Chapter 4

Exchange rate, import prices, and their interconnections: A macroeconomic perspective

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Brief Content

4.1. Introduction

This chapter investigates the empirical relationship between exchange rate variations and import price inflation in India during the period 1991-92 to 2021-22 at the aggregate level while also examining a series of interrelated issues that reflect the current state of debate on this subject. The genesis of the need to investigate the extent of pass-through can be traced to the observations that pass-through to a country's trade prices can be incomplete, thereby creating a divergence between the price of a commodity in terms of local currency versus producer currency. In other words, the existence of a less-than-full pass-through to the price of an imported commodity would imply that the price of that commodity does not conform to the postulate of the law of one price. Under these circumstances, the difference between the prices of a commodity cannot be explained merely by the exchange rate, and the inflation differentials between the trading countries are not fully proportional to the exchange rate movements between their currencies. At the macroeconomic level, there may be large and possibly persistent divergences in relative national price levels which are not fully captured by exchange rate movements alone, giving rise to the need for explaining the other 'missing' factors in this puzzle. One of the early works that laid the foundations of pass-through literature was Dornbusch (1987) who provided the framework within the industrial organization literature to derive the optimal pricing model for exporting firms enjoying market powers in destination markets through mark-up variations. Recognition of the existence of mark-ups in the pricing behavior of exporting firms is a necessary condition to rationalize the incompleteness of pass-through. The very idea of incompleteness implies the presumption that pass-through should ideally be complete in the first place, as implied by the law of one price.

After the work of Dornbusch, a series of empirical works emerged that estimated the extent of pass-through of exchange rate variations to local import prices at both disaggregate and aggregate levels. Campa and Goldberg (2005) provided another thrust to this subject by incorporating macroeconomic features into the optimal pricing theory of explaining incomplete pass-through as proposed by Dornbusch in 1987. The empirical works since then have developed, extended, and improved the framework of Campa and Goldberg. Thus, their framework continues to guide the research on import price pass-through literature, both internationally and in India. A recent examination of the transmission effects of exchange rate changes on import prices was undertaken by Rajan and Yanamandra (2015) who studied the import price pass-through at the aggregate level for the Indian economy using an Error Correction Model (ECM) while deriving the structure of the model from the work of Campa

and Goldberg. After the work of Rajan and Yanamandra, there have not been any works that exhaustively study the import price pass-through issue though the literature on asymmetric pass-through and domestic price pass-through have remained areas of lively debate. An important purpose of this study is to fill this gap.

The need to examine this subject matter arises from several fronts. First is the implications of pass-through to import prices for domestic inflation itself. As is well-known, the import price pass-through is considered the first stage in the larger process of the price impact of exchange rate variations on an economy. The impact that currency movements can impose on domestic prices is channelled through the import price variations and thus it is necessary to establish the extent of the so-called stage-one pass-through before the larger price implications of the exchange rate can be ascertained. Second, if import prices are highly responsive to currency movements, then this can accentuate the fear of allowing a floating exchange rate regime. As discussed earlier in chapter three, RBI has adopted a managed floating stance and considerable leeway is given to market forces for shaping the behavior of the exchange rate of the rupee. Thus if import prices are highly reactive to exchange rate behavior, there can be severe inflationary consequences for the domestic economy. Another important dimension is that change in import prices will induce adjustments in the relative prices of tradable and non-tradable goods (Carrière-Swallow et al., 2016). These adjustments are necessary for the further adjustments in the distribution chain and the final pass-through of exchange rate changes into domestic prices. The extent of adjustments between tradables and non-tradables will depend on the extent of import price pass-through. Third, India being an emerging developing economy, there is a strong thrust to expenditure switching policies which are highly dependent on the exchange rate elasticity of trade prices. If import prices are sensitive to currency changes, then exchange rate devaluations can help in the reduction of imports while enabling a shift of domestic consumption to domestic production. While the switching of expenditure is conditional upon the substitutability between imported and domestic goods, the import composition of India has considerable room for high substitutability.

Fourth, the exchange rate plays a pivotal role in trade balance adjustments. The degree of pass-through will determine the rapidity and size of adjustments in trade balance following an exchange rate shock. The fulfillment of the Marshall-Lerner conditions is also conditional upon the sensitivity of trade prices to exchange rate changes. Hence, understanding the extent of the pass-through effects of the exchange rate is critical in utilizing currency management as

a tool for improving the Balance of Payments position of a country. Fifth, the terms of trade play a critical role in determining the gains from trade and the overall competitiveness of a nation in the international goods markets. Higher pass-through would allow a larger increase in export prices following a depreciation, but may also cause import prices to swell too. In case there is an appreciation, the reverse would be true. The improvements in terms of trade would be conditional on the relative pass-through effects of exchange rate movements on aggregate export and import prices. Sixth, domestic monetary management cannot afford to ignore the pass-through issue if the currency is floating. It has been found that Exchange Rate Pass-Through, i.e. ERPT, is endogenous to domestic monetary conditions (Taylor, 2000). The feedback and interactions between monetary policy stance and exchange rate's impact on trade prices can distort the policy signals and may cause unplanned effects on domestic conditions. This may lead to a larger uncertainty, giving rise to a spiral of monetary reactions followed by exchange rate counter reactions which may lead to negative consequences in terms of high inflation, weaker output growth, and possibly other economic uncertainties. Studying the import price pass-through is thus a critical step in examining the larger issue of domestic inflation pass-through of the exchange rate.

4.2. Issues under consideration

Given the above background, this chapter focuses on four key issues. The first matter is the estimation of ERPT to import prices. Literature has time and again pointed out the fundamental differences between the immediate and lagged behavior of pass-through. The immediate impact is considered to be the short-run impact of the exchange rate on import prices while the response of import price variations from lagged exchange rate variations is subsumed under the long-run pass-through[1]. Monetarists and classical generally believe that the transmission of exchange rate changes to import prices should be immediate and while they allow for the short-run pass-through to be incomplete, it is staunchly expected that the longer-run[2] transmission of exchange rate variations into import prices shall be complete. They usually do not allow for long-run incomplete pass-through or more-than-complete pass-through. This belief largely originates from the adherence to the purchasing power parity idea and adherence to the neutrality of money. On the other hand, the schools emerging from the Keynesian framework allow for long-run persistence of incomplete or even more-than-complete pass-through. This is particularly asserted by the new open economy macro approach to pass-through analysis. Various imperfections in markets such as menu costs, switching costs, local non-traded costs, and other factors are utilized to explain the deviation of pass-through from the normally

expected behavior for small open economies like India. The issue of short and longer-horizon behaviors of pass-through plays a pivotal role in the debates on this subject both internationally and in the Indian context. In the longer run, prices are expected to adjust fully to exchange rate shocks and thus stabilize to a near complete pass-through. However, this is an empirical question and the consensus in the Indian context has been blurry. As discussed in chapter two, there are findings on both ends of the spectrum with some studies inferring that import prices adjust fully to exchange rate variations after a horizon of six to twelve months while others have found that pass-through remains incomplete even after longer durations. This matter requires a fresh assessment with updated data, improved specifications, and an alternative perspective by examining this matter for yearly as well as monthly frequencies of data. This is the first task which is undertaken in the current chapter.

The second issue is to examine the nature of import price behavior at the aggregate level by moving beyond the impact of exchange rate changes and incorporating other possible determinants of import price variations. The nature of import price variations is a critical element in the ERPT determination. This matter is addressed in this study by incorporating macroeconomic hypotheses into the import price function and an attempt is made to capture the impacts generated by key macroeconomic dimensions in shaping the nature of import price variations during the sample period. Consequently, the estimate of the ERPT coefficient is also refined within the import price framework by incorporating additional factors which are controlled for while deriving the pass-through estimate[3].

The third issue under consideration is the stability of the pass-through coefficients across time. Literature has strongly asserted the need for establishing the stability property of pass-through coefficients, in the absence of which, such estimates may result in unreliable policy designs. Any economic relationship needs to portray a certain degree of consistence across time to become a useful consideration in the decision-making process of economic agents. The stability of the pass-through coefficient across time or the instability thereof can provide information on the secular changes in the transmission effects of exchange rates and the price impacts caused by currency movements. Monetary policy needs to account for not only the extent of pass-through, whether short-run or long-run but also the trend in the pass-through. If the pass-through is becoming weaker with time, there are very different macroeconomic implications as compared to the case where pass-through is assuming strength across time. Stability or the instability of the pass-through coefficient can imply important structural changes in the economy in terms of inflation persistence, inflation volatility, and the

credibility of monetary policy. The ideal scenario is a time-invariant pass-through behavior so that the inferences drawn from such a model have analytical relevance across time and can allow the derivation of stable economic relationships for analysts and policymakers. Utilizing the pass-through analysis in policy formulation necessitates the analysis of its behavior over time and reasoning the macroeconomic rationale for the observed stability. This chapter undertakes this task for the chosen sample period.

