Chapter 6

Size, directional and composite asymmetries in the pass-through from exchange rate to prices in India

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Brief Content

6.1. Introduction and Background

This chapter examines the issue of asymmetric Exchange Rate Pass-Through (ERPT) and relaxes the assumption of directional and size symmetry which was implicitly made in the previous chapter. The issue of size and directional asymmetries are looked into from the perspective of the price impact of exchange rate variations on imports and domestic inflation. Both the perspectives are developed from the linear models presented in chapters 4 and 5, and thus the present chapter is an extension of the previous chapters.

The literature on ERPT has generally approached the subject matter with the implicit assumption that the price impact of exchange rate on prices is exactly the same irrespective of whether there is an appreciation or a depreciation, or a large change or a small change. Such an assumption implies that a single coefficient can be used to represent the pass-through phenomenon. This has led to a large number of studies producing different estimates of the ERPT coefficient in the Indian as well as international contexts. The literature in the Indian setting has been limited (Yanamandra, 2014). Thus, a larger scope exists to complement the extant wisdom with newer empirical evidences that covers a larger sample period and provides a parsimonious analytical framework to tackle this issue. In recent times, some important studies tackling this issue include Brun-Aguerre et al. (2014), Yanamandra (2014), Rajan and Yanamandra (2015), Patra et al. (2018), Balcilar et al. (2019), and Bhat and Bhat (2022), among some others[1]. These studies have found evidence of asymmetrical behaviour of ERPT and concluded that the pass-through process in India has important non-linear dimensions that need to be captured to understand the true nature of price impacts emanating from currency fluctuations.

From a policy perspective, an asymmetric pass-through poses both challenges and opportunities. A truly symmetric ERPT would imply that while currency fluctuations can produce inflationary impact, it is equally possible to induce disinflationary impact of the same intensity were the exchange rate to move in the reverse direction. A symmetrical pass-through would ensure that the exchange rate channel behaves in a stable manner and the adjustments induced by exchange rate movements remain consistent irrespective of the size or direction of its change. This would ensure lesser uncertainty over the price implications of exchange rate and allow better incorporation of the exchange rate channel into the monetary policy design. From an operational perspective, symmetrical pass-through allows a stable risk exposure to exchange rate and could enable firms and consumers to hedge the exchange rate risks optimally. Under symmetrical pass-through, the implications of volatile exchange rate for importers and exporters remains the same irrespective of the magnitude and direction of the volatility. Given that exchange rate tends to be considerably volatile, particularly after the collapse of the Bretton woods system, a symmetrical pass-through reduces the extent of uncertainties that economic agents have to account for in their "ordinary business of life" (Marshall, 1980). While the vagaries of currency markets will not cease to exist under a symmetrical pass-through environment, the extent of uncertainties are lesser as compared to the case of asymmetrical pass-through.

The violation of the 'symmetry condition' creates the phenomenon of asymmetric pass-through. While there is no common definition of asymmetry in the present context, it may broadly be defined as the situation where the magnitude of the price impact from exchange rate changes are conditional upon the direction and size of exchange rate itself. In other words, the extent of pass-through is endogenous to the size and direction of the change in exchange rate itself. Hence, the point estimates from linear models, whether single equation or systems based, will not provide capture the total extent of the pass-through if asymmetries are present. Hence, asymmetry in the present context implies lack of independence of pass-through and the nature of exchange rate changes. Such a behavior of pass-through process requires alternative approaches to capture these dynamics that linear econometric models will be unable to accommodate. There are at least three forms of asymmetries addressed in the macroeconomic literature on pass-through issue. The first is the differences in ERPT when exchange rate appreciates versus during its depreciation. This phenomenon is termed as 'directional asymmetry' in the present chapter. The second is the differences in ERPT when exchange rate change is small as compared to when it is large. This is termed as 'size asymmtery' in the present chapter. The third form of asymmetry can be conceptualized as a combination of both the size and directional asymmetries where in small appreciations, large appreciations, small depreciations and large depreciations can produce different responses from prices. This is termed as the 'composite asymmetry'. There is another form of asymmetry that has not been generally addressed in the Indian context. Prices are expected to react differently when exchange rate change is temporary versus when it is permanent (Froot and Klemperer, 1989). The present chapter focuses on the first three forms of asymmetries and does not address the fourth form.

Literature has pointed various factors that could explain the directional asymmetry in the price impact of exchange rate variations. The first explanation links asymmetry in direction of exchange rate change to the 'Pricing to Market' (PTM) behaviour by exporting firms. Under this analytical setting, exporting firms are expected to vary the price charged in accordance with objectives other than maintaining the markups. Exporting firms will thus tend to restrict price increases in order to maintain their market share in destination country, while they will recover the reductions in markups during appreciation of exchange rate and pass over the fall in prices to expand market share in the destination markets (Pollard and Coughlin, 2004). Another explanation focuses on the 'switching of production' phenomenon wherein exporting firms depend on imported inputs and the firms switch between imported inputs and domestic substitutes depending on the exchange rate variations. In these circumstances, the extent of pass-through will depend on the extent to which foreign exporting firms switch between both the set of inputs. Put differently, the substitutability between imported and domestic inputs for foreign exporting firms will determine the extent of pass-through (Webber, 2000).

Hence, when destination market's currency depreciates, firms would rely on imported inputs and thus no pass-through would occur. However, when the currency of destination market appreciates, exporting firms would switch to domestic inputs thus pass over the inflationary impact on their markups to the import prices in destination currency (Pollard and Coughlin, 2004). Another explanation of asymmetry issue is with reference to the quantity constraints faced by exporting firms. When exporting firms are functioning at their maximum production capacities, increasing the production further to capture larger sales on account of appreciation of destination currency is not feasible, at least in the short-run. Hence, exporting firms may prefer to expand their markups and prevent a rise in demand so as to avoid running into 'capacity stresses'. In the long-run, however, exporting firms will be able to overcome the production constraints and pass over the disinflationary impulses to destination markets and increase their market share as well as profits.

Turning attention to size asymmetries, several explanations have been advanced in the literature. The most common explanation arises from the menu cost theory. Under this model, exporting firms tend to keep the price fixed and allow their markups to rather absorb exchange rate fluctuations, unless the exchange rate change is sizeable enough to warrant price revisions.

Frequent revisions of prices by exporting firms impose costs on the firms. Revision of contracts is time consuming and costly, renegotiations may not yield a mutually beneficial outcome, and a host of other such constraints may render frequent price revisions redundant. Hence, when exchange rate changes cross a tolerable threshold, the exporting firms may then be induced to prevent their markups from changing and passing over the impact of the exchange rate change to the importing country (Mann, 1986; Goldberg and Knetter, 1997). Another explanation proposed to explain this issue is the switching cost model. The pass-through relationship is conceptualized as concave in this scenario (Bussiere, 2013; Patra et al., 2018). If the elasticity of substitution is high between the domestic and imported goods in the destination markets, consumers would face lower switching costs and hence could rapidly alter their consumption from imported commodities to local substitutes in the wake of inflationary impact from exchange rate. Foreign firms could stand to lose a larger market share under such circumstances and hence would prefer to absorb the inflationary impact of exchange rate by reducing their markups and maintaining the price constant. If the switching costs are high, the elasticity of substitution would be lower and foreign firms could afford to pass over the increased costs due to exchange rate changes with less severe implications for their market shares (Bussiere, 2013).

The last approach to size and directional asymmetries emerge from macroeconomic factors such as nominal rigidities, staggered pricing, stage of business cycle in the destination market and the inflationary environment in the destination country. Following Taylor (2000), the role of inflation environment in explaining the extent of pass-through has obtained larger attention. An environment of low inflation with monetary policy actively practicing inflation targeting results in lower pass-through as the Central Bank is expected aggressively counter excessive price variations to maintain its stability. On the other hand, when inflationary environment is unstable and high, foreign firms can much more conveniently pass-through the inflationary impulses as consumers would be tolerable of further inflation in an already inflationary environment. Moreover, existence of persistently high inflation implies that Central Bank in the destination country is perhaps ready to tolerate the high inflation and would not counteract to stabilize such impulses from exporting firms. This approach has also received some attention off lately in the Indian context but the evidence is very limited.

There is considerable scope to explore the issue of directional, size and composite asymmetries in the Indian setting given the paucity of evidence covering the entire period after reforms and addressing this subject for both the import price and domestic inflation pass-through phenomena. Hence, the present chapter investigates whether there is any evidence of asymmetric ERPT in India. Furthermore, it attempts to address this matter for both the stage one pass-through and the complete pass-through mechanism. First, the issue of directional asymmetry in import price pass-through is investigated by developing the perspective on the basis of estimated models from chapter four. Second, the issue of size asymmetry is addressed in the same context, and third, the issue of composite asymmetry is looked into. Thereafter, the same exercises are undertaken for locating asymmetric pass-through to domestic inflation in India using the estimated models from chapter five. Hence, this chapter provides an extended perspective on the findings from the previous two chapters.

6.2. Methodological and data issues

The present study develops the methodological approach on the basis of Pollard and Coughlin (2004), Bussiere (2013), Aron et al. (2014), and Brun-Aguerre et al. (2014). The literature on asymmetric ERPT has provided several approaches to address the matter. While some approaches focus exclusively on addressing directional asymmetry, other approaches focus on size asymmetries. The first and a frequently employed methodological approach is to use dummy variables for capturing size, directional and composite asymmetries. In this approach, one dummy variable is specified for each of the cases of appreciation, depreciation, small change, and large change. Hence, four dummy variables are specified which are valued as 'one' for the asymmetry of interest, and 'zero' otherwise. The issue of composite asymmetry is addressed by interacting these dummy variables to yield dummy variables for small appreciation, large appreciation, small depreciation and large depreciation. The present study adopts this method following Pollard and Coughlin (2004) and specifies relevant dummy variables for each type of asymmetry as narrated above. The advantage of this method, among others, is that it permits the extension of linear models and allows incorporating nonlinearities, i.e. asymmetries, into the linear framework itself. Hence, it is a parsimonious approach whose results have largely been verified by a large body of literature.

