of consecutive distributions supports the hypothesis that each time currency volatility changed, the exposure of firms changed. Pairwise comparisons across all the four periods reveals clearly distinct distributions for $\overline{|\beta_2|}$ across the four levels of exchange rate volatility.

In summary, we find that when currency volatility switched from a low level in Period 1 to a high level in Period 2, the currency exposure of firms dropped sharply. When currency volatility dropped again in Period 3, the exposure of firms went up. Finally, when currency volatility rose again in Period 4, the exposure of firms went down.

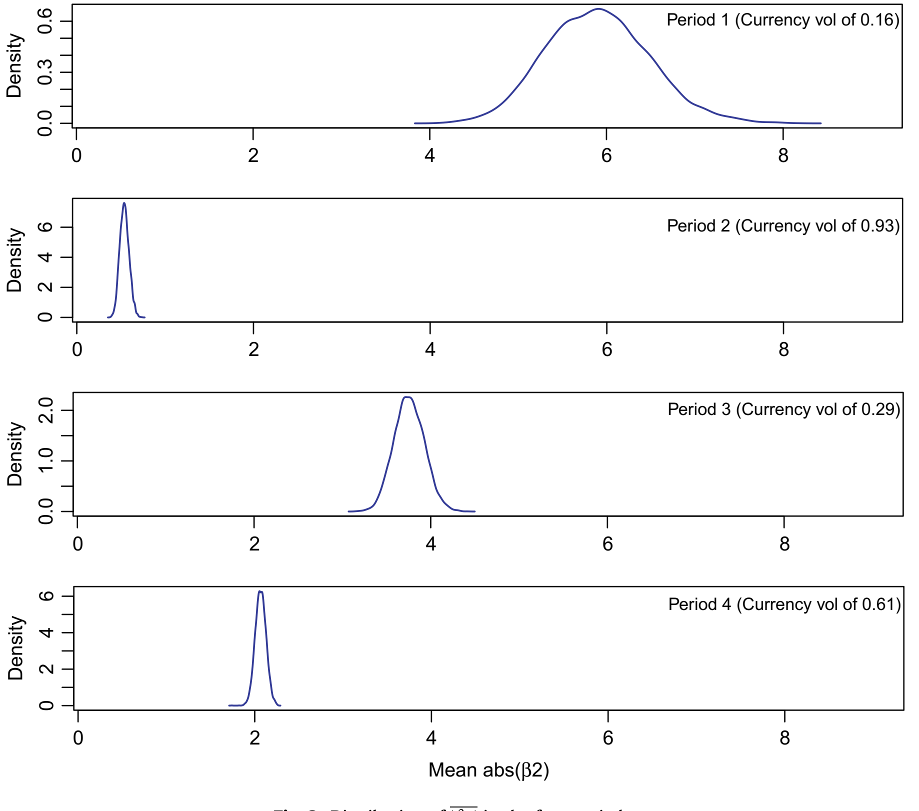

Fig. 2. Distribution of $\overline{|\beta_2|}$ in the four periods.

4. Conclusions

This paper shows that in the Indian setting, implicit guarantees offered by the central bank shaped the behaviour of firms. Firms chose to hedge or not to hedge their exposures depending on exchange rate flexibility. In each of the three transitions of the currency regime, substantial changes in firm exposure took place. These results support the hypothesis that pegged exchange rates induce moral hazard and increase financial fragility.

These results pertain to the Indian setting, where financial markets gave firms adequate opportunities to modify their currency exposure. In countries where financial markets are underdeveloped, central banks may peg the currency in response to balance sheet mismatches based on an incomplete markets argument. This paper finds that in the Indian setting, the implicit government guarantee provided through low currency volatility gave an incentive to firms to carry unhedged exposure. Markets were complete enough to allow firms to modify their currency exposure in response to these incentives.

In this paper, a cross-sectional exploration of firm characteristics, seeking to understand which firms hold bigger currency exposure, has not been undertaken. The pattern of ownership, especially the role played by government ownership and its impact on incentives, could be a factor shaping the decisions of firms. This is left to future research.

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