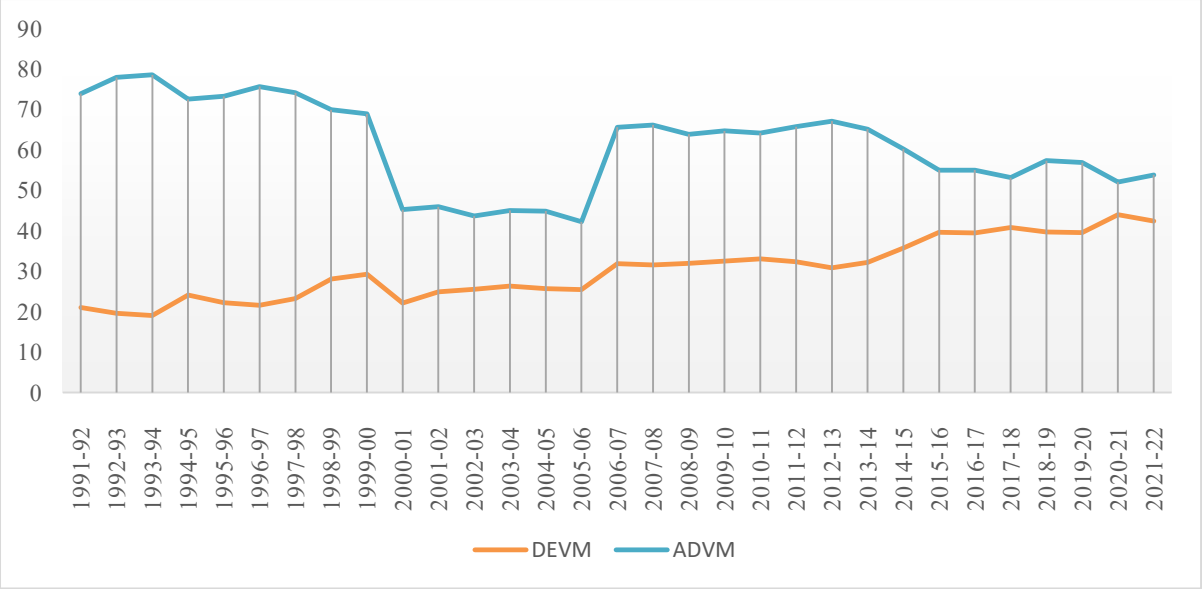
The fourth and thornier issue is the examination of the factors affecting the stability of the import price pass-through coefficient. To date, there has not been any systematic attempt to explicitly empirically study the factors shaping the stability of the behavior of ERPT to import prices in India. While there have been a few studies that engaged in estimating the extent of short and long-run pass-through coefficients, the analysis of factors that determine these coefficients is perhaps missing. At best, the literature in the Indian context provides evidence on VAR or ECM-based estimates of short-run and long-run import price pass-through coefficients and some studies have studied the dynamic path of the impulses generated by exchange rate shocks. This chapter attempts to fill this gap by explicitly accounting for the factors that could possibly induce or constrain the instability of exchange rate changes to impact import prices. Constructing such a framework is a challenge due to the fact that an econometrically derived coefficient is generally time-invariant, and for given data and period[4] there will be a point estimate of the pass-through coefficient. Thus, after surveying the alternative methodologies, a Time-Varying Coefficient (TVC) framework is utilized to allow the pass-through coefficient to vary across each year of the sample period and examine its properties before assessing the factors shaping its observed behavior. This matter is addressed in this chapter and the examination of key macroeconomic factors shaping the stability of the import price pass-through coefficient is conducted herewith[5].

4.3. Nature of Indian imports

Before delving into the examination of import price pass-through effects of currency movements, it is necessary to gauge the broad nature and structure of the aggregate imports of India. The Dornbusch-Campa-Goldberg framework of import price pass-through analysis as examined later and adopted in this chapter necessitates an assessment of the nature of India's imports in terms of the major countries and commodity groupings. As noted earlier, the fundamental premise of the import price-exchange rate nexus is provided by the variations in the mark-up of imperfectly competitive exporting firms fulfilling the import needs of India.

Given the aggregate nature of the analysis undertaken in this chapter, it is not possible to delve into the highly disaggregated levels of market structure analysis. However, utilizing the country and commodity groupings to analyze the direction of imports can provide indicative insights into the kind of market that the Indian importers have to face in the international arena. Ideally, the analysis of the market structure and relative market power should ground itself on pricing behavior. However, given the aggregative nature of the analysis in this chapter, the amount of imports and its sources are looked into so as to understand the kind of market that India faces in the international arena as a buyer of goods and merchandise.

Figure 4.1: Major imports suppliers of India since the reforms

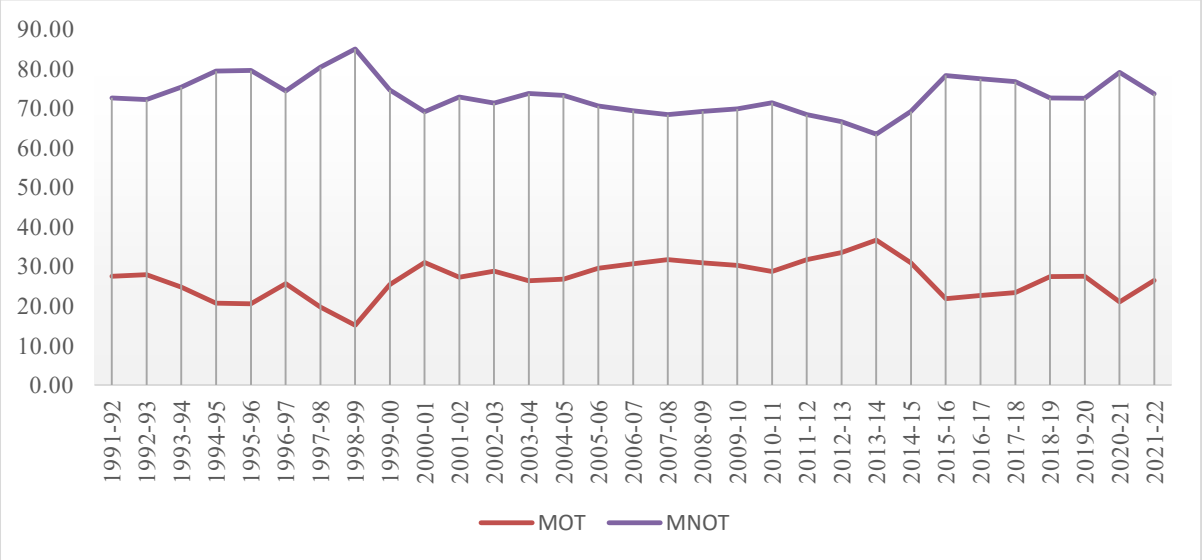


Notes: DEVM = Amount of imports supplied by all major developing countries to India as a proportion of total imports, ADVM = Amount of imports supplied by major advanced countries (OPEC and OECD) to India as a proportion of total imports; All data are expressed in %. **Source**: Author's estimation.

Three ways can be conceptualized to gauge the nature of the import market faced by India[6]. The first is to observe the commodity composition of aggregate imports and the most visible dimension in this regard is the sizeable share of oil imports in the aggregate imports basket of India as shown in Figure 4.2. The share of oil imports has hovered around 30 percent share throughout the period 1991-92 to 2021-22. The high contribution by crude oil and related products in the imports basket has immediate implications for the kind of pricing behavior that Indian buyers would have to face in the international markets. Organization of the Petroleum Exporting Countries (OPEC) is the primary supplier of crude oil to India, though off-late, Russia and the US have become increasingly important suppliers. These supplying nations, and especially the OPEC bloc of countries, display oligopolistic pricing behavior. It is natural to

presume that exchange rate variations would be readily passed over into India's import prices by OPEC. However, given the increasing competition from Russia and the US in meeting the global crude oil needs, it is possible that some degree of reduction in the market power of the OPEC bloc might have occurred. It is thus empirically difficult to expect a particular direction on this account, but prima facie, oil price pass-through to the import inflation should be high and rather immediate. Bhanumurthy et al. (2014) examined the issue of oil price pass-through in India and found that oil price shocks had an immediate and adverse impact on domestic growth and inflation while their negative impulses receded slowly over time. Hence, the possibility of incomplete pass-through should largely emerge from the pricing behaviour of non-oil foreign suppliers to India.

Figure 4.2: Oil versus non-oil imports in India since the reforms

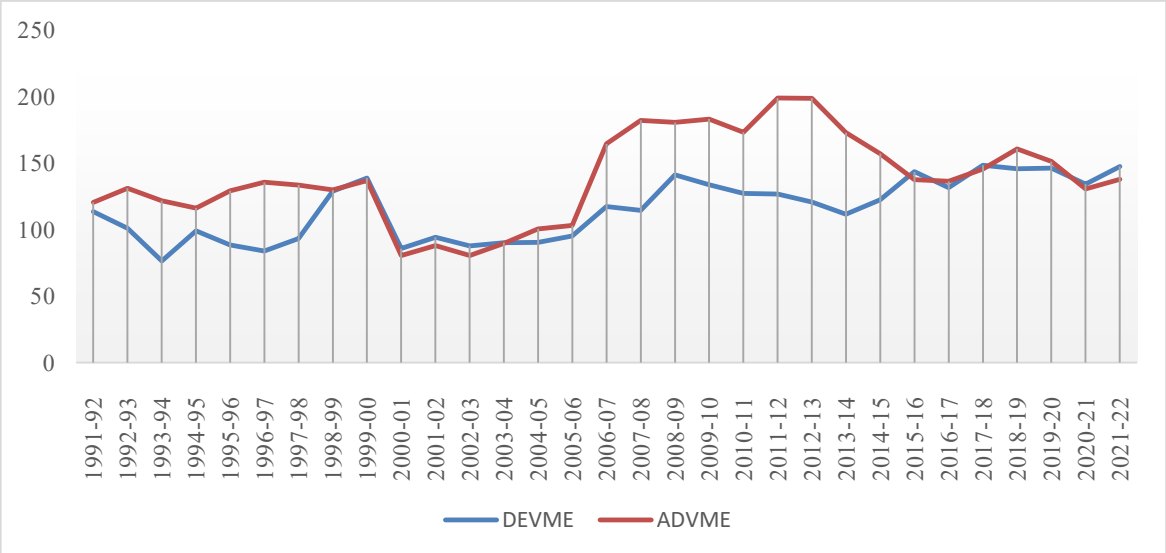


Notes: MTOT = proportion of oil imports as a percentage of total imports expressed in US $ million; MNOT = proportion of non-oil imports as a percentage of total imports expressed in US $ million; All data are expressed in %. **Source**: Author's estimation.

The second aspect in this context is the country blocs that have been active import suppliers to India. Figure 4.1 highlights this dimension where the share of developing economies and advanced economies in the aggregate imports of India are displayed. Developing economies tend to be relatively on a similar footing to India as far as market power and the consequent pricing behavior are concerned. Most of these economies such as China, Indonesia, and others portray quite similar macroeconomic features at least concerning the international trade pattern. The advanced economies, on the other hand, are the ones that may possess a higher degree of market power and this could allow them to practice Pricing-to-

Market (PTM) behavior, so well-cherished in the pass-through literature. Structurally, these economies have a stronger footing in the international arena and generally engage in exporting high-value inputs and final commodities. Thus, it is natural to presume these countries practicing PTM behavior and this implies that pass-through of exchange rate variations could move in any direction depending on the optimization objective of these exporters to India. In the Local Currency Pricing (LCP) case, the pass-through would be zero, and in the case of Producer Currency Pricing (PCP0, the pass-through should be unity, implying complete transmission of exchange rate changes to import prices. Naturally, the actual behavior would be located somewhere within these extreme ends and thus an empirical investigation of the pass-through coefficients is necessary. Figure 4.1 makes it clear that the advanced economies, consisting of the OPEC and Organization for Economic Cooperation and Development (OECD) countries dominate India's aggregate imports with an average share of around 60 percent throughout the study period. While there is a slow decline in this share and a shift towards developing markets, India still depends largely on these countries and their firms generally exhibit PTM behavior as it is well-established in the international literature on pass-through analysis.