Increasingly, another approach that is gaining relevance in the pass-through literature is the use of non-linear econometric structure to capture asymmetries. Frameworks such as Nonlinear

Auto Regressive Distributed Lag (NARDL) models, Non-linear Vector Auto Regressive (NVAR) models, Threshold Regression models, Switching Regression models, among some others, are being employed by the literature to capture asymmetries endogenously rather than imposing the asymmetric constraints exogenously as done in the dummy variables approach. Despite their complexities, not surprisingly enough, the evidence from non-linear models have largely corroborated the findings from linear dummy variables-based models of asymmetry. Adopting the principle of occam's razor, this study adopts the dummy variable approach to capture non-linear and asymmetric pass-through and shed some light on the nature of nonlinearity of pass-through in India.

The baseline models from the previous chapters are extended in this chapter to test the key hypotheses of asymmetric pass-through. Specifically, equation 13 in chapter four, and equations 5 and 6 from chapter five are utilized to account for direction, size and composite asymmetries. The variables, their sources and the econometric properties of those variables have already been elaborated in the respective chapters. Both the bilateral Rupee-US Dollar exchange rate and the NEER[2] are used to specify the dummy variables, and given the largely similar picture emerging from both the cases, the results with NEER are reported in this chapter to maintain consistency and comparability with the previous chapters. The use of the 'dummy variables approach' requires specifying the nature of the dummy variables and the definition of the criteria used to specify them. The issue of directional asymmetry has been well-agreed upon in the Indian setting.

$$\%\Delta \textbf{NEER} > 0\textbf{: Appreciation} \quad \text{....(1)}$$

$$\%\Delta \textbf{NEER} < 0\textbf{: Depreciation} \quad \text{....(2)}$$

While there is complete agreement on the definition of appreciation and depreciation in exchange rate, larger debates have raged on the issue of defining the size of exchange rate changes. Literature has proposed several approaches to handle this matter. The first set of approaches are those that impose an exogenous definition of small and large exchange rate change. Pollard and Coughlin (2004), and Bussiere (2013), for example, define any change in exchange rate being more than 3% as large; otherwise it is defined as a small change. Other studies have used the standard deviation to define small and large changes. Rajan and Yanamandra (2015) is an illustration in this regard. A third approach in the Indian context has been to define any change above the mean change in exchange rate as large; otherwise it is specified as small. Yanamandra

(2014) is an illustration of such an approach. Yet another framework has been to define any change larger than the median as large, or otherwise it is defined as small (Yanamandra, 2014). All these approaches are the exogenous approaches, wherein the size constraint is specified a-priori. There is another approach on this issue which locates the size constraint endogenously from the exchange rate variable itself. Such approaches suggest that the 'threshold' to differentiate the small and large changes should emerge from the exchange rate movements themselves. Threshold regression models and NARDL models are employed to locate this threshold and estimate separate pass-through coefficients for small and large changes. Some problems with these approaches include their complexity, larger data requirements and difficulties in capturing the composite asymmetry. Furthermore, these approaches are highly sensitive to the movements in exchange rate data and particularly its distributional characteristics. These methods are also conditional upon the form of specification for the inflation equation within which the threshold value will be located. The last approach is this regards is the use of polynomial terms, specifically the squared and cubic terms of exchange rate variable, into the linear models to measure both directional and size asymmetries, as well as handle the composite asymmetry issue. A recent illustration of this approach is Patra et al. (2018).

%ΔNEER ≥ 1 Standard Deviation from Mean: Large change[3] **….(3)**

%ΔNEER ≤ 1 Standard Deviation from Mean: Small change **….(4)**

Given this background, specifications 3 and 5 show the definition of 'small' and 'large' exchange rate change as adopted in the present chapter. This definition compactly captures the quantum of exchange rate change. A precondition of meaningfully using this approach is to ensure that the underlying variable is normal (Pollard and Coughlin, 2004; Brun-Aguerre et al., 2014). As shown in table 5.1 in chapter five, the Jacque-Berra test revealed that NEER has behaved normally across the study period. The dummy variable for appreciation is defined as below.

$$D_A = 1, \text{ if } \%\Delta NEER > 0 \quad \text{….(5)}$$

$$D_A = 1, \text{ if } \%\Delta NEER > 3\% \quad \text{…(5.1)}$$

$$D_A = 0, \text{ otherwise} \quad \text{….(6)}$$

Where D_A is the dummy variable for appreciation in exchange rate. Similarly,

$$D_D = 1, \text{ if } \%\Delta NEER < 0 \quad ....(7)$$

$$D_D = 1, \text{ if } \%\Delta NEER < 3\% \quad ...(7.1)$$

$$D_D = 0, \text{ otherwise} \quad ....(8)$$

Where, D_D is the dummy variable for depreciation in exchange rate. While the above specifications define the dummy variables for appreciation and depreciation in exchange rate, the following specifications reflect the dummy variables for small and large changes in the exchange rate. Similarly, defining D_S and D_L as the dummy variables for small and large changes.

$$D_S = 1, \text{ if } \%\Delta NEER \leq 1 \text{ Standard Deviation from Mean} \quad ....(9)$$

$$D_S = 0, \text{ otherwise.} \quad ....(10)$$

$$D_L = 1, \text{ if } \%\Delta NEER \geq 1 \text{ Standard Deviation from Mean} \quad ....(11)$$

$$D_L = 0, \text{ otherwise.} \quad ....(12)$$

These definitions of the dummy variables account for the intercept of directional and size asymmetries but not the extent to which these asymmetries shape the ERPT behaviour. Hence, following Goldfajn and Werlang (2000), and Pollard and Coughlin (2004), Kennedy (2008)[4], following interaction variables are defined to capture the asymmetry issues as shown in Table 6.1.

Table 6.1: Measurement of Asymmetry variables in the present study

Sr. No.	Variable	Definition	Asymmetric dimension of exchange rate change
1	D_{D*NEER}	$D_D * \Delta InNEER$	Pass-through under Depreciation
2	D_{A*NEER}	$D_A * \Delta InNEER$	Pass-through under Appreciation
3	D_{L*NEER}	$D_L * \Delta InNEER$	Pass-through under Large change
4	D_{S*NEER}	$D_S * \Delta InNEER$	Pass-through under Small change
5	D_{LD}	$D_L * D_D * \Delta InNEER$	Pass-through under Large Depreciation
6	D_{SD}	$D_S * D_D * \Delta InNEER$	Pass-through under Small Depreciation
7	D_{LA}	$D_L * D_A * \Delta InNEER$	Pass-through under Large Appreciation
8	D_{SA}	$D_S * D_A * \Delta InNEER$	Pass-through under Small Appreciation

Source: Author's specification based on Goldfajn and Werland (2000), Pollard and Coughlin (2004), and Kennedy (2008).

6.3. Empirical perspectives on asymmetries in pass-through to import price inflation

Given the analytical background laid in sections 6.1 and 6.2, this section presents the empirical estimates on the issue of the three forms of asymmetry highlighted earlier in section 6.2. The baseline linear econometric models from chapters four and five are extended to account for asymmetric pass-through in India. Following equations signify the empirical models for the present investigation. The issue of direction, size and composite asymmetries are investigated using equations 13 and 14 with reference to asymmetric pass-through to import price inflation in India.

$$\Delta \mathbf{lnIPX} = \beta_1 \Delta \mathbf{lnOILIND} + \beta_2 \Delta \mathbf{lnWCPI} + \beta_3 \Delta \mathbf{lnRGDP} + \beta_4 D_{GFC} + \beta_5 D_D + \beta_6 D_A + \beta_7 D_{D*NEER} + \beta_8 D_{A*NEER} + \varepsilon \quad \text{....(13)}^{5}$$

As explained in chapter four earlier, the markup pricing model is utilized to construct the baseline model to capture the import price pass-through relationship. This relationship is contained in the coefficient of exchange rate. However, this coefficient is decomposed into depreciation and appreciation episodes and is represented by the relevant dummy variables. Given that there has not been any year during which the exchange rate movement was exactly zero, the two intercept dummy variables represent all the exchange rate movements but in terms of depreciations and appreciations respectively. Using two mutually exhaustive dummy variables together would result into the dummy variable trap (Kennedy, 2008). Hence, the constant term is dropped from the baseline equation and it is modified into the specification shown in equation 13. This equation accounts for the cost pressures emanating from external sector and the demand pressure emanating from the domestic sector. The oil price and world inflation variables represent these cost pressures, while the real output variable presents the demand pressure perspective. Hence, an extended baseline model from chapter four is represented in equation 13.

$$\begin{aligned} \Delta \mathbf{lnIPX} = {} & \beta_1 \Delta \mathbf{lnOILIND} + \beta_2 \Delta \mathbf{lnWCPI} + \beta_3 \Delta \mathbf{lnRGDP} \\ & + \beta_4 D_{GFC} + \beta_5 \Delta \mathbf{lnCINF} + \beta_6\, \mathbf{lnCINF}_{SD} + \beta_7 \mathbf{lnNEER}_{SD} \\ & + \beta_8\, \mathbf{lnRTOPEN}_{t-1} + \beta_9 \Delta \mathbf{lnIPX}_{t-1} + \beta_{10} D_D + \beta_{11} D_A \\ & + \beta_{12} D_{D*NEER} + \beta_{13} D_{A*NEER} + \varepsilon \quad \text{....(14)} \end{aligned}$$

The baseline model in chapter four was also extended to examine the larger set of determinants of price momentum for aggregate import. The partial adjustment dynamic specification proposed in chapter four is augmented to account for directional asymmetries by decomposing the exchange rate variable into two parts – namely the depreciation episodes and appreciation episodes. Compared to equation 13, the above equation incorporates more complex dimensions of import price inflation, thereby controlling the ERPT relationship for a richer set of control variables. Level of inflation, volatility in inflation, volatility in exchange rate, trade openness and lagged value of import price inflation itself, are incorporated leading to the equation 14. However, the four dummy variables representing the intercept and slope of the n on-linear pass-through relation are also incorporated in equation 14.