Figure 4.3: Direction of trade across country groupings for India since the economic reforms



Notes: DEVME = Ratio of total imports supplied by developing nations to the total exports supplied by India to these developing economies, ADVME = Ratio of total imports supplied by advanced economies to the total exports supplied by India to these advanced economies; All data are expressed in %. **Source**: Author's estimation.

The last dimension to observe here is the direction of trade that India engages in, with the developing and advanced economies. If India imports much more than it exports to its

trading partners, then it would not be incorrect to assume India as a price taker in the international goods market. This does not in itself necessitates complete pass-through, but implies that the extent of pass-through can vary as per the pricing behavior of the firms from these countries. The ratio of imports that India receives to the exports that India provides to these country groupings is shown in Figure 4.3. One can readily note that, on a net basis, India is an importer rather than an exporter to both developing and advanced economies. Along with this, import reliance on India has been increasing over time from both developing and advanced economies. It is difficult to rationalize monopsony behavior from Indian buyers and thus the immediate conclusion seems that India is a price taker in the imports market and that the degree of pass-through should be high and rather rapid. These observations can only be rationalized once the empirical analysis is conducted.

4.4. Theoretical Model

This section elaborates on the theory of import price pass-through and extends the discussion touched upon in chapter one. There are many vintage points from which an analyst can construct the ERPT process concerning imported commodities. The connections between exchange rates, import prices, and a host of macroeconomic variables emerge out of the various approaches that are supplied by economic theory. It is possible to conceptualize different ways of capturing the pass-through relationship by utilizing the rich stock of theoretical models in international finance literature. Several of these possible approaches are examined in the next section below.

4.4.1. Alternative approaches

The open economy macroeconomic literature is replete with models that examine the price impact of exchange rates at the trade and domestic fronts. The primary concern in the pass-through analysis is the specification of the import price function. Import prices, or rather import price inflation rate, is theorized as a function of a host of economic variables depending on the underlying approach chosen. The purpose of this discussion is to highlight several of these possible alternatives, and evaluate them while focusing on their merits and pitfalls.

One of the approaches in this context is the ad-hoc approach wherein the subjective wisdom of the analyst is the primary guiding force in building the import price function. While different theoretical concerns may drive this approach, the fundamental prescription of the theoretical model of pass-through is obtained through the analyst's subjective understanding,

depth of the subject matter, and wisdom. Needless to say, this is a rather naïve approach but can be utilized when the domain of pass-through analysis is highly narrow or when sufficient literature is not available. The second set of approaches is rather theory-driven and corresponds to a specific set of specific economic theories. These approaches can be classified as disaggregated and microeconomic, and aggregate and macroeconomic approaches (Aron et al., 2014; Phuc and Duc, 2021). The microeconomic approach to import price pass-through can be conceptualized in terms of partial equilibrium analysis and general equilibrium analysis. The partial equilibrium approach largely focuses on a single market, firm, industry, or sector while subsuming the feedback and interactions with other markets, firms, industries, or sectors under the ceteris paribus condition. One way of theorizing the pass-through process is to examine the firm-specific import price pass-through using highly granular data. In this case, the import price function of a particular single firm will be theorized in terms of the pricing behavior of the exporting firms. Both micro and macro factors can form a part of such a model. Such a model will be highly specialized and its inferences will not be generalizable, thus making this approach more useful for firm-level decision-making on the optimal quantum of imports rather than providing many insights for policymaking. However, if a giant firm is under consideration, then its import price function may still provide useful inputs for policy analysis, albeit if such a firm commands a large bulk of the local imports basket. The Indian Railways, for illustration, may be theorized as such a firm, enjoying some degree of monopsony powers in the international inputs market, particularly as a buyer of coal (Kamboj and Tongia, 2018). Such studies are unavailable in the Indian context, given the paucity of granular firm-level data. However, this framework may be well suited for the firms in their internal decision-making process regarding their preferred level and composition of imports.

The second level of analysis for disaggregated pass-through dynamics can be at the commodity level, with the pricing behavior of firms supplying a particular imported commodity aggregated into an import price function with the exchange rate and other variables as control variables. In such a framework, the import price pass-through can be conceptualized as emerging from the combined pricing behavior of the foreign import suppliers for a single commodity. The specification of the import price function shall vary across commodities and there will be a large amount of information to be handled if an analyst wishes to study multiple commodities. In particular, aggregate exchange rate and other variables shall be rendered less useful for such an analysis, and commodity or at least industry-specific costs, revenue, and exchange rate[7] information shall be required. The third level of analysis can be for an individual

industry wherein the import price functions of firms buying similar commodities in the international markets are aggregated or modelled separately to examine pass-through effects from exchange rate variations. Such a model may be capable of accounting for intra-industry heterogeneities that cut across various commodities being imported within that industry. The level of information requirement shall be very large in this kind of analysis but the insights obtained from such studies shall portray a rather more realistic picture of the pass-through dynamics at disaggregated levels. However, theorizing the pricing practices of an entire industry complicates the matter further because inter-firm data, such as cost and revenue dependencies, may not be accessible by the analyst. Furthermore, industrial policies of the Government may also have a bearing on the pass-through process, and accounting for such dimensions may prove difficult in the light of the limited availability of detailed industry-specific import data in India.

The other analytical approach to pass-through analysis within the disaggregated and microeconomic framework is the general equilibrium approach, which implies building a detailed microeconometric model of different segments of the pass-through process and allowing for cross-interactions and feedback among them. One approach can be to examine the imports demand and imports supply sectors with detailed behavioral relationships between various firms, or blocs of firms, and then estimate the pass-through via a simultaneous equation system. Another way of undertaking such an analysis can be to theorize the imports segment, domestic goods segment, and exchange rate segment through individual sector-specific functional relationships and allow for feedback effects. Perhaps, the closest empirical strategy to this framework is embodied in Goldstein and Kahn (1985) who examine the pass-through to import prices within a simultaneous equations model by assuming imperfectly competitive import suppliers and buyers[8]. Each of these segments is a critical component in the import price pass-through mechanism. By examining how they interact simultaneously, insights into the pass-through coefficient and its nature can be made more reliable and robust. Unfortunately, the data needs are very high and the current state of data infrastructure on international trade in India does not allow for such an exercise. The alternative approach is to use aggregate information to model these segments in the pass-through process as a part of the larger issue of the trade balance adjustment process as undertaken by Dholakia and Saradhi (2000).

The alternative to the disaggregated and microeconomic framework is the aggregate framework that utilizes macroeconomic information much more robustly. The analysis of import price pass-through has oscillated between the microeconomic and macroeconomic

approaches in the international literature. There are several theoretical models within the rich tradition of the macroeconomic analysis of pass-through that utilize well-established macro models to examine pass-through dynamics. Works of Taylor (2000) and Obstfeld (2002) are considered to be the primary foundations of the so-called macroeconomic approach to pass-through analysis (Phuc and Duc, 2021). Fundamentally, within the macroeconomic strand, pass-through is subsumed under the theory of inflation as evident in the recent works of Mendali and Das (2017), Patra et al. (2018), and Balcilar et al. (2019), among others. Necessarily, examining the role of import price variations as a transmission channel for allowing exchange rate changes to impact domestic inflation is the primary concern in this framework. Two strands of inflation theory are particularly useful in this context. The first is the cost-push inflation theory wherein the import price pass-through may be theorized as emanating largely from supply-side factors such as marginal cost shocks in an industry or average cost shifts due to technological disruptions. Such an approach would largely focus on building the import price function as emanating from the supply-side factors and thus theorize import price pass-through as a supply-side response of the country to exchange rate shocks. This kind of approach is particularly useful for small open economies that do not enjoy much market power as buyers and thus are largely price takers. The aggregate mark-up variations model of the new open economy macroeconomic school is a possible illustration in this regard.

On the other end of the spectrum of macroeconomic models to examine import price pass-through is the theory of demand-pull inflation where the transmission effects of the exchange rate to import prices are assumed to largely emanate from demand-side factors such as a shift in the aggregate income of the importing nation, inflationary environment and exchange rate volatility. While many of these factors have implications for both the import demand and supply, they can be channelled exclusively through any of them to estimate the pass-through to import prices. The more popular approach, both internationally and in India, is to combine both the cost-push and demand-pull inflation models to specify and examine the aggregate import price function. The aggregate mark-up variations model is also an illustration in this context where both the aggregate import demand and supply side factors are accounted into the import price function and the pass-through coefficient is estimated after incorporating the appropriate exchange rate variable. Studies such as Rajan and Yanamandra (2015) are applications of this approach in the Indian context during recent times. Pass-through analysis under this method is conducted within both the single equation and the multi-equations approach. In the Indian context, the estimates of pass-through to import prices have largely

been robust to alternative methodological specifications. The Vector Auto Regression (VAR) and the Vector Error Correction Model (VECM) have been the most popular methodological choices in this context.

Another theoretical framework to capture the import price pass-through mechanism is to adopt an expectations-augmented import price function. Both adaptive and rational expectations models can be utilized to specify the import price function that accounts for the expectations of agents regarding import prices in the future. The expectations formation mechanism will be different under both approaches, but the primary idea is to capture how expected future values of import price inflation can impact the current import price inflation level. A forward-looking import price function could be specified to account for the lead values of the import price variable itself, while a backward-correcting import price function could be modelled to include the difference between current and previously expected import price inflation, which will be used as a regressor into the import price function itself. Another approach can be to theorize a backward-looking import price relationship wherein the lagged values of import price inflation, i.e. dependent variable, is itself accounted as a regressor. This gives rise to the partial adjustment model, which is one of the frameworks employed in the present study. Such a perspective can allow import prices to adjust for their past behavior and help the analyst track the extent of self-correction inherent in the pass-through relationship. If the partial adjustment process is significant and strong, the extent of pass-through may be reduced substantially, while ignoring the partial adjustment process could hyperbole the true extent of ERPT to import prices.

The final theoretical model in import price pass-through analysis is the aggregate mark-up variations model within the new open economy macroeconomic philosophy. This framework deserves a separate mention as it happens to be the most popular approach in the Indian and also international contexts. Dornbusch (1987) and Campa and Goldberg (2005) are the epitomes of this approach and have been the guiding force till data in this regard. This approach has been used at both disaggregate and aggregate levels and is capable of handling both kinds of information within the same analytical model itself. The major drawback of this approach is that the extension from individual exporting firms' pricing behavior to the pricing behavior of the firms supplying the aggregate imports sector of a country requires dealing with aggregation problems and related index number issues. One important problem in the aggregate application of this theoretical model is the possibility of two-way causality between import price variations and exchange rate changes. For examining the pass-through process, estimating

the pass-through coefficient is critical. The pass-through coefficient is inherently a one-way causality idea and presumes that exchange rate changes cause import price variations. However, at the aggregate level, it may be possible, that large-scale exogenous import price shocks may themselves cause exchange rates to vary and such feedback effects are generally ignored in this approach. Despite its limitations, this theoretical construct of import price pass-through is by far the most popularly utilized model and has several merits such as its computational ease, suitability for both the aggregate and disaggregate analysis, and the ability to account for various macroeconomic hypotheses on the factors determining the behavior of import price pass-through. This approach is then thus utilized in this study while also incorporating features of some other compatible theoretical models to ensure a richer and more robust theoretical specification.

4.4.2. Theoretical Model employed in the study

The aggregate mark-up variations model as discussed in the previous sub-section is appropriately modified and employed in this chapter to estimate the extent of import price pass-through in India at the aggregate level for the period 1991-92 to 2021-22. Both yearly and monthly data are utilized to gauge the implications of data frequency on pass-through behavior. The studies that have helped shape the theoretical model in this chapter can be traced to Dornbusch (1987), Campa and Goldberg (2005), Bussiere (2013), Rajan and Yanamandra (2013), and Aron et al. (2014). These five studies capture the essence of the theoretical approach developed in this chapter.

The analysis of the import price function begins with the idea that the price of an imported commodity in local currency is a product of the price of that commodity in the exporting country's currency[9] and the exchange rate. Here, the exchange rate is defined in terms of units of local currency per unit of the exporting country's currency[10].

$$\mathbf{P_X = P_M * \frac{1}{E}} \qquad \textbf{....(1)}$$

Routing the pricing problem of imports via the exporter's perspective implies the possibility of price discrimination by foreign sellers to the destination markets. In the import price pass-through literature, this has been termed the Pricing-to-Market (PTM) hypothesis. It states that foreign sellers may charge different prices from different destination markets depending on various economic considerations such as market share objective, profit maximization, or value-chain integration either vertically or horizontally. The nature of Indian

imports discussed in the previous section indicates that India is largely a price taker in the international commodity markets. Naturally, the influence of buyers in India on the price of imported commodities, particularly the final goods, should be limited if India portrays the characteristics of a price-taking importer[11]. This has been corroborated by various studies in the domestic context such as by Mallick and Marques (2006), Yanamandra (2015), and Balcilar et al. (2019) among others. Hence, both the findings in the previous section and the broad consensus laid in the literature are utilized to assume that India acts as a small open economy with price-taking behavior in terms of its import behavior. Equation one also implies that the purchasing power parity is fulfilled if the data strictly correspond to the said equation. In other words, if the relative differences in price levels between two trading countries are explained solely by the exchange rate, then pass-through is always complete and the parity hypothesis is upheld. The main issues emerge when the price differences are not explained solely by the exchange rate, implying incomplete pass-through and violation of the purchasing power parity hypothesis[12].

Given the PTM hypothesis, the occurrence of complete pass-through and thus consistent and universal fulfillment of the purchasing power parity is not plausible. It is very much possible for prices of imported commodities, expressed in the aggregate import price index inflation, to not be proportionate to exchange rate variations. In other words, the price in local currency and the price in producer currency may diverge and may not be fully explained solely by exchange rate variations only. The incongruence between the local currency and producer currency prices gives rise to the problem of incomplete pass-through. The two competing approaches, viz. Local Currency Pricing (LCP) and Producer Currency Pricing (PCP), can both be subsumed under the PTM framework. Exporters are assumed to display LCP-style pricing behavior when their contracts are largely invoiced in the currency of destination markets. This may be the case when exporting country is a small open economy with limited market power and faces large countries as buyers. On the other end of the pricing spectrum is the PCP idea wherein foreign exporters invoice the price of their commodities in their own currency; largely ignoring the exchange rate issue itself. The LCP model implies zero pass-through and thus exporting firms, absorb all exchange rate variations into their own mark-ups and bear the brunt solely by themselves[13]. The PCP idea, on the other hand, implies complete pass-through as the price is fixed in the exporting country's currency, and all exchange rate changes, whether small or large, whether appreciation or depreciation, are immediately passed into the price charged from importing country in its local currency terms.

Quite obviously, data and empirics do not support any of these extreme pricing models directly. Exporters are thus found to engage in different behaviors for different markets at different times, giving rise to the PTM behavior. The spatiotemporal variations in the prices charged by exporting countries from importing countries imply that much more complex economic mechanisms are at work. This economic mechanism is the subject matter of the import price pass-through analysis undertaken in this chapter.

Under perfectly competitive markets, the price charged by exporters from an importing nation will be fully proportional to the marginal costs of these firms. Thus, the variations in marginal costs will be the sole factor that could explain the variations in the price charged by exporters. This is captured by equation two below, where P_X is the aggregate price of exported commodities and MC_X is the aggregate marginal costs of exporters[14].

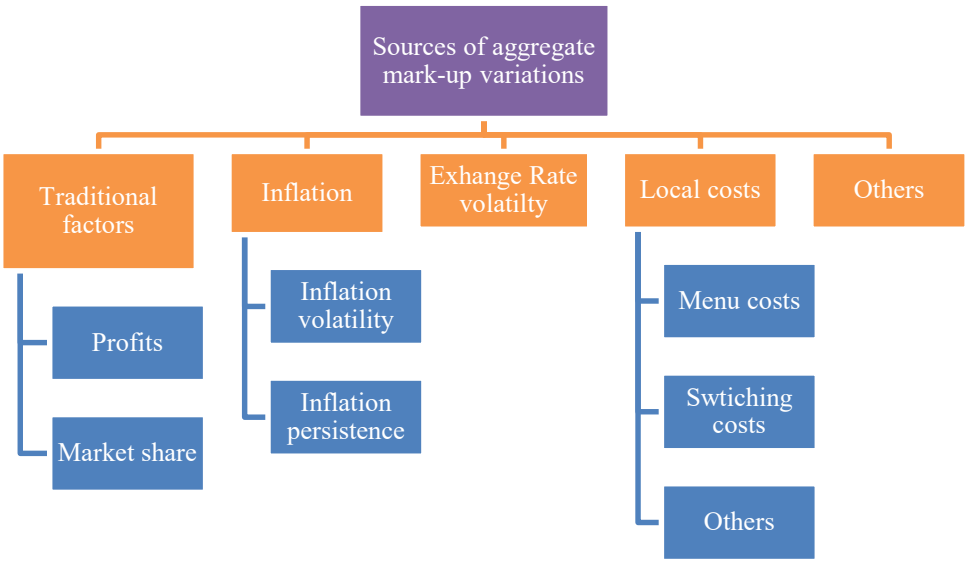
$$\mathbf{P_X = MC_X} \qquad \textbf{....(2)}$$

As one relaxes the assumption of competitive markets and allows exporting and importing nations to have unequal degrees of market influence, mark-ups over and above the marginal costs also emerge that capture the abnormal profits[15] that exporting nations can practice in international trade. The emergence of this mark-up component plays a pivotal role in explaining the different degrees of ERPT observed in the Indian context. This can be captured by equation three below, where MKP_X is the aggregate mark-up component, which is added to the price as a proportion of the marginal cost[16], in the aggregate export price[17].

$$\mathbf{P_X = MC_X(MKP_X + 1)} \qquad \textbf{....(3)}$$

The existence of the mark-up component in the aggregate export price implies that exporting firms that are fulfilling the imports requirements of Indian importers, have room for determining what they charge from Indian consumers and can determine the changes that they make to the price based on the level of mark-up that they wish to maintain in the Indian market. Various objectives may drive the mark-up variations by exporters as shown in Figure 4.1. Literature focusing on the disaggregate levels of analysis has found that profits and market-share considerations are the major sources of incomplete pass-through of exchange rate changes to import prices while the remaining sources as delineated in Figure 4.1 are important sources of the incompleteness of pass-through due to asymmetric response of import prices to exchange rate changes across its size and direction.

Figure 4.4: Theoretical sources of mark-up variations affecting import prices in India



Source: Author's analysis.

The studies focusing on aggregate macroeconomic dimensions of the import price pass-through process have found that inflation persistence, volatility, and exchange rate volatility are the primary sources of mark-up variations that result in incomplete pass-through to local import prices[18]. Given equation three, equation one can be modified as below.

$$\mathbf{P_M = P_X * E} \qquad \textbf{....(4)}$$

This equation expresses the aggregate import price facing India, in local currency terms, as a product of the price charged by exporters in their currency and the exchange rate which is defined in terms of units of local currency per unit of foreign currency[19]. While the theoretical specification focuses on the price levels, the actual empirical estimation has to be undertaken in the first-difference form as aggregate price indexes have to be employed to measure P_M and P_X. Moreover, stationarity considerations make it necessary to employ the log difference form of variables. Thus, equation four can be expressed in logarithmic form than in level form as expressed in equation five.

$$\mathbf{InP_M = InP_X + InE} \qquad \textbf{....(5)}$$

Equation five better captures the approach adopted in actual empirical analysis to theorize the import price pass-through. Similarly, equation three can be expressed in logarithmic form by approximating it as shown in equation six.

$$\mathbf{InP_X = InMC_X + InMKP_X + InE} \quad \textbf{....(6)}$$

Equation six represents the crux of the basic theoretical model adopted in this chapter. Thus, import prices are expressed as a function of three key elements. The first is the marginal cost component which represents the supply-side conditions and captures the underlying import supply function. The second element is the mark-up component which is in turn shaped by various macroeconomic and microeconomic factors, depending on the level of aggregation employed[20], while the third component is the exchange rate. Thus, equation seven captures the essence of the theoretical model used in this chapter.

$$\mathbf{IPX = f(Costs, Markups, Exchnage\ rate)} \quad \textbf{....(7)}$$

Note: IPX in equations seven to twelve refers to the Import Price Index.