Thereafter, following Patra et al. (2018), another approach is adopted to capture the directional asymmetry in pass-through using polynomial terms in the baseline models of chapter four. Polynomial terms are capable of handling nonlinearities within the linear econometric models, just as the dummy variables approach. However, the problem with polynomial terms is that they cannot provide separate estimates of pass-through for the two different directions in which exchange rates can evolve. However, it is interesting to assess the sensitivity of the asymmetries to alternative methodological approaches. If the results are indeed reliable, they should remain broadly resilient to alternative methods. To test the null hypothesis that the results from alternative methods are exactly equal, i.e. the differences in the degree of asymmetry is the same irrespective of the methodology employed, equation 15.1 is specified by augmenting the equation 14 by dropping the dummy variables, reinstating the constant term, including the exchange rate variable and also accounting for the quadratic term of the exchange rate variable.

$$\begin{aligned}\mathbf{\Delta InIPX} = \; & \boldsymbol{\beta_0 + \beta_1 \Delta InOILIND + \beta_2 \Delta InWCPI + \beta_3 \Delta InRGDP + \beta_4 D_{GFC} + \beta_5 \Delta InCINF} \\ & \boldsymbol{+ \beta_6\, InCINF_{SD} + \beta_7 InNEER_{SD} + \beta_8\, InRTOPEN_{t-1} + \beta_9 \Delta InIPX_{t-1}} \\ & \boldsymbol{+ \beta_{10} \Delta InNEER + \beta_{11} \Delta InNEER^2 + \varepsilon} \qquad \mathbf{....(15.1)}\end{aligned}$$

The quadratic specification contained in equation fifteen can provide a perspective on the nonlinearities in terms of directional asymmetry. The quadratic term may be understood as an interaction of exchange rate to itself. By incorporating this variable into the pass-through framework, the extent of pass-through is allowed to depend on the level of exchange rate change itself. Hence, if the value of the quadratic term is positive, it would indicate that larger levels of exchange rate changes induce larger impact on import prices. However, the total impact of exchange rate will not be represented solely by the exchange rate coefficient. The nonlinearity introduced into the pass-through relationship through the quadratic term will also need to be accounted for. Hence, the total pass-through from exchange rate to import prices when quadratic term for the exchange rate variable is included, will be estimated by the following equation.

$$\mathbf{ERPT_M = \beta_{10} + 2\beta_{11} * \Delta InNEER} \qquad \text{....(15.2)}$$

Given equation 15.2, it is clear that when β_{11} is positive, depreciation in NEER, i.e. negative changes in NEER will have larger pass-through as compared to the case when β_{11} is negative. If β_{11} is negative, then appreciation in NEER, i.e. positive changes in the exchange rate will induce larger impact on import prices. While equations 13 to 15 capture the specifications used for estimating the directional asymmetry in import price pass-through, the issue of size asymmetry is captured through the following specifications as adopted from chapter four itself. Equation 16 exemplifies equation 14 but by augmented the dummy variables explained in Table 6.1 that represent size asymmetries. The cost, demand and external pressures are incorporated into this baseline model. The exchange rate variable is decomposed into two components – namely the small and large changes. The delineation of exchange rate changes into small and large counterparts is a debated matter, unlike the issue of directional asymmetry. As explained in section 6.2, the relevant dummy variables are incorporated into the equation fourteen and these dummy variables account for the pass-through from small and large exchange rates to import prices.

$$\begin{aligned}\mathbf{\Delta InIPX} \;=\; & \mathbf{\beta_1 \Delta InOILIND + \beta_2 \Delta InWCPI + \beta_3 \Delta InRGDP + \beta_4 D_{GFC}} \\ & \mathbf{+ \beta_5 D_L + \beta_6 D_S + \beta_7 D_{L*NEER} + \beta_8 D_{S*NEER} + \varepsilon} \qquad \text{....(16)}\end{aligned}$$

In a similar vein, the extended baseline model in equation 15 is also augmented to account for the dummy variables as included in equation 16. Additional set of control variables are thus allowed to impact the estimated pass-through, providing purer estimates of the price impact of exchange rate. This leads to equation 17 as shown below.

$$\Delta \mathbf{InIPX} = \beta_0 + \beta_1 \Delta \mathbf{InOILIND} + \beta_2 \Delta \mathbf{InWCPI} + \beta_3 \Delta \mathbf{InRGDP} + \beta_4 \mathbf{D_{GFC}} + \beta_5 \Delta \mathbf{InCINF} + \beta_6\ \mathbf{InCINF_{SD}} + \beta_7 \mathbf{InNEER_{SD}} + \beta_8\ \mathbf{InRTOPEN_{t-1}} + \beta_9 \Delta \mathbf{InIPX_{t-1}} + \beta_{10} \mathbf{D_L} + \beta_{11} \mathbf{D_S} + \beta_{12} \mathbf{D_{L*NEER}} + \beta_{13} \mathbf{D_{S*NEER}} + \varepsilon \qquad \text{....(17)}$$

Equation 17 represents the empirical model for capturing size asymmetries and the equation takes into consideration cost, demand, external as well as internal pressures that induce inflationary momentum in import prices *per se* and also allow the inclusion of additional control variables while estimating the pass-through coefficients. Following Patra et al. (2018), the empirical model in equation 17 is modified to account for size asymmetries within the polynomials approach as expressed in equation 18 below.

$$\Delta \mathbf{InIPX} = \beta_0 + \beta_1 \Delta \mathbf{InOILIND} + \beta_2 \Delta \mathbf{InWCPI} + \beta_3 \Delta \mathbf{InRGDP} + \beta_4 \mathbf{D_{GFC}} + \beta_5 \Delta \mathbf{InCINF} + \beta_6\ \mathbf{InCINF_{SD}} + \beta_7 \mathbf{InNEER_{SD}} + \beta_8\ \mathbf{InRTOPEN_{t-1}} + \beta_9 \Delta \mathbf{InIPX_{t-1}} + \beta_{10} \Delta \mathbf{InNEER} + \beta_{11} (\Delta \mathbf{InNEER})^3 + \varepsilon \qquad \text{....(18)}$$

Equations 16, 17 and 18 capture the issue of size asymmetry in pass-through to import prices. However, this study also investigates the composite asymmetry, and uses the variables 5 to 8 as defined in Table 6.1. The motivation to account for composite asymmetries is to recognize that size and directional asymmetries are interlinked. Large depreciations, small depreciations, large appreciations and small appreciations can have very different price impacts on aggregate imports. The pricing decisions underlying these exchange rate movements can emerge from drastically different competitive, structural, and institutional concerns and thus focusing exclusively on the linear impact of exchange rate alterations on prices may not be substantive enough to warrant meaningful economic inferences. Hence, the empirical models contained in equations 13 and 14 are augmented and presented below in equations 19 and 20.

$$\Delta \mathbf{InIPX} = \beta_1 \Delta \mathbf{InOILIND} + \beta_2 \Delta \mathbf{InWCPI} + \beta_3 \Delta \mathbf{InRGDP} + \beta_4 \mathbf{D_{GFC}} + \beta_5 \mathbf{D_{LD}} + \beta_6 \mathbf{D_{LA}} + \beta_7 \mathbf{D_{SD}} + \beta_8 \mathbf{D_{SD}} + \varepsilon \qquad \text{....(19)}$$

Equation 19 represents the baseline model of chapter four augmented with dummy variables representing small appreciation, small depreciation, large appreciation and large depreciation. Similarly, the extended baseline model contained in equation 14 of chapter four is augmented with the relevant dummy variables as shown in Equation 20 below.

$$\begin{aligned}\mathbf{\Delta InIPX} = \; & \boldsymbol{\beta_1 \Delta InOILIND + \beta_2 \Delta InWCPI + \beta_3 \Delta InRGDP} \\ & \boldsymbol{+ \beta_4 D_{GFC} + \beta_5 \Delta InCINF + \beta_6 \, InCINF_{SD} + \beta_7 InNEER_{SD}} \\ & \boldsymbol{+ \beta_8 \, InRTOPEN_{t-1} + \beta_9 \Delta InIPX_{t-1} + \beta_{10} D_{LD} + \beta_{11} D_{LA}} \\ & \boldsymbol{+ \beta_{12} D_{SD} + \beta_{13} D_{SA} + \varepsilon} \qquad \mathbf{....(20)}\end{aligned}$$

Equations 19 and 20 represent the composite asymmetry issue and its estimates are reported in the next section. It is to be noted that the issue of size asymmetry is approached from three angles with reference to the import price pass-through. The first approach measures dummy variables as defined in specification 5 and 7. The second approach measures the dummy variables as defined 5.1 and 7.1. And the third approach addresses the issue of size asymmetry using the polynomials approach. The subsequent section presents the empirical estimates on various dimensions of asymmetries for import price pass-through from exchange rate variations.

6.3.1. Asymmetric pass-through of exchange rate changes to import price inflation in India

Before estimating asymmetries and nonlinearities in the pass-through relationship, it is necessary to establish the existence of nonlinearity in the estimated linear models (Balcilar et al., 2019). Accordingly, an auxiliary regression approach is adopted wherein the residuals from the linear models in chapter four are used as dependent variables along with the other independent variables, while also accounting for the quadratic terms of the regressors. If the quadratic term of any of the variables is significant, it would provide evidence on nonlinearity emerging from that variable. The test for linearity also helps in testing the thesis that asymmetries emerge from exchange rate variations only as against from other variables included in the baseline and extended baseline models. Accordingly, the results for the test for non-linearity in this context are presented in Table 6.2 below.