The macroeconomic factors can be incorporated into this import price pass-through mechanism via the mark-up component. Mark-ups can vary due to a host of macroeconomic factors as examined in chapter two. Inflation persistence and volatility are one of the important factors affecting the mark-ups at the aggregate level. Highly volatile domestic inflation can induce exporting firms to practice PCP and thus pass-over and thus avoid inflation risks in their contracts with Indian importers. On the other hand, persistently low inflation can result in lower pass-through to import prices as monetary policy credibility is established and exporters can foresee aggressive counter-actions by the central bank to tackle any kind of inflation-promoting behavior by the exporting firms to India. Similarly, exchange rate volatility is considered to be another important source of mark-up variations wherein increased volatility in the value of a currency, for example, the Indian rupee, can cause foreign exporting firms to move towards PCP and avoid bearing any exchange rate risks. This implies that the volatile movements in the exchange rate will be shifted either in part or fully to local import prices in India. The problem becomes more complicated when one allows for PTM to occur and in this case, the foreign firms supplying imports to India can diverge drastically from the LCP and PCP behaviors in the wake of maintaining market shares or to avoid menu costs, or possibly due to fear of low switching costs. It is thus possible that a high and volatile inflation and exchange rate may still result in an incomplete or low transmission of exchange rate changes to the import prices of India.

Thus, only an empirical analysis can reveal the true picture and allow for rationalizing the results with this theoretical model. Different empirical possibilities can be accommodated

into this model. This chapter diverges from the traditional approach and modifies the framework to account for some additional control variables to test some additional hypotheses. Following Aziz et al. (2014), this study also accounts for trade openness in the analysis of import price pass-through, primarily because trade liberalization has been a characteristic feature of the period adopted in this study[21]. It is generally expected that increased trade openness would result in higher pass-through and this hypothesis is put to empirical examination in this study. Unlike the studies that have investigated import price pass-through using the mark-up model, we utilize alternative measures for the different components of the pass-through process to check for the robustness of the results and the sensitivity of pass-through coefficients to alternative macroeconomic variables. Thus, the initial benchmark model to be used in this study is expressed in equation eight.

$$\mathbf{IPX = f(COST,\ GDP,\ E)} \qquad \mathbf{....(8)}$$

The choice of variables in equation eight represents the primary concerns of this chapter and is grounded in the macroeconomic literature on ERPT analysis in India. Both the import supply and demand side factors are incorporated into the analysis and additional hypotheses are tested by incorporating inflation volatility, exchange rate volatility, and trade openness into the import price function. The domestic and international literatures have guided the inclusion of the additional variables and allow the analysis in this chapter to improve upon the traditionally employed framework. The inclusion of inflation volatility, exchange rate volatility, and trade openness in the import price pass-through analysis, as shown in equations nine to twelve, is perhaps an improvement over existing approaches and enable us to test if these macroeconomic factors play a meaningful role in the stage one pass-through process

The baseline model provided above reflects the three key components laid down in equation six earlier. The variable COST represents the cost component of equation six and captures the aggregate cost changes in the major import suppliers of India. Two variables are employed for this purpose with the first being the OECDI and the second being the WCPI. OECDI represents the consumer price inflation for OECD countries. Similarly, following Yanamandra (2014), and Rajan and Yanamandra (2015), another variable is employed to replace OCEDI, which is the WCPI. It represents the World Consumer Price Inflation[22]. Both variables are employed as proxies for the cost conditions prevalent in the key import suppliers of India. As noted in section 4.3, the bulk of India's imports emerges from OPEC and OECD nations, with both of them accounting for nearly 2/3rd of India's aggregate imports. Given their

predominance in our imports, the mark-up variations model elaborated in equations one to five necessitates accounting for the cost conditions of these two blocs of countries. While OECDI and WCPI measure the cost conditions in one of the key import suppliers of India, namely the bloc of advanced economies, the other bulk of imports are oil imports, and the OPEC cartel dominates India's oil import basket. While the crude oil price of the Indian basket (OILIND) is represented by both sour and sweet grade oils in the ratio of roughly 75:25, its data are available only from the year 2000 onwards[23]. Thus, an alternative variable is employed which is the average crude oil price for all major grades, dominated by the Dubai and Brent crude oils, as provided by the World Bank Commodity Database, also called the 'pink sheet'. The World Bank database accounts for other major crude oil variants also such as the West Texas Intermediate (WTI), but the major weights are assigned to the Dubai and Brent variants which are also the key components of India's oil basket. Hence, this variable, termed OILWB, and measured in current US dollars per barrel, is employed to represent the cost conditions of the OPEC bloc. It is necessary to account for the cost conditions of both the blocs as India's imports are sourced from both of these and thus a single cost measure would rather be theoretically biased and incomplete.

Currently, the few studies that have studied this issue in the Indian context, have not separately accounted for the cost conditions of these two blocs. The theoretical model delineated above also needs to account for the mark-up variations which are considered a key explanation for the behavior of the import price inflation within the new open economy macroeconomic approach to pass-through analysis (Campa and Goldberg, 2005). The mark-up variations are the second primary concern in the aggregate macroeconomic import price pass-through analysis. What factors cause mark-ups to vary and how do these factors affect the behavior of import prices? In this context, the oil price variations can be perceived as a rough approximation of the movements in the imports demand of India, given that oil price inflation percolates into the general price level and induces inflationary momentum across the domestic markets. Thus, increased oil prices could be theorized as impacting import demand negatively. Furthermore, the import demand may be considered positively associated with aggregate GDP[24]. Moreover, it is also plausible to consider aggregate GDP movements as impacting the mark-up component of equation 7. Expansion in the aggregate income can be a source of increase in mark-ups and larger variations therein indicating increased pass-through to Indian import prices while maintaining or even expanding the extent of mark-ups enjoyed by the exporter Thus, the sign of the coefficient of oil prices would concurrently represent the

direction of impact from changes in the cost conditions of OPEC bloc nations as well as the changes in import demand function of India. Finally, the exchange rate variable is used to estimate the pass-through coefficient[25]. The exchange rate is measured by two variables as stated earlier in chapter one. The first is the bilateral exchange rate and the other is the 36-currency trade-weighted NEER with base 2004-05[26].

The determinants of import price inflation are further examined by enlarging the set of macroeconomic factors that shape its behavior. Thus the baseline model shown in equation eight is expanded to account for additional hypotheses relevant to the pass-through analysis and are hypothesized as key determinants of the variations in aggregate import prices. The role of the level of domestic inflation, volatility of domestic inflation, volatility of exchange rate, and trade openness, in shaping the behavior of import prices are examined in this chapter. These concerns are critical to contextualize the pass-through coefficient and its interactions with these macroeconomic processes. Accordingly, the role of the initial level of inflation (INF), following Taylor (2000), is included in the pass-through equation. Three macroeconomic candidates are located for proxying this factor. The first is the WPI for all commodities (WINF), the second is the CPI for industrial workers (CINF) and the third variable is the aggregate GDP deflator (GDEF). Each of these three variables has been employed in literature as found in chapter two. The use of these three alternative measures allows for obtaining multiple estimates of the import price equation while also enabling us to gauge the effects of these three measures on the import price pass-through coefficient.

Thereafter, attention is put on the role of inflation volatility (INF_{vol}) in affecting import price behavior and subsequently on import price pass-through. This is captured by the Coefficient of Variation of WPI (WINFVOL) and CPI (CINFVOL) using their monthly inflation rates estimated on both month-on-month and year-on-year basis[27]. Inflation volatility has been located as a key determinant of the domestic price pass-through in the macroeconomic literature. Various analysts in the international context have focused on the initial level of inflation, and volatility in inflation as key determinants in the full pass-through process. Goldfajn and Welang (2000), Taylor (2000), Obstfeld (2002), Ca'Zorzi et al. (2007), Goldberg and Hellerstein (2008), Devereux and Yetman (2010), Lopez-Villavicencio and Mignon (2016), Forbes et al. (2017), among few others, provide the broad structure of thought on the role of different dimensions of inflation in explaining the aggregate price movements. In the Indian context, some recent evidence on this account includes Ranadive and Burange (2015), Mendali and Das (2017), Patra et al. (2018), and Balcilar et al. (2019).

Similarly, the role of exchange rate volatility (E_{vol}) in shaping the behavior of import price inflation and its impact on import price pass-through is investigated. The volatility of both the bilateral (BEXVOL) and nominal effective exchange rates (NEERVOL) are utilized[28]. Finally, trade openness (OPEN) is included to test the hypothesis of whether increasing trade integration since the reforms has resulted in largely increased import price inflation or has lowered it due to the import substitution tendency of each consecutive government. Both nominal trade openness (NTOPEN) and real trade openness (RTOPEN) are utilized alternatively. Each of these factors is introduced into the baseline model to estimate different models with differing estimates of coefficients associated with them as well as of the ERPT coefficient. The same is represented in equation twelve. To date, no study has, to the best of our understanding, examined the role of these factors in shaping the behavior of import prices themselves and thus these macroeconomic factors are accounted into the import price equation in this chapter as shown hereafter.

$$\mathbf{IPX = f\ (WCPI, OILIND, GDP, E, INF, INF_{vol}, E_{vol}, OPEN)} \qquad \mathbf{....(9)}$$

Equation 12 represents the model for examining the determinations of import price inflation in India and it emanates from the theoretical framework ascribed in this chapter. The variables incorporated in this equation embody the key macroeconomic factors that shape the behavior of the aggregate import price inflation that emanates from both the domestic and international sectors.

4.5. Variables, data, and sources

This chapter employs data on key macroeconomic variables which are sourced from official government sources and international official publications. The use of such data necessitates an overview of their nature, sources, and other related aspects before they can be employed in empirical analysis. The variables used for measuring exchange rate and import price are already elaborated on in chapter one. Oil prices are measured by two different variables, namely the global crude oil price expressed in current US dollars per barrel[29] and the price for the Indian basket of crude oil measured in current US dollars per barrel of the Indian basket which is composed of two components. The first is the sour grade oil and is measured by the average of the Oman and Dubai crude oil prices, while the second is the sweet grade oil measured by the price of Brent crude oil. The current weightage is 75.62 to 24.38 for the sour and sweet grade crude oils respectively, in the Indian basket. Hence, this variable better captures the price dynamics of crude oil facing Indian importers. However, its data are available from 2000-01

onwards and thus the global crude oil price is also taken into consideration. Both variables are used in the analysis to check for their impact on the empirical results. The global crude oil price data are available from the World Bank Commodity Price database, the so-called 'Pink Sheet', while the price for the Indian crude basket is available from the Petroleum Planning and Analysis Cell, Ministry of Petroleum & Natural Gas, Government of India. The higher backward data availability of the World Bank crude oil price data allows its usage across the sample period while the Indian basket crude price data are available from 2000-01 onwards.

The variable representing the marginal cost changes in the key import suppliers is captured by the World CPI, data on which are available from the World Bank database. The World CPI variable represents the average inflation rate across the globe and accounts for price data from the member nations of the World Bank. Fixed weights are used to construct this variable using official inflation data from the member nations. This variable is used as a proxy of the marginal cost component of the pass-through function specified in equation eight[30]. The other important macroeconomic variable in this framework is the volatility of inflation and this is measured by the Coefficient of Variation of the WPI for all commodities using its monthly data. This is undertaken for analysis using annual data. In the case where monthly data are employed, the moving CV is employed to measure the inflation volatility. Import demand is proxied by the domestic aggregate output as measured by the real Gross Domestic Product (GDP) of India. In the case where monthly data are employed, the Index of Industrial Production (IIP) data is used. These data are available from the RBI's handbook of statistics on the Indian economy and the Database on the Indian economy of the RBI. These data are sourced by the RBI from the respective ministries and regulatory authorities and thereafter are compiled into the handbook and the online data warehouse. The variable representing trade openness is measured by the ratio of total trade to GDP where the total trade data are deflated using the WPI index, and subsequently, another variable is estimated by using the GDP deflator as the deflation factor for measuring trade openness.[31] Data on total trade are available from the Directorate General of Foreign Trade. Finally, the variable representing exchange rate volatility is measured as the Coefficient of Variation using monthly data on the bilateral exchange rate as well the 36-currency trade-weighted NEER. Both these exchange rate variables are employed as literature has found a considerable difference in the empirical results when these alternative exchange rate measures are used. In the case where monthly data are directly employed, the volatility in the exchange rate is measured by the moving CV of the exchange rate data.

4.6. Descriptive Statistics, Time-series properties, and related issues

The narrative so far has clarified the basic building blocks of the empirical analysis to be conducted in this chapter. This section describes the variables selected for the estimation of the import price function and thereafter for the estimation of the determinants of import prices and the factors shaping the behavior of the time-variant pass-through coefficient. Furthermore, this section examines the basic time series properties of the chosen variables. Each of the variables represents a particular component of equation six at the aggregate level. The use of macroeconomic variables in equation nine is to assess not only the macroeconomic nature of the import price pass-through process but also to test various hypotheses prevalent in the macroeconomic strand on this issue, thereby expanding the scope of analysis beyond simply estimating the extent of import price pass-through.

Table 4.1 presents the descriptive statistical estimates of the macroeconomic data environment within which empirical concerns are addressed in this chapter. The immediate observation is the persistent inflation in aggregate import prices as depicted by the mean value of IPX which is at 7.19% with a high variability as seen in the value of its CV. The Indian economy has experienced large fluctuations in import price inflation and apparently an unstable path throughout the post-reforms period as indicated by the high excess kurtosis. Large deviations from the observed mean growth rate of the Import Unit Value Index, as depicted by IPX, have been frequent, indicating frequent shocks to the import sector of the country through the price channel. Not only inflation but there were several years during which the aggregate import prices deflated as indicated in the Appendix. These observations raise an important question: what could have been the driving force behind such an unstable and volatile path of aggregate import price inflation in India?

Table 4.1: Descriptive statistical estimates of the macroeconomic variables across the entire sample period

Statistic	**IPX**	**WCPI**	**OECDI**	**OILIND**	**OILWB**	**RGDP**
Mean	7.19	4.43	3.06	7.27	4.41	6.08
SD	17.27	2.44	1.51	26.15	18.50	2.93
CV	240.27	55.24	49.35	359.84	418.95	48.30
Kurtosis	8.23	0.05	-0.17	0.87	-0.63	11.66
Skewness	1.69	1.03	0.61	0.71	-0.07	-2.92
Statistic	**BEX**	**NEER**	**REER**	**WINF**	**CINF**	**GDEF**
Mean	4.00	-1.80	0.59	5.48	7.01	6.22
SD	6.92	5.21	4.31	3.51	2.87	2.61
CV	173.19	-289.95	729.62	64.09	40.93	42.01
Kurtosis	2.23	1.42	-0.14	0.71	-0.90	-1.31
Skewness	0.79	-1.06	-0.32	-0.04	0.40	0.11

Table 4.1 *(continued)*						
Statistic	**WINFVOL**	**CINFVOL**	**BEXVOL**	**NEERVOL**	**RTOPEN**	**NTOPEN**
Mean	187.76	205.09	2.36	1.93	37.82	26.73
SD	367.61	287.92	1.82	1.04	11.94	8.92
CV	195.79	140.39	77.04	53.84	31.57	33.39
Kurtosis	15.14	27.75	2.50	3.15	-0.77	-1.03
Skewness	3.35	5.15	1.60	2.02	-0.01	0.36

Notes: SD is Standard Deviation; CV is Coefficient of Variation; all data are expressed in percentage except OILIND (in rupees per barrel), OILWB (in US dollars per barrel), and BEX (in rupees per US dollar).

Theoretically, import prices are impacted by both domestic and international factors and tend to move closely with the economic fluctuations in the foreign countries that our imports. From this perspective, the persistence of the world inflation rate as indicated by the mean value of 4.43% in WCPI and the mean inflation rate of 3.06% of the OECD bloc could be perceived as the first traces of persistent import price inflation in India. Inflationary movements in the global economy and specifically in the major trading partners of India could have induced cost-shifts and this may have been passed over into our import prices. While it is premature to presume a particular degree of pass-through at this stage, purely from the perspective of variables WCPI and OECDI, it appears that the increased pressure on local production costs of our key imports suppliers may have contributed to the inflationary path of our aggregate import price. While at the level of the first moment of their distributions, IPX, WCPI, and OECDI seem to have a meaningful association, further concerns are raised by the gap in their variabilities. While IPX has been considerably volatile with a high CV and high excess kurtosis, WCPI and OECDI seem to have been fairly stable and their movements have been compactly anchored to their mean growth rates as shown by their lower CV and a fairly symmetrical distribution in terms of the low excess kurtosis.

In terms of the variability and instability of import price inflation, it appears that the variability of NEER and BEX may have been contributing factors. The value of CV for the growth rate of the bilateral exchange rate, as shown by BEX, is 173.19% while that of NEER is 289.95% implying a volatile path of the changes in India's exchange rate. Larger fluctuations in the exchange rate can induce uncertainties for import suppliers who could be motivated to pass-over this increased volatility to import prices in local currency, and thus keep their mark-ups intact (Frankel et al., 2005). It is also evident that oil price inflation, as indicated by OILIND and OILWB, has been on an upwards trajectory for the Indian economy throughout the period with very high variability as compared to import price inflation. With a CV of 359.84% for the oil price inflation of the Indian basket and 418.95% for the world crude oil prices, the path of Indian import price inflation could have been lent further instability due to

frequent oil price shocks. However, it does not seem there have been frequent deviations of oil prices from their mean path as indicated by the low excess kurtosis and a fairly low skewness, both of which indicate a fairly stable distribution of oil price inflation across the period under consideration.

Shifting from the international to domestic factors associated with import price inflation, attention is driven to the positive mean growth rate of real aggregate income in India depicted by RGDP. While the variability of output expansion was low, as shown by the CV of RGDP, its kurtosis is very high at 11.66. While this may seem to indicate frequently large deviations from the normal growth path, the actual yearly growth rate clearly shows that the year 2020-21 saw a GDP contraction with a negative growth of 6.60%, which has contributed to the high excess kurtosis. As shown in the Appendix, once this year is excluded, the excess kurtosis is only -1.06 indicating a fairly symmetrical distribution of the growth in aggregate income. Expansionary domestic income has been hypothesized as a major source of increasing import demand, which can put upward pressure on import prices due to robust demand conditions (Pyne and Roy, 2008). Under such an expansionary environment, foreign firms supplying the imports can afford to maintain constant or even increasing mark-ups while passing over any unfavorable exchange rate variation to the import prices in Indian rupees.

More importantly, in an expansionary economy, domestic prices tend to be inflationary and an inflationary environment allows higher pass-through to import prices by foreign firms displaying PTM behavior (Ito and Sato, 2008; Devereux and Yetman, 2010; Lopez-Villavicencio and Mignon, 2016). The persistence of inflation is sharply depicted in the mean values of WINF and CINF which are 5.48% and 7.01% respectively with a fairly normal distribution of inflation rate across the period. It appears that the Indian economy was persistently inflationary and largely remained anchored to the mean growth rate experienced during this period, as seen from the low values of skewness and excess kurtosis. This opens up the question of whether domestic inflation has in itself caused higher pass-through to import prices and thereby helps explain the import price inflation experienced by the Indian economy since the economic reforms. The inflationary environment not only accounts for the level of inflation but also its volatility.