Table 6.2: Test for non-linearity in the models for import price pass-through

Variable	***Dependent Variable is the residual from the linear version***			
	Model 1	**Model 2**	**Model 3**	**Model 4**
	Baseline	*Baseline without Dummy*	*Baseline without ΔIn(RGDP)*	*Baseline without Dummy and ΔIn(RGDP)*
Constant	0.03 (0.058)	0.01 (0.058)	0.004 (0.027)	0.01 (0.028)
ΔInOILIND	-0.03 (0.104)	-0.01 (0.104)	-0.02 (0.103)	-0.003 (0.099)
ΔInNEER	-0.80 (0.608)	-0.90 (0.632)	-0.83 (0.616)	-0.92 (0.619)
ΔInWCPI	0.04 (0.096)	-0.01 (0.079)	0.02 (0.098)	-0.02 (0.077)
ΔInRGDP	0.10 (0.819)	0.068 (0.854)	-	-
D_{GFC}	-0.06 (0.152)	-	-0.01 (0.149)	-
$(\Delta InOILIND)^2$	0.08 (0.230)	0.15 (0.236)	0.07 (0.234)	0.14 (0.231)
$(\Delta InNEER)^2$	-7.87# (4.583)	-8.33* (4.784)	-7.76# (4.686)	-8.17* (4.745)
$(\Delta InWCPI)^2$	0.07 (0.115)	-0.05 (0.099)	0.02 (0.113)	-0.06 (0.098)
$(\Delta InRGDP)^2$	-7.72 (13.077)	-2.95 (13.365)	-	-
Test Statistic	5.11 [0.276]	4.25 [0.373]	3.74 [0.290]	3.85 [0.278]

Notes: 1. Test Statistic is based on the LM test for nonlinearity based on auxiliary regression of residuals obtained from the linear version of the estimated equation, and the test statistic follows a chi-square distribution; 2. Figures in round bracket indicate the standard error of the respective coefficient; 3. Figures in squared brackets indicate the associated p-value; 4. ***, ** and * indicate significance at 1%, 5% and 10% levels respectively; 5. # indicates significant at 12% level and represents a borderline significant case with minimum permissible significance set at 10% level. 6. The residuals from the extended baseline model was also regressed on the variables included in the linear model along with the squared term of exchange rate variable. The coefficient of the squared term of exchange rate was worked out to be -16.87 with t-ratio of -2.562 and thus was significant at 5% level. This implied the possibility of non-linearity emerging from the exchange rate variable in the extended version of the baseline model also. **Source**: Author's estimation.

Table 6.3: Directional asymmetry in ERPT to import prices in India via the dummy variables approach

Variable	Model 1	Model 2	Model 3	Model 4
	Baseline	Baseline without dummies	Extended Baseline	Extended Baseline without dummies
Constant	-	0.11** (2.179)	-	-0.53*** (-2.990)
ΔlnOILIND	0.29*** (2.885)	0.30*** (2.923)	0.29*** (3.999)	0.29*** (4.064)
ΔlnWCPI	0.17** (2.221)	0.17** (2.315)	0.23*** (4.603)	0.23*** (4.734)
ΔlnRGDP	-1.24# (-1.694)	-1.06 (-1.487)	-2.49** (-2.610)	-2.40** (-2.596)
D_{GFC}	-0.18 (-1.458)	-0.19 (-1.496)	-0.30*** (-3.186)	-0.30*** (-3.310)
ΔlnCINF	-	-	1.11 (1.444)	1.25* (1.752)
$lnCINF_{SD}$	-	-	-0.07** (-2.226)	-0.08** (-2.584)
$lnNEER_{SD}$	-	-	0.12** (2.356)	0.11** (2.327)
$lnRTOPEN_{t-1}$	-	-	0.16*** (3.396)	0.16*** (3.414)
D_D	0.15** (2.383)	-	-0.52** (-2.873)	-
D_A	0.08 (1.311)	-	-0.55*** (-2.993)	-
D_{D*NEER}	-0.75 (-1.339)	-1.01* (-2.012)	0.09 (0.129)	-0.10 (-0.165)
D_{A*NEER}	-0.96 (-0.539)	-2.21$ (-1.679)	-2.55** (-2.148)	-2.95*** (-3.029)
R^2	0.65	0.64	0.93	0.91
F-statistic	5.94***	6.75***	12.75***	14.58***

Notes: # is significant at 13%. $ implies significant at 11%. **Source**: Author's estimation.

As shown in Table 6.2, the coefficient of the quadratic term of exchange rate is significant across all the different specifications, indicating that there is nonlinearity emerging from exchange rate behaviour. However, the quadratic terms for all other variables are insignificant, indicating that exchange rate can play an important role in explaining any nonlinear behaviour in import price itself. Thus, an empirical ground is prepared to test for asymmetries using the empirical models explained in the previous section. Table 6.3 presents the evidence on directional asymmetry in the aggregate ERPT to imports in India.

Table 6.4: Directional asymmetries in ERPT to import prices through the polynomial approach

Variable	**Model 1**	**Model 2**
	Baseline	Extended Baseline
Constant	0.11** (2.495)	-0.43** (-2.623)
ΔInOILIND	0.28*** (2.980)	0.30*** (4.487)
ΔInNEER	-2.10*** (-3.710)	-1.59*** (-3.572)
ΔInWCPI	0.18** (2.627)	0.24*** (4.917)
ΔInRGDP	-1.09# (-1.637)	-1.88*** (-3.955)
D_{GFC}	-0.21* (-1.767)	-0.23** (-2.413)
ΔInCINF	-	1.40* (1.953)
$InCINF_{SD}$	-	-0.07** (-2.285)
$InNEER_{SD}$	-	0.09* (2.042)
$InRTOPEN_{t-1}$	-	0.12** (2.778)
$\Delta InNEER^2$	-8.27* (-1.925)	-15.66** (-2.334)
R^2	0.68	0.89
F-statistic	8.15***	14.29***

Notes: # is significant at 13%. $ implies significant at 11%. **Source**: Author’s estimation.

The results contained in Table 6.3 are estimated using equations 13 and 14. Estimated results in Table 6.3 provide important interferences with regards to the nature of asymmetries in the price impact of exchange rate variations on India's aggregate imports. Across majority of the alternative speficaitions in table 6.2, the dummy variable for appreciations is significant and higher than that of depreciation. It appears that pass-through to import price inflation is higher during appreciation rather than depreciations in the exchange rate, measured by the nominal effective exchange rate. The evidence seems to be indicating that firms exporting to India are passing over the disinflationary impact of appreciation much more than the inflationary impact of depreciation. The model 2 shows that pass-through for depreciation is complete, but it also shows that pass-through from appreciation is more than complete, indicating perhaps PTM behaviour. The exporting firms may be focusing on expanding their market share when Indian currency appreciates; though, they are also fully passing over the inflationary impact to India's import prices indicating that Indian importers are largely price takers in the international markets. While the observed pass-through confidents cannot directly imply market power, it is indicative of exporting firms that are at least not price-takers.

Table 6.4 presents the findings on the issue of directional asymmetries when the polynomial approach is used, and the quadratic term of exchange rate is used instead of the dummy variables. If the "coefficient of the quadratic term is positive, it would amplify the linear term and make depreciations more inflationary..." (Patra et al., 2018). This implies that depreciations will have a larger impact than appreciation. Consistent with the findings in Table 6.3, the quadratic term is negative and significant, indicating that the pass-through from exchange rate appreciations is larger than the pass-through from depreciations. Irrespective of the approach – whether the dummy variable approach or the polynomial terms approach, the finding remains robust. Table 6.5 presents the estimates of size asymmetries in the pass-through to import price inflation using equations 16 and 17.

The estimated results also show strong consistency with the estimates of chapter four. The cost pressures are exerting upwards momentum in import price inflation and ERPT seems to be extrapolating this influence further. The demand pressure is exerting a downwards compression. Perhaps, expanding output is inducing larger expenditure switching, thereby causing a fall in the demand for imports and a shift to domestic substitutes, which could induce a fall in the import price inflation.

Table 6.5: Size asymmetry in ERPT to import prices within the first approach

Variable	Model 1	Model 2	Model 3	Model 4
	Baseline	Baseline without dummies	Extended Baseline	Extended Baseline without dummies
Constant	-	0.10** (2.591)	-	-0.47** (-2.884)
ΔInOILIND	0.26** (2.813)	0.26*** (2.909)	0.24*** (4.282)	0.22*** (3.510)
ΔInWCPI	0.17** (2.567)	0.17** (2.616)	0.21*** (5.434)	0.22*** (4.898)
ΔInRGDP	-1.17* (-1.821)	-1.16* (-1.851)	-2.52*** (-3.319)	-2.66*** (-3.120)
D_{GFC}	-0.15 (-1.290)	-0.15 (-1.305)	-0.29*** (-3.655)	-0.33*** (-3.706)
ΔInCINF	-	-	1.09* (1.766)	0.70 (1.045)
$InCINF_{SD}$	-	-	-0.09*** (-3.438)	-0.07** (-2.553)
$InNEER_{SD}$	-	-	0.13*** (3.200)	0.13** (2.863)
$InRTOPEN_{t-1}$	-	-	0.15*** (3.834)	0.14*** (3.361)
D_L	$0.12^{\#}$ (1.621)	-	-0.58*** (-3.791)	-
D_S	0.10** (2.521)	-	-0.50*** (-3.439)	-
D_{L*NEER}	-0.68 (-1.351)	-0.75* (-1.954)	-1.08** (-2.749)	-0.74* (-1.827)
D_{S*NEER}	-2.81*** (-4.159)	-2.80*** (-4.245)	-1.74*** (-3.661)	-2.07*** (-4.058)
$\Delta In(IPX)_{t-1}$	-	-	$-0.13^{\#}$ (-1.605)	-0.16*
R^2	0.72	0.72	0.95	0.93
F-statistic	8.06***	9.81***	19.33***	16.34***

Notes: # is significant at 13%. $ implies significant at 11%. **Source**: Author's estimation.