Consequently, literature on pass-through to import prices has located the volatility of inflation as a key element in the inflationary environment. Higher volatility in inflation, i.e. in domestic wholesale and consumer prices, is theorized as a source of larger pass-through of exchange rate variations to import prices. The rationale proposed in this context is that an unstable inflation rate creates uncertainty for the value of the currency and thereby promotes

PCP instead of LCP which can result in a larger use of non-rupee currencies, such as the US Dollar, for international trade and finance contracts between Indian importers and foreign suppliers. Such a practice will inevitably cause the transactions to be invoiced in non-local currencies and thus the brunt of exchange rate variations will have to be borne by the Indian importers in terms of high prices of imports in local currency (Lopez-Villavicencio and Mignon, 2016; López-Villavicencio and Pourroy, 2017). Lastly, the inflation in aggregate import prices as noted at the beginning of this section can be linked to the increased openness of the Indian economy in both real and nominal terms as demonstrated by the mean values of RTOPEN and NTOPEN which are 37.82% and 26.73% respectively. The lower CV coupled with low skewness and excess kurtosis, indicate that the Indian economy has continued to integrate into the international trade and financial architectures during the period under consideration[32].

While the descriptive estimates indicate that there may exist theoretically meaningful interconnections between import price inflation and the other macroeconomic variables are taken into consideration, it is equally important to gauge the co-movements between these variables as portrayed in Table 4.2 which presents the estimates of the correlation structure among the chosen variables. The primary interest lies in the correlations between IPX and the other macroeconomic variables. The correlation between IPX and NEER is -0.32 and indicates the theoretically expected direction of the relationship. Given that NEER is defined in terms of units of foreign currency per Indian rupee, the negative sign indicates that depreciation has a positive relationship with import price inflation. However, the relationship between IPX and BEX is both theoretically and statistically insignificant, possibly lending credence to the dominance of NEER as the exchange rate variable of choice in the majority of the studies in the Indian context as far as import price pass-through is concerned. The relationship between import price inflation and exchange rate volatility, whether with volatility in the bilateral exchange rate (BEXVOL) or the effective exchange rate index (NEERVOL) is positive and indicates that years with higher volatility in the exchange rate of the rupee are also the years when import price inflation was higher than usual. The exchange rate volatility hypothesis – which states that an increase in exchange rate volatility causes increased pass-through to import prices, seems to be standing the preliminary scrutiny. The empirical models estimated later in this chapter test this hypothesis but there appears to be a strong indication that exchange rate volatility may be a factor causing import price inflation and perhaps could be inducing a larger degree of pass-through of exchange rate variations to local import prices in India.

Table 4.2: Correlation Structure among the macroeconomic variables throughout the sample period

Variables	BEX	BEXG	BEXVOL	CINF	CINFVOL	GDEF	IPX
BEXG	-0.1						
BEXVOL	-0.08	0.42**					
CINF	-0.35*	0.46**	0.36**				
CINFVOL	0.38**	0.02	-0.11	-0.2			
GDEF	-0.49***	0.17	0.19	0.64***	-0.14		
IPX	0.02	0.05	0.43**	0.07	-0.07	0.29#	
NEER	0.16	-0.82***	-0.52***	-0.46***	0.15	-0.29#	-0.32*
NEERVOL	-0.13	0.42**	0.82***	0.48***	-0.1	0.32*	0.54***
NTOPEN	0.39**	-0.05	0.44**	0.15	-0.08	-0.04	0.34*
OECDI	-0.49***	0.28	0.40**	0.35*	-0.04	0.46**	0.15
OILIND	0.47***	-0.04	0.39**	0.18	-0.1	0.11	0.44**
OILWB	0.51***	0.05	0.40**	0.21	-0.04	-0.02	0.24
REER	0.01	-0.63***	-0.48***	-0.30#	-0.06	-0.19	-0.32*
RGDP	-0.22	-0.25	-0.13	0.04	-0.78***	0.06	-0.06
RTOPEN	0.17	-0.28	0.31*	0	-0.13	-0.1	0.17
WCPI	-0.75***	0.29#	0.30#	0.49***	-0.27	0.71***	0.13
WINF	-0.46**	0.13	0.13	0.37**	-0.26	0.80***	0.46**
WINFVOL	0.19	0.06	0.23	0.08	-0.04	-0.1	0.08
Variables	**NEER**	**NEERVOL**	**NTOPEN**	**OECDI**	**OILIND**	**OILWB**	**REER**
NEERVOL	-0.61**						
NTOPEN	-0.15	0.33*					
OECDI	-0.27	0.41**	-0.35*				
OILIND	-0.16	0.34*	0.93***	-0.31*			
OILWB	-0.16	0.30#	0.94***	-0.32*	0.94***		
REER	0.68***	-0.55***	-0.03	-0.48***	0	0	
RGDP	0.05	-0.04	0.06	-0.23	0.07	0.01	0.25
RTOPEN	0.03	0.08	0.82***	-0.34**	0.68***	0.69***	0.14
WCPI	-0.38**	0.39**	-0.34*	0.76***	-0.31*	-0.36*	-0.30#
WINF	-0.36*	0.31*	-0.15	0.37**	0.06	-0.16	-0.16
WINFVOL	-0.12	0.13	0.1	0.11	0.14	0.07	-0.2
Variables	**RGDP**	**RTOPEN**	**WCPI**	**WINF**			
RTOPEN	0.17						
WCPI	0.01	-0.34*					
WINF	0.14	-0.17	0.65***				
WINFVOL	-0.26	0.07	0.04	0.02			

Notes: ***, **, and * imply significance levels of 1%, 5%, and 10% respectively. # implies the significance of 13% level. BEXG is the annual growth rate of BEX.

The direction of association between import price inflation and domestic inflation, depicted by three indicators – namely, GDPDEF, WINF, and CINF portray a positive association. This is also a first indication of the theoretical belief following Taylor (2000) that an inflationary environment at home can cause a larger degree of pass-through to import prices and may be contributed to fuelling the import price inflation in home currency. The correlation

coefficient between IPX and CINF is positive but statistically insignificant and practically negligible. Perhaps, the inflation dynamics at the retail level do not play a larger role in the pricing decisions of foreign firms supplying the imports. This may be because Indian imports are largely driven by capital inputs and crude oil, and thus the inflation dynamics at the retail level may not enter into the pricing functions of exporting firms who specialize in supplying capital inputs and oil commodities, which are not meant for direct retail consumption. The meaningful correlation between IPX and WINF is an indication that there might exist a causal connection between these variables, though the nature of causality and its direction requires further empirical investigation as undertaken later in this chapter. It also seems that years with higher oil prices tend to be associated with years with higher import price inflation and thus the role of oil prices in shaping the import price behavior and the larger process of import price pass-through need to be addressed. Increased trade openness is also associated with higher import prices and perhaps the integration of the Indian economy into the global trade flows has allowed larger transmission of exchange rate variations to India's import prices. Surprisingly, the correlation between aggregate real GDP (RGDP) and IPX is statistically insignificant and practically negligible. As stated earlier, movements in domestic income play a pivotal role in the import price pass-through process mainly because the aggregate import demand function moves in congruence with the aggregate GDP (Pyne and Roy, 2008). Perhaps, modifying the variable in other forms, such as the logarithmic scale, might improve its association with IPX.

In summary, the correlation structure depicted in Table 4.2 indicates the existence of meaningful associations between the variables that are of theoretical interest within the ERPT mechanism pertaining to import prices. The baseline model developed earlier focuses on the aggregate import price inflation of India, exchange rate variations, world inflation, oil price inflation for the Indian basket, and domestic aggregate income. The correlations between import price and the other macroeconomic variables are indicative of a possibly meaningful relationship between them. Equally of interest are the correlations between the macroeconomic variables themselves without accounting for their association with import price variables. Highly correlated regressors can cause multicollinearity and thus may distort the true causal relationships while inflating the standard errors of the regression coefficients and possibly producing spurious causal relationships while also increasing the probability of type-II error and parameter bias (Lavery et al., 2019; Gregorich et al., 2021). The use of such variables may also lead to specification errors and in order to ensure that such perturbations do not distort the theoretical structure being constructed, attention needs to be paid to the inter-correlations between the theorized regressors.

In this context, NEER has a statistically significant correlation with WINF, WCPI, and CINF while not displaying any meaningful linear co-movements with other variables. Similarly, OILIND displays significant correlations with WCPI, RTOPEN, BEX, BEXVOL, NEERVOL, and OECDI. Using any of these combinations of variables in their level form may cause econometric problems as delineated above and thus appropriate transformations will be required to incorporate this information into the estimation of pass-through models. RGDP on the other only shows a significant correlation with CINFVOL while not displaying any statistically significant co-movement with other macroeconomic variables. Weaker correlations among the theorized regressors are perhaps an indication of the independent and unique information being contributed by these variables and thus their usage with appropriate transformations can allow empirically sound inferences. The broader picture that emerges from the inter-correlations among the variables is that their use in level form might not lend itself to reliable econometric inferences and thus necessary transformations will be required to estimate the pass-through relationship and its extensions thereof.

With the descriptive background set in the previous discussion, the time series properties of the chosen variables are examined hereafter. Three dimensions of the time-series properties of the variables are examined: first, the temporal evolution of the major variables is presented; second, the existence of structural breaks in the chosen time-series variables is investigated; and third, the issue of stationarity of the selected variables is tested using appropriate tests. The need to check for structural breaks emerges from the fact that ignoring substantial breaks in data can lead to incorrect specifications and perhaps incorrect inferences from estimated models (Kočenda and Černý, 2015). Time series econometricians have developed voluminous literature on the problems brought by structural breaks in estimating linear econometric models[33]. A structural break is broadly conceptualized as a sudden shift in the intercept, trend, or both, of a time series variable, and such a break may change the trajectory of the variable fundamentally. Structural breaks in economic time series may occur due to shocks emanating from domestic or international markets, or possibly due to policy shifts that may cause regime changes[34]. Not incorporating this information into the empirical analysis can lead to several econometric problems such as spurious relationships, and incorrect results from stationarity tests, among others. It is also necessary to establish the existence or absence of structural breaks before engaging in stationarity tests to avoid incorrect inferences (Enders, 2014). Structural changes may also be indicative of fundamental changes in the underlying Data Generating Process (DGP) which implies that a plain-vanilla empirical

approach that ignores such breaks will produce surprising and problematic results with no policy or analytical relevance.