The results in Table 6.5 indicate that the pass-through when exchange rate change is small, is more than the pass-through when exchange rate changes are large, with regards to import prices in India. The results seem to be suggesting that import prices are more susceptible to smaller variations in exchange rate as compared to larger variations. Perhaps, there may be market share considerations that are preventing exporting firms from passing over large changes to India's import prices. Despite not being price takers, countries exporting to India appear to be absorbing large changes into their markups and only allowing smaller changes to pass over to the destination market. From a macroeconomic point of view, it may be the case that the aggressive stance of the Central Bank in maintaining price stability and its intolerance of high inflation may be inducing foreign firms from passing over large changes.

On similar lines, Table 6.6 presents the issue of size asymmetry by defining the dummy variables for large and small changes using the criterion of 3% change as defined in speficaitions 5.1 and 7.1 earlier. Clearly, the pass-through impact from exchange rate variations is larger from small changes as compared to large changes. The findings from Table 6.5 are again corroborated in Table 6.6 and indicates the robustness of the inferences made here. Table 6.7 presents the results on size asymmetries in import price pass-through suing the polynomials approach on lines of Patra et al. (2018). It is expected that the cubic term of exchange rate will be positive, indicating that smaller changes in exchange rate induce higher pass-through than large changes. The dominance of small changes over large changes provides indications on the nature of market and pricing policies that Indian importers may be experiencing in the international markets. While the extent of pass-through is very well complete for large changes also, the same is more than complete for smaller exchange rate alterations. The completeness of pass-through indicates that Indian imports are experiencing the full brunt of exchange rate volatility. However, the transmission is restricted when changes are large but are extrapolated when they are small, implying the competitive concerns of foreign firms supplying our imports. Given the size and scope of the Indian market, it is not surprising to learn that smaller impulses emanating in exchange rate variations are finding larger room for transmission to import prices of India compared to larger changes. Indian importers could be having access to multiple substitutes in the international markets, which the current foreign suppliers would not want to give any leeway to.

Table 6.6: Size asymmetry in ERPT to import prices within the second approach

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
	Baseline	Baseline without dummies	Extended Baseline	Extended Baseline without dummies
Constant	-	0.10** (2.265)		-0.47** (-2.495)
ΔInOILIND	0.27** (2.674)	0.27** (2.708)	0.25*** (3.243)	0.26*** (3.405)
ΔInWCPI	0.19 (2.488)	0.20** (2.630)	0.26*** (4.216)	0.26*** (4.489)
ΔInRGDP	-1.07 (-1.530)	-1.08# (-1.550)	-1.69*** (-3.167)	-1.70*** (-3.308)
D_{GFC}	-0.21$	-0.21$ (-1.683)	-0.36*** (-3.511)	-0.36*** (-3.614)
ΔInCINF	-	-	1.17 (1.412)	1.18 (1.468)
$InCINF_{SD}$	-	-	-0.05 (-1.283)	-0.05 (-1.301)
$InNEER_{SD}$	-	-	0.07 (1.419)	0.08# (1.599)
$InRTOPEN_{t-1}$	-	-	0.14** (2.571)	0.13** (2.631)
D_L	0.12** (2.226)	-	-0.47** (-2.430)	-
D_S	0.09* (1.925)	-	-0.48** (-2.442)	-
D_{L*NEER}	-1.01** (-2.346)	-1.12*** (-2.921)	-0.98** (-2.194)	-1.02** (-2.403)
D_{S*NEER}	-2.92* (-2.035)	-2.99** (-2.119)	-2.60* (-1.990)	-2.60* (-2.049)
$\Delta InIPX_{t-1}$	-	-	-0.12 (-1.093)	-0.11 (-1.079)
R^2	0.66	0.65	0.87	0.87
F-statistic	6.07***	7.22***	9.20***	10.59***

Notes: # is significant at 13%. $ implies significant at 11%. **Source**: Author's estimation.

Continuing the examination of results in Table 6.6 and 6.7, the fact that smaller changes are more-than-fully compensated for in terms of variations in local currency price of Indian imports further imply that menu cost explanations do not provide much of a credence to the empirical facts. The foreign exporting firms are not sensitive to any threshold level in the first place; otherwise small exchange rate changes could not be inducing such large transmissions to import prices.

Table 6.7: Size asymmetries in ERPT to import prices within the third approach

Variable	**Model 1**	**Model 2**
	Baseline	Extended Baseline
Constant	0.10** (2.448)	-0.40** (-2.438)
ΔInOILIND	0.27*** (2.918)	0.28*** (4.122)
ΔInNEER	-2.19*** (-4.412)	-2.17*** (-3.346)
ΔInWCPI	0.19** (2.793)	0.24*** (4.854)
ΔInRGDP	-1.13* (-1.740)	-1.86* (-3.875)
D_{GFC}	-0.25** (-2.128)	-0.19* (-1.811)
ΔInCINF	-	0.98 (1.304)
$InCINF_{SD}$	-	-0.05 (-1.467)
$InNEER_{SD}$	-	0.09* (1.970)
$InRTOPEN_{t-1}$	-	0.12** (2.639)
$(\Delta InNEER)^3$	50.79** (2.338)	187.7** (2.190)
R^2	0.70	0.88
F-statistic	8.94***	13.84***

Notes: # is significant at 13%. $ implies significant at 11%. **Source**: Author's estimation.

Table 6.8: Composite asymmetries in the ERPT to import prices

	Dummy Variable Approach - I		**Dummy Variable Approach – II**	
Variable	Model 1	Model 2	Model 3	Model 4
	Baseline	Extended Baseline	Baseline[%]	Extended Baseline
Constant	0.08 (1.469)	-0.40** (-2.483)	-	-0.43** (-2.330)
ΔlnOILIND	0.26** (2.768)	0.29*** (4.377)	0.23** (2.079)	0.31*** (3.850)
ΔlnWCPI	0.17** (2.570)	0.22*** (4.767)	0.23** (2.522)	0.22*** (3.263)
ΔlnRGDP	-1.09[$] (-1.680)	-1.75*** (-3.817)	-0.09 (-0.173)	-1.88*** (-3.590)
D_{GFC}	-0.14 (-1.193)	-0.22** (-2.399)	-0.20 (-1.440)	-0.27** (-2.488)
ΔlnCINF	-	1.61** (2.231)	-	1.48* (1.818)
$lnCINF_{SD}$	-	-0.08** (-2.734)	-	-0.06[$] (-1.673)
$lnNEER_{SD}$	-	0.07 (1.483)	-	0.09[$] (1.727)
$lnRTOPEN_{t-1}$	-	0.11** (2.541)	-	0.13** (2.589)
D_{LD}	-0.88* (-1.886)	-0.10 (-0.178)	-1.53*** (-2.924)	0.08 (0.104)
D_{LA}	-0.85 (-0.592)	-2.41** (-2.368)	-0.49 (-0.347)	-2.50** (-2.230)
D_{SD}	-3.58*** (-3.127)	-1.87* (-2.115)	-5.28* (-1.745)	0.70 (0.255)
D_{SA}	-1.30 (-0.697)	-0.53 (-0.363)	-0.48 (-0.184)	-4.64* (-2.053)
R^2	0.73	0.91	0.65	0.88
F-statistic	7.10***	13.40***	5.06***	9.96***

Notes: 1. # is significant at 13%; 2. $ implies significant at 11%; 3. % - The second approach was employed in the baseline model without the intercept term as the results for each of the interaction dummy was insignificant. The estimates of this model should be referred with this caveat.

The results contained in Table 6.7 are based on equation 18, and they further corroborate the results in Tables 6.5 and 6.6, as the coefficient of the polynomial term, the cubic term of NEER, is positive. Smaller changes clearly appear to be inducing a higher extent of pass-through than larger changes. This finding is robust to all the three alternative perspectives. The market share concerns may be one force at work in this case. It is also evident that the menu cost model does fit the findings well in this regard. Large changes are fully passed over into the import prices in local currency, while the pass-through from smaller changes are more-than-complete. The notion of threshold exchange rate variation, which is an important cornerstone of the menu cost theory, does not seem to be playing a meaningful role in explaining the completeness of pass-through from large changes.

Finally, Table 6.8 presents the estimates on the dimension of composite asymmetry and is based on equations 19 and 20. The estimates in Table 6.8 provide mixed results. While the estimates in the previous tables are consistent with each other, the evidence here seems to be sensitive to the specification adopted. Model 1 indicates that the pass-through is the highest for small depreciations. Model 2 indicates that large appreciations have the highest pass-through. Model 3 provides evidence in favour of small depreciation, while Model 4 favours small appreciation. The bulk of the evidence, however, is in favour of small changes, as indicated by models 1, 3 and 4. However, there is disagreement in the results on whether small appreciation or small depreciation causes larger pass-through. The Models 1 and 2 represent the dummies representing the size of exchange rate variation in terms of the 'standard deviation' approach explained earlier. Models 3 and 4 represent the size dummies measured using the '3 percent' criterion as highlighted earlier.

Given that there are two models – Model 1 and 3, that favor small depreciation, it may be tentatively concluded that small depreciations in exchange rate induce higher inflationary impact than large depreciations and the alternative cases of appreciation. The higher pass-through from small depreciations may be indicative of the less desirability of foreign firms in passing over large changes and thereby negatively impacting their share in the Indian market. Alternatively, following the Taylor's hypothesis, stable and targeted inflationary environment in India may be responsible for large changes not being passed over to India's import prices[6]. It is also evident that specification of the size of exchange rate is critical in deciphering the nature of composite asymmetries. The next section examines the issues investigated in this section but with reference to the pass-through from exchange rate to domestic inflation in India. The baseline models from chapter five are extended and the asymmetry dynamics are explored therein.

6.4. Empirical perspectives on the asymmetries in exchange rate pass-through to domestic price in India

Consequent to section 6.3.1, this section investigates the two core issues on asymmetries in the pass-through relationship. This section raises some pertinent questions. The first is whether there exists asymmetric pass-through from exchange rate changes to domestic inflation in India? If it does, then what is the nature of these asymmetries? Are there directional asymmetries? Are there size asymmetries? Or are there both forms of asymmetries that are inducing nonlinearity in the pass-through relationship? These matters are addressed here.

Following the approach in the previous section, this section also tests for the existence of nonlinearity in the linear econometric models estimated in chapter five embodied in the estimates of baseline models 5 and 6. Two tests were employed for this purpose. The first was the auxiliary regression as undertaken in the previous chapter. The second approach was the Brock-Dechert-Scheinkman (BDS) test for detecting nonlinearity as developed in Brock et al. (1987). The test is a non-parametric approach to nonlinearity detection. Bisaglia and Gerolimetto (2014) provide a detailed analysis of the test, its statistical properties and its ability to detect nonlinearity in linear models. Both these approaches did not yield evidence of existence of nonlinearity in the estimated linear models from chapter five. Despite this finding, it may plausible that these tests may not have detected the nonlinearity, or perhaps, the form of nonlinearity tested by these approaches may not be relevant in the present context. Put differently, there may be non-linear impact of exchange rate on domestic prices which is perhaps not effectively captured by the chosen tests for nonlinearity. Empirically, ERPT to domestic inflation has been found asymmetric in the Indian context by studies such as Patra et al. (2018), Suryavanshi (2022), and a few others in the recent period.

On similar lines, the second baseline model of chapter five, contained in equation six, was also tested for nonlinearity with the above two approaches. Firstly, an auxiliary regression method was employed. There was evidence of non-linearity emerging from the variable of call rate, i.e. the proxy variable for monetary policy. However, no such evidence emerged for the exchange rate variable. Similar attempts were made with squared residuals but the results remained the same. Thereafter, the BDS test was undertaken and evidence suggested that there was nonlinearity in the estimated model from 2nd to 10th dimension indicating room for introducing non-linearity and testing if exchange rate was impacting domestic prices asymmetrically. The test statistic for BDS test was 3.634 for test order up to 2 with p-value of 0.006, where the initial first-order correlation was assumed to be 0.7, which is a 'standard practice in the literature' (Bisaglia and Gerolimetto, 2014). Thus, further investigation to explore the nature of asymmetries in the pass-through relationship between exchange rate alternations and inflation in India is necessitated. This forms the subject-matter of the present section.

Following the approach in the previous section, the baseline empirical models from chapter five are augmented to account for the dummy variables and the polynomial terms and thus capture the nature of asymmetric pass-through in India. Equation 9 from chapter 5 is augmented to account for directional asymmetry which yields Equation 21. The first baseline model captures monetary policy from the perspective of money supply variations. The backwards-looking open economy Philips curve framework is utilized to specify the inflation function as examined in detail in chapter five. The resultant equation is modified to account for dummy variables that capture directional asymmetries as explained in table 6.1 earlier in this chapter.

$$\mathbf{\Delta InWPI = \beta_1 OGAP + \beta_2 \Delta InNM3_{t-2} + \beta_3 InOILP + \beta_4 D_{PAND} + \beta_5 \Delta InWPI_{t-1} + \beta_6 D_D + \beta_7 D_A + \beta_8 D_{D*NEER} + \beta_9 D_{A*NEER} + \varepsilon} \quad \mathbf{....(21)}$$

Equation 21 expresses the inflation function modified for directional asymmetries. The most essential determinants of inflation behavior are captured along with the exchange rate variable. The exchange rate variable is decomposed into depreciation and appreciation components through the two interactive dummy variables. This permits obtaining two separate pass-through coefficients, each indicating the extent of pass-through in either direction – whether appreciation or depreciation. Similarly, the second baseline model from chapter five is also augmented to account for directional asymmetry which yields the Equation 22 as below.

$$\Delta \mathbf{InWPI} = \boldsymbol{\beta}_1 \mathbf{OGAP} + \boldsymbol{\beta}_2 \Delta \mathbf{InOILP} + \boldsymbol{\beta}_3 \mathbf{InWACR}_{t-3} + \boldsymbol{\beta}_4 \mathbf{D}_{\mathbf{FIT}}$$
$$+\boldsymbol{\beta}_5 \mathbf{D}_{\mathbf{PAND}} + \boldsymbol{\beta}_6 \Delta \mathbf{InWPI}_{t-1} + \boldsymbol{\beta}_7 \mathbf{D}_{\mathbf{D}} + \boldsymbol{\beta}_8 \mathbf{D}_{\mathbf{A}}$$
$$+\boldsymbol{\beta}_9 \mathbf{D}_{\mathbf{D*NEER}} + \boldsymbol{\beta}_{10} \mathbf{D}_{\mathbf{A*NEER}} + \boldsymbol{\varepsilon} \qquad \text{....(22)}$$

The second baseline model accounts for monetary policy via the interest rate route, accounting for the short-term interest rate as proxied by the weighted average call money rate as defined by the RBI. As explained earlier, this variable has been adopted as the monetary policy operational target variable. Given its nature as the target variable, theoretically it will represent the 'impact' of monetary policy rather than monetary policy itself. Hence, the lagged value of this variable is used to avoid committing the specification error and one can conceptualize the lagged value of this interest rate variable as the impact of past monetary policy changes on the current inflation rate. A lag of three quarters is incorporated on statistical considerations. The use of this version of the inflation function is to recognize the role of interest rate movements in explaining inflationary momentum while also testing the null hypothesis that ERPT is invariant to monetary policy control variables.

As per the approach in the previous section, the polynomial approach to directional asymmetry is also investigated by incorporating the quadratic term into the baseline equations five and six from chapter five which yields Equation 23 and 24. Both the baseline models are augmented to account for directional asymmetry; however, now the earlier Philips curve specification is augmented with the quadratic term rather than the dummy variables delineated in table 6.1.

$$\Delta \mathbf{InWPI} = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1 \mathbf{OGAP} + \boldsymbol{\beta}_2 \Delta \mathbf{InNM3}_{t-2} + \boldsymbol{\beta}_3 \mathbf{InOILP} + \boldsymbol{\beta}_4 \mathbf{D}_{\mathbf{PAND}} + \boldsymbol{\beta}_5 \Delta \mathbf{InWPI}_{t-1}$$
$$+\boldsymbol{\beta}_6 (\Delta \mathbf{InNEER})^2 + \boldsymbol{\varepsilon} \qquad \text{....(23)}$$

$$\Delta \mathbf{InWPI} = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1 \mathbf{OGAP} + \boldsymbol{\beta}_2 \Delta \mathbf{InOILP} + \boldsymbol{\beta}_3 \mathbf{InWACR}_{t-3} + \boldsymbol{\beta}_4 \mathbf{D}_{\mathbf{FIT}}$$
$$+\boldsymbol{\beta}_5 \mathbf{D}_{\mathbf{PAND}} + \boldsymbol{\beta}_6 \Delta \mathbf{InWPI}_{t-1} + \boldsymbol{\beta}_7 (\Delta \mathbf{InNEER})^2 + \boldsymbol{\varepsilon} \qquad \text{....(24)}$$

Equations 23 and 24 represent the core models for capturing ERPT while also accommodating the critically important factors affecting inflation itself. While equations 21 to 24 account for the empirical models used to capture directional asymmetries, the same equations are augmented to account for size asymmetries also. This is undertaken by incorporating the relevant dummy variables as explained in Table 6.1 earlier. This yields the following equations.

$$\begin{aligned}\Delta \mathbf{InWPI} = {} & \boldsymbol{\beta}_1\mathbf{OGAP} + \boldsymbol{\beta}_2\Delta\mathbf{InNM3}_{t-2} + \boldsymbol{\beta}_3\mathbf{InOILP} + \boldsymbol{\beta}_4\mathbf{D}_{\mathbf{PAND}} + \boldsymbol{\beta}_5\Delta\mathbf{InWPI}_{t-1} \\ & + \boldsymbol{\beta}_6\mathbf{D}_{\mathbf{L}} + \boldsymbol{\beta}_7\mathbf{D}_{S} + \boldsymbol{\beta}_8\mathbf{D}_{\mathbf{L*NEER}} + \boldsymbol{\beta}_9\mathbf{D}_{\mathbf{S*NEER}} + \boldsymbol{\varepsilon} \qquad \text{....(25)}\end{aligned}$$

$$\begin{aligned}\Delta \mathbf{InWPI} = {} & \boldsymbol{\beta}_1\mathbf{OGAP} + \boldsymbol{\beta}_2\Delta\mathbf{InOILP} + \boldsymbol{\beta}_3\mathbf{InWACR}_{t-3} + \boldsymbol{\beta}_4\mathbf{D}_{\mathbf{FIT}} \\ & + \boldsymbol{\beta}_5\mathbf{D}_{\mathbf{PAND}} + \boldsymbol{\beta}_6\Delta\mathbf{InWPI}_{t-1} + \boldsymbol{\beta}_7\mathbf{D}_{\mathbf{L}} + \boldsymbol{\beta}_8\mathbf{D}_{\mathbf{S}} \\ & + \boldsymbol{\beta}_9\mathbf{D}_{\mathbf{L*NEER}} + \boldsymbol{\beta}_{10}\mathbf{D}_{\mathbf{S*NEER}} + \boldsymbol{\varepsilon} \qquad \text{....(26)}\end{aligned}$$

The same baseline models are now extended to account for size asymmetries within the dummy variables approach. The equation 25 defines the large and small changes in exchange rate using the 'standard deviation' approach as explained earlier in section 6.3. Similarly, the second approach is also utilized where the changes in exchange rate above 3% in either direction are defined as large, and others as small, following Pollard and Coughlin (2004). Both approaches are incorporated into equations 25 and 26. The alternative approach is the polynomial approach wherein the cubic term of exchange rate is incorporated into the baseline models to specify the empirical models for detecting size asymmetries. The following equations are obtained accordingly.

$$\begin{aligned}\Delta \mathbf{InWPI} = {} & \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1\mathbf{OGAP} + \boldsymbol{\beta}_2\Delta\mathbf{InNM3}_{t-2} + \boldsymbol{\beta}_3\mathbf{InOILP} + \boldsymbol{\beta}_4\mathbf{D}_{\mathbf{PAND}} + \boldsymbol{\beta}_5\Delta\mathbf{InWPI}_{t-1} \\ & + \boldsymbol{\beta}_6(\Delta\mathbf{InNEER})^3 + \boldsymbol{\varepsilon} \qquad \text{....(27)}\end{aligned}$$

$$\begin{aligned}\Delta \mathbf{InWPI} = {} & \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1\mathbf{OGAP} + \boldsymbol{\beta}_2\Delta\mathbf{InOILP} + \boldsymbol{\beta}_3\mathbf{InWACR}_{t-3} + \boldsymbol{\beta}_4\mathbf{D}_{\mathbf{FIT}} \\ & + \boldsymbol{\beta}_5\mathbf{D}_{\mathbf{PAND}} + \boldsymbol{\beta}_6\Delta\mathbf{InWPI}_{t-1} + \boldsymbol{\beta}_7(\Delta\mathbf{InNEER})^3 + \boldsymbol{\varepsilon} \qquad \text{----(28)}\end{aligned}$$

While the above specifications account for directional and size asymmetries separately, both perspectives are synthesized by incorporating the relevant dummy variables as explained in

Table 6.1 earlier in this chapter. This exercise results into the following estimable models. The primary aim of these models is to account for the interactions between size and directional asymmetries. While the nature of nonlinearities in terms of differential impact of appreciation and deprecation, and small and large changes have already been captured by the previous models, the Phillips curve association is further augmented to clarify how the interactions between these nonlinearities can produce different pass-through estimates. Interaction of both the asymmetries can produce even more complicated pass-through dynamics. The underlying null hypothesis of this exercise is that the synthesis of size and directional asymmetries does not have a differential impact on domestic prices. These considerations yield Equation 29. Similarly, the second baseline model from chapter five is also augmented to account for composite asymmetries which yields the Equation 30 as below.

$$\begin{aligned}\boldsymbol{\Delta \mathrm{InWPI} = \beta_1 \mathrm{OGAP} + \beta_2 \Delta \mathrm{InNM3}_{t-2} + \beta_3 \mathrm{InOILP} + \beta_4 D_{PAND} + \beta_5 \Delta \mathrm{InWPI}_{t-1}} \\ \boldsymbol{+\beta_6 D_{LD} + \beta_7 D_{SD} + \beta_8 D_{LA} + \beta_9 D_{SA} + \varepsilon} \qquad \textbf{....(29)}\end{aligned}$$

$$\begin{aligned}\boldsymbol{\Delta \mathrm{InWPI} = \beta_1 \mathrm{OGAP} + \beta_2 \Delta \mathrm{InOILP} + \beta_3 \mathrm{InWACR}_{t-3} + \beta_4 D_{FIT}} \\ \boldsymbol{+\beta_5 D_{PAND} + \beta_6 \Delta \mathrm{InWPI}_{t-1} + \beta_7 D_{LD} + \beta_8 D_{SD}} \\ \boldsymbol{+\beta_9 D_{LA} + \beta_{10} D_{SA} + \varepsilon} \qquad \textbf{....(30)}\end{aligned}$$

This concludes the specification of the empirical models used for measuring the extent of nonlinearity and asymmetry in the ERPT to domestic inflation in India. The next section presents the estimated results for models 21 to 30. Each of the proposed model is tested against the macroeconomic data to locate the extent and nature of asymmetries. As noted earlier, these asymmetries will introduce good amount of nonlinearities into the pass-through relationship. These nonlinearities can distort the findings from linear models and perhaps result into incorrect economic inferences. Furthermore, if there is indeed a nonlinear relationship between exchange rate variations and domestic prices, then the reliance on linear estimates for macroeconomic inferences may prove fatal.

6.4.1. Asymmetric pass-through of exchange rate changes to aggregate domestic prices in India

Table 6.9: Directional asymmetries in ERPT to domestic prices

	Dummy Variable Approach		Polynomial Term Approach	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
	Baseline – I	*Baseline - II*	*Baseline – I*	*Baseline – II*
Constant	-	-	-0.004 (-0.925)	0.017** (2.602)
OGAP	0.14*** (3.669)	0.15*** (3.695)	0.13*** (3.272)	0.14*** (3.206)
$lnNM3_{t-2}$	0.29*** (2.722)	-	0.29*** (2.649)	-
$\Delta lnOILP$	0.04*** (4.946)	0.04*** (5.159)	0.04*** (4.582)	0.04*** (4.813)
D_{FIT}	-	-0.008** (-2.413)	-	-0.007** (-2.063)
D_{PAND}	0.016*** (3.760)	0.017*** (3.165)	0.015*** (3.734)	0.015*** (2.993)
$lnWACR_{t-3}$	-	-0.01$ (-1.655)	-	-0.005# (-1.591)
$\Delta lnWPI_{t-1}$	0.26*** (3.569)	0.24*** (3.173)	0.28*** (3.614)	0.26*** (3.256)
D_D	-0.003 (-0.889)	0.018** (2.623)	-	-
D_A	-0.003 (-0.719)	0.018** (2.581)	-	-
D_{D*NEER}	-0.20*** (-2.688)	-0.195** (-2.616)	-	-
D_{A*NEER}	-0.15 (-1.037)	-0.174 (-1.199)	-	-
$(\Delta lnNEER)^2$	-	-	2.02*** (2.191)	1.96** (2.089)
R^2	0.57	0.57	0.53	0.52
F-statistic	16.04***	14.20***	17.98***	15.01***

Notes: 1. # is significant at 13%; 2. $ implies significant at 11%.

The results from equations 21 to 29 are contained in Tables 6.9, 6.10 and 6.11. Table 6.9 reports the findings on directional asymmetry with regards to the ERPT to inflation in India. It is apparent from the estimates in Table 6.9 that the pass-through is higher during depreciation than during appreciation as indicated by the negative and significant coefficients in Models 1 and 2, and by the positive and significant coefficients of Models 3 and 4. Pass-through is higher from depreciations that from appreciations when looked from the perspective of domestic inflation. Given the finding in the previous section where appreciation had a larger impact on import prices as compared to depreciations, the finding in this section presents a different perspective. Perhaps, the price reduction impulses from foreign firms are largely absorbed by the firms importing the commodities and not passed into the wholesale prices. While, the increases in price from foreign firms following depreciation are passed into the wholesale markets.

The absorption of the exchange rate's transmission signals must be occurring between the stages where imports are sold downstream and distributors sell the commodities in the wholesale markets. It is a matter of further study how this absorption occurs and which industries are contributing to such an absorption of exchange rate impulses, if such absorption really takes place in the first place. The findings are consistent with the previous sections as it was found that the pass-through is complete in case of depreciations. However, the inflationary impacts are passed over further downstream whereas disinflationary impacts are not.

The results in table 6.9 are consistent with the findings from the linear framework of chapter five, as far as the coefficients other than the exchange rate are concerned. The impact of output gap consistently hovers around 14% across all model specifications indicating inflationary impact of domestic economic expansion. Money supply also continues to portray 29% impact on inflation for every 100% increase in broad money stock. Oil price inflation is rather a weaker force in inducing inflationary momentum with the coefficient showing only 4% impact for every 100% change in world crude oil prices. Compared to import prices, domestic prices are lesser impacted by oil price inflation. The interesting finding is on account of the introduction of the Flexible Inflation Targeting (FIT) regime which shows a significantly negative coefficient across all specifications; though, the size of the coefficient is small. It is commendable to see that the monetary policy regime change contained in this dummy variable remains a significant source of disinflation despite the passage of seven years since its introduction. The Indian economy has been gaining the fruits of the introduction of the inflation targeting regime since its inception.

Table 6.10: Size asymmetries in ERPT to domestic prices

Variable	Dummy Variable Approach		Polynomial Term Approach	
	Model 1	Model 2	Model 3	Model 4
	Baseline – I	*Baseline - II*	*Baseline – I*	*Baseline – II*
Constant	-	-	-0.003 (-0.864)	0.019*** (2.838)
OGAP	0.14*** (3.651)	0.15*** (3.670)	0.13*** (3.262)	0.13*** (3.181)
$InNM3_{t-2}$	0.29*** (2.699)	-	0.29*** (2.736)	
ΔInOILP	0.04*** (4.880)	0.04*** (5.115)	0.04*** (4.586)	0.04*** (4.831)
D_{FIT}	-	-0.008** (-2.392)	-	-0.007** (-2.094)
D_{PAND}	0.016*** (3.741)	0.017*** (3.126)	0.016*** (3.669)	0.016*** (2.896)
$InWACR_{t-3}$	-	-0.005* (-1.674)	-	-0.006* (-1.728)
$\Delta InWPI_{t-1}$	0.26*** (3.538)	0.24*** (3.178)	0.28*** (3.759)	-
D_L	-0.003 (-0.803)	0.019*** (2.786)	-	-
D_S	-0.003 (-0.627)	0.019*** (2.906)	-	-
D_{L*NEER}	-0.173* (-1.842)	-0.16* (-1.730)	-	-
D_{S*NEER}	-0.179*** (-3.509)	-0.19*** (-3.699)	-	-
$(\Delta InNEER)^3$	-	-	-29.66** (-2.626)	-29.16** (-2.552)
R^2	0.57	0.57	0.53	0.53
F-statistic	16.01***	14.21***	18.68***	15.62***

Notes: 1. # is significant at 13%; 2. $ implies significant at 11%.

In continuation of the analysis of table 6.9, as found in chapter five, the pandemic has portrayed an inflationary impact; though, the size of the coefficient is small. The role of the short-term interest rate in impacting inflation is rather weak from both economic and statistical points of view. It seems that, consistent with the thesis underlying the quantity theory of money, monetary expansion has continued to contribute a sizeable inflationary momentum in India since the reforms with its coefficient being 29%. Lastly, one can note the persistence of inflation and its backwards dependency by the lagged value of the dependent variable which shows a statistically significant coefficient valued at 26% on an average across all specifications in table 6.9.

Table 6.10 presents the estimated results on size asymmetries in India using two approaches – namely the dummy variables approach and the polynomial term approach. These results are based on the Equations 25 to 28 are reported in Table 6.10. The coefficients of the interactive dummy variables in Table 6.10 are significant, but do not show much of a difference. In models 1 and 2, the coefficient D_{S*NEER} is slightly higher, but not by any meaningful margin. The signs of the cubic term in models 3 and 4 is negative and significant. As noted by Patra et al. (2018, pp. 11), "if the coefficient of the cubic term is also positive, it would imply that ERPT associated with higher exchange rate changes is lower than with lower exchange rate changes". While models 1 and 2 represent the dummy variable approach, models 3 and 4 represent the polynomial approach. The stark difference in results is evident when once compares both the set of estimates. The polynomials approach reveals a negative and significant coefficient, indicating that larger changes have higher pass-through than smaller changes. However, the dummy variable approach does not reveal economically relevant evidence of any form of asymmetry in the present case. Methodological sensitivity of the asymmetry estimates is also evident from Table 6.10 where the results vary considerably between the core baseline model and the extended baseline model.

Thereafter, Table 6.11 presents the estimated results for equations 29 and 30 and accounts for the composite asymmetries as explained in table 6.1 earlier. The results are presented for both the baseline models using the dummy variable approach. The dummy variables presented in this table are interaction terms between the concerned underlying intercept dummy variable and the exchange rate variable. The four dummy variables represent the four compartments of the exchange rate variable, each representing the case of small appreciation, large appreciation, small depreciation and large depreciation. The advantage of the dummy variables approach is that it can provide the separate estimates of pass-through for each of the composite asymmetries and thus allows deeper insights into the source of nonlinearities in the ERPT relationship. Unlike the polynomials or the explicitly nonlinear econometric approaches, the interpretation of the results from this approach are relatively straightforward. This allows utilizing a parsimonious model to examine an inherently complex issue.

Table 6.11: Composite asymmetries in ERPT to domestic prices

Variable	Dummy Variable Approach	
	Model 1	**Model 2**
	Baseline – I	*Baseline - II*
OGAP	0.14*** (3.673)	0.15*** (3.778)
InNM3_{t-2}	0.27** (2.486)	
ΔInOILP	0.04*** (4.876)	0.04*** (5.119)
D_{FIT}		-0.008** (-2.400)
D_{PAND}	0.015*** (3.520)	0.017*** (3.032)
InWACR_{t-3}	-	-0.001* (-1.710)
ΔInWPI_{t-1}	0.26*** (3.511)	0.24*** (3.111)
D_{LD}	0.007 (1.201)	0.029*** (4.137)
D_{SD}	-0.001 (-0.139)	0.021*** (3.084)
D_{LA}	-0.007 (-1.492)	0.014** (2.063)
D_{SA}	-0.004 (-0.943)	0.017** (2.549)
R^2	0.55	0.56
F-statistic	14.94***	13.54***

Notes: 1. # is significant at 13%; 2. $ implies significant at 11%. **Source**: Author's estimation.

Continuing the examination of results in table 6.11, the four dummy variables combined together will represent the entire exchange rate variable. None of the coefficients of the interactive dummy variables are significant in Model 1, while all of them are significant for the second baseline model. The evidence seems to be pointing that large changes have a higher pass-through than the small changes as indicated by the values of D_{LD}. However, this is followed by D_{SD} and thus evidence seems to be in favour of depreciations having a stronger impetus for domestic prices than appreciations. Clearly, the inflationary implications of exchange rate channel have been more prevalent than the disinflationary tendencies and perhaps the fears associated with floating regimes may not be unfounded after all. However, there is a start contrast in the nature of the asymmetries when one approaches to issue from the perspective of aggregate import prices versus the aggregate domestic prices.

6.5. Concluding remarks

This chapter examined the issue of directional asymmetry – defined as the differences in pass-through between appreciation and depreciation of exchange rate, size asymmetry – defined as the difference in pass-through coefficient for large change versus small change, and composite asymmetry – defined as the differences in pass-through coefficient for combinations of size and directional asymmetries. The analysis was conducted separately for pass-through to both the import prices, as well as to domestic prices. Multiple methodologies were adopted to specify the dummy variables used for estimating asymmetries along with other alternative approaches.

Section 6.2 examined the nature of the asymmetries to be captured in the chapter. The theoretical model adopted for capturing asymmetry was elaborated therein. Thereafter, section 6.3 addressed the dimensions of asymmetries in pass-through to import prices using annual data from 1991-92 to 2021-22. It was found that pass-through from depreciation was complete while the pass-through from appreciations was more-than-complete. Appreciations were found to be inducing larger pass-through than depreciation in the case of import prices. Furthermore, smaller changes were found to be associated with larger pass-through as compared to larger changes and the finding was robust to alternative size criteria. The findings on the size asymmetry in import price pass-through was found to be consistent across all the three approaches. With regards to the issue of composite asymmetry, the findings were not strongly evident, though indications were obtained that small depreciations had a larger pass-through than other forms of asymmetries.

Similarly, section 6.4 examined these dimensions with reference to the ERPT to local inflation within the Indian economy during 1991-92 to 2021-22 while using quarterly data. With reference to directional asymmetry, evidence suggested that Depreciations in exchange rate had a higher pass-through as compared to appreciations. This finding was consistent with the findings in literature such as Brun-Aguerre (2014), Patra et al. (2018), and others. This finding was robust to the alternative empirical methodologies adopted for examining this issue. With regards to size asymmetries, small changes were found to have larger pass-through than large changes in exchange rate, though the ‘incompleteness hypothesis’ was maintained in both the cases. This finding was not consistent for the two approaches employed in this context. While the dummy variable approach indicated smaller exchange rate changes as inducing larger pass-through, the polynomials approach suggested that larger changes had a higher extent of price impact from exchange rate alterations. Lastly, composite asymmetry in pass-through to domestic prices was scrutinized and evidence depicted that large depreciations had the highest impact on domestic prices while large appreciations had the lowest impact.

This chapter has thus provided important insights on not only whether asymmetry exists, but also on the nature of asymmetries in the pass-through mechanism in India. Three-dimensional asymmetries were empirically tested for – namely directional, size and composite. The evidence with regards to import prices indicated that India is a price-taker as far as imports are concerned, though the exporting firms were displaying PTM behaviour and perhaps were focused on increasing their market shares while not sacrificing their markups in the wake of depreciation of the Indian currency. Such a behaviour fits well with the observed results in chapter four and there is considerable evidence that nonlinear behaviour is prevalent in the import price pass-through mechanism. Similarly, the evidence on the issue of asymmetries in pass-through to domestic prices suggests that there is considerable absorption of the inflationary impulses emanating from currency fluctuations, but the pass-through is larger for depreciations as compared to appreciation. Despite being incomplete, the inflationary impact of exchange rates remains a matter of concern. It was also seen that small changes were having a larger transmission to domestic prices as compared to large changes, which is consistent with the findings for the import price pass-through also. However, when the size and directional asymmetries are synthesized, the findings suggested that large depreciations were inducing the highest pass-through as compared to other forms of nonlinearities. This is another testimony of the fact that ERPT remains an important channel for transmission of inflationary momentum to the domestic prices in India. The fears of the floating regime continue to prowl the policymaker.

Notes

[1] These studies were elaborately surveyed in chapter three. Hence, their reference in this chapter is brief.

[2] This chapter employs the log difference in NEER to define the size and direction of exchange rate changes is undertaken to maintain congruence with the form of exchange rate variable used in previous chapters. Alternative approaches were also used, such as defining the dummy variables with Year-on-Year growth of NEER, but the results remained the same. Hence, the present approach has been adopted in this chapter.

[3] Alternative definitions were also employed. Following Yanamandra (2014), change around the median was also used. Thereafter, 0.75 standard deviation change above and below the arithmetic mean was also utilized. The results remained largely similar.

[4] Kennedy (2008) provides a detailed account of the measurement and econometric issues in using interactive dummy variables in linear econometric models.

[5] The use of the constant term when a completely exhaustive set of dummy variables are used will result into the Dummy Variable trap (Gujarati and Porter, 2008; Kennedy, 2008). Hence, the constant term is dropped where necessary.

[6] The underlying rationale for this finding requires a more detailed macroeconomic model. The primary aim of this chapter is to investigate whether asymmetry exists, and if it does, the nature of these asymmetries.