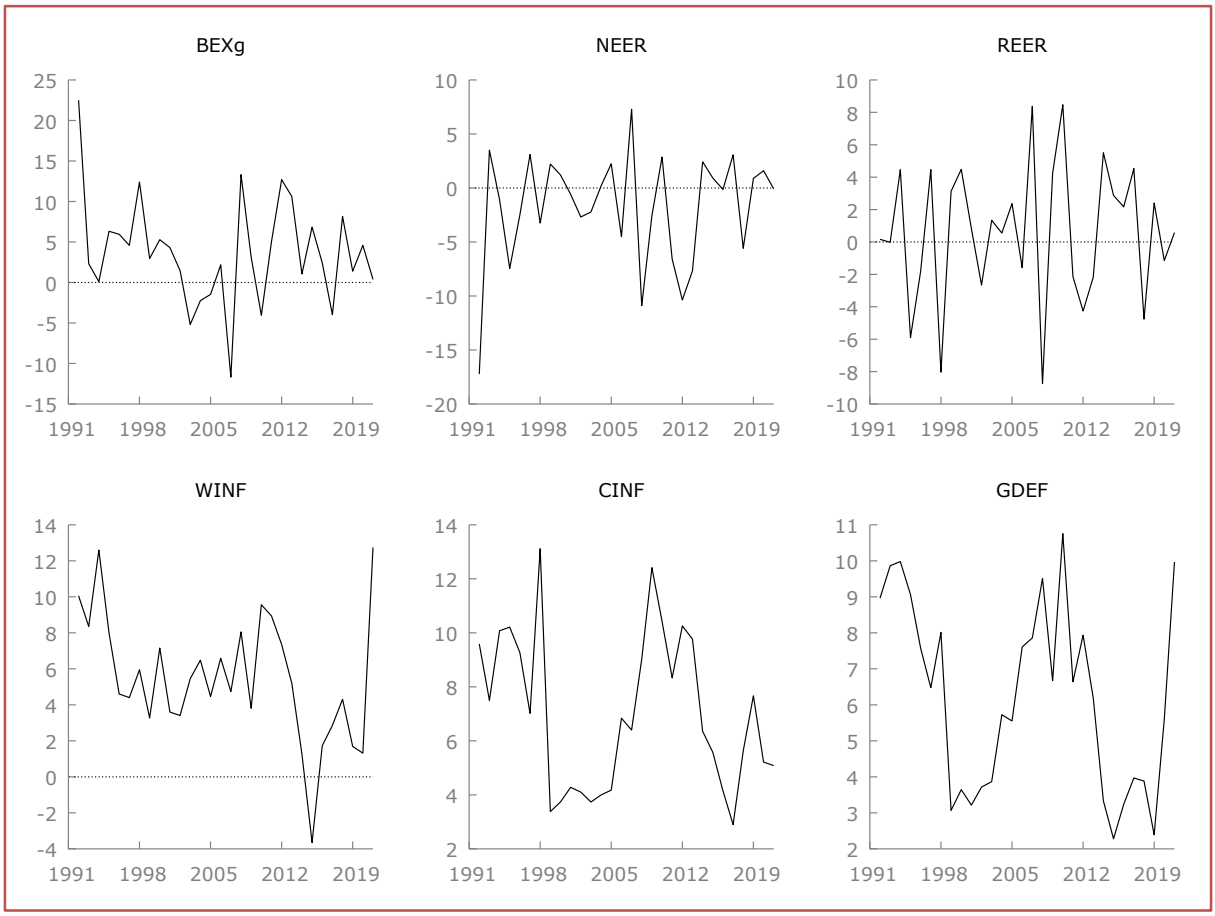
However, there is a serious problem when one engages in testing for structural breaks in time series data. There are two approaches on this account: the first one are the proponents of testing for a structural break by employing exogenous and *a priori* breaks that an analyst suspects by observing the data itself; the second set of proponents argue against this subjective approach and propose that structural breaks should be determined through the data itself rather than being imposed upon it. The first approach presupposes a strong belief that particular years have experienced fundamental changes either in policy, markets, or other institutions, which are bound to change the behavior of the time series under consideration. Such an approach may open up the dangers of data mining whereby an analyst keeps on trying different points of structural breaks only to 'locate' the 'correct' one through trial and error rather than imposing it exogenously. Inevitably, such an approach implies that the data itself was allowed to reveal the true breaks.

Figure 4.5: Behavior of the selected macroeconomic variables across the entire sample period

Source: Author's estimation.

Put differently, this approach presumes that all structural break points are 'known' in advance to the analyst. The second approach, on the other hand, recognizes the existence of unknown breaks and hypothesizes such breaks as emerging from the behavior of the time series data itself (Hashimzade and Thornton, 2013). Structural breaks are examined and modeled to allow for the underlying DGP to change but only discreetly rather than continuously. A continuously changing economic model would imply instability of the economic relationships and perhaps would not be captured by traditional time-invariant models that are largely employed in the ERPT analysis. Recognition of structural breaks implies that relationships have undergone a shift in the time-domain but the shift is discrete and after the break, the underlying DGP assumes stability. The approach adopted in this chapter takes into consideration both approaches to locating structural breaks in the time series data. The temporal evolution of the variables is examined graphically as shown in Figures 4.1 to 4.3 and thereafter an approach is selected that estimates the breaks endogenously from the data. The breaks located by the selected method and the *a priori* information on critical years are combined to locate important breaks that may have occurred in variables under consideration.

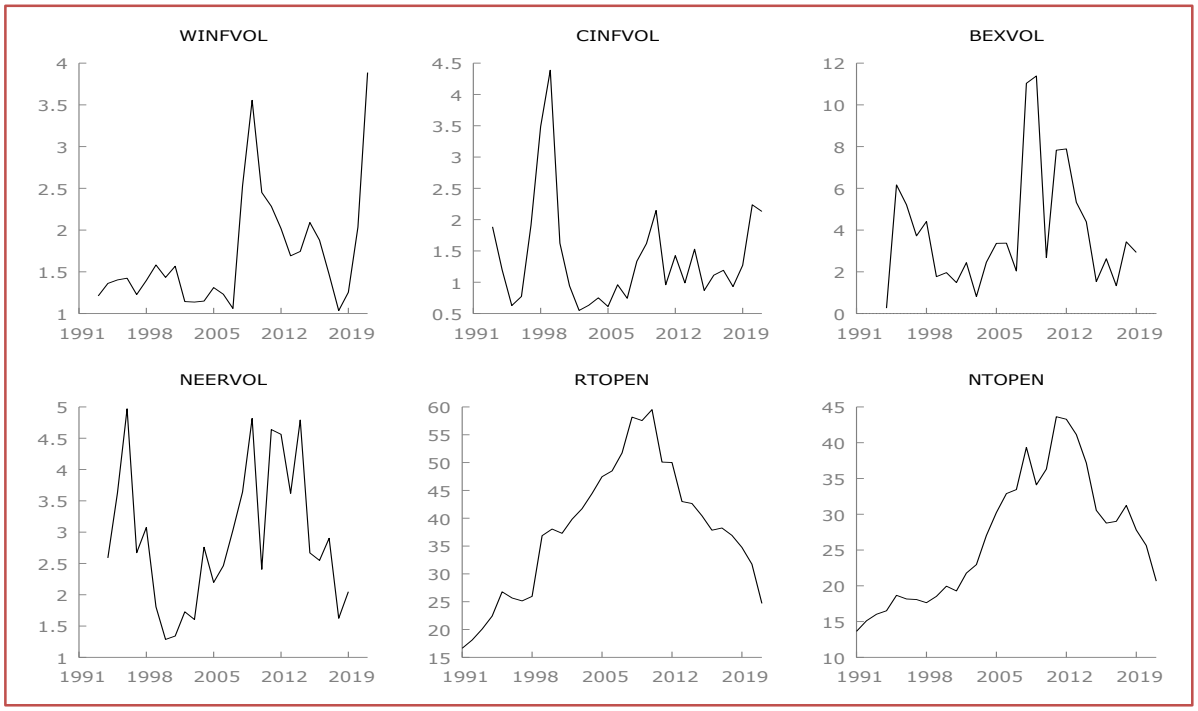
Figure 4.6: Behavior of the selected macroeconomic variables across the entire sample period



Source: Author's estimation.

Another question on this account is the existence of single versus multiple structural breaks in the time series variables. Single breaks can rather be dealt with much more easily using the first approach. The Chow test[35] is an example of such an approach. The analyst can hypothesize a particular period as critical due to perceived regime shifts or other important economic changes. The sample can be split before and after this period and various methods can be used to check for significant differences between these periods[36]. Alternatively, the same may be examined through a dummy variable approach and a statistically significant coefficient of the dummy variable in a regression against the time series of interest could provide evidence of a meaningful structural break in the series. However, when the period is longer, there may exist a possibility of multiple structural breaks in the variables and these breaks may be unknown. A generalized approach that can account for such cases while also nesting the case of a single known break is required to meaningfully extract the important shifts in the underlying data-generating process. The popular tests of stationarity in time series variables such as the Dickey-Fuller test and its extended version – the Augmented Dickey-Fuller test, cannot be meaningfully employed if structural breaks exist in the variables. Both from economic theory and econometric points of view, it is thus necessary to test for structural breaks before one can proceed towards tests for stationary/non-stationarity of the variables.

Figure 4.7: Behavior of the selected macroeconomic variables across the entire sample period



Source: Author's estimation.

The issue of structural break can be traced to the early research on the "change-point problem" of the late 1980s (Kočenda and Černý, 2015). Both structural change and structural breaks have since then been investigated rigorously and the econometrics of structural change has evolved a range of methods to locate single and multiple breaks both exogenously and endogenously. The issue of structural breaks is generally subsumed under the larger issue of coefficient stability analysis. Various approaches are employed in this regard that includes the Chow test, bootstrapping methods, and recursive approaches including the Cumulative Sum of Recursive Residuals (CUSUM) test, among several others. The most popular approach in testing for unknown multiple breakpoints is the Bai and Perron (1998) approach (Hashimzade and Thornton, 2013). Primarily, the advantage of this test is it produces estimates that are econometrically consistent for the break locations (Bai and Perron, 1998). There are three variations of this test: the first one is testing for zero breaks as against a known number of breaks; the second is testing for zero breaks as against multiple discrete breaks that are unknown up to a constant upper bound; and the third approach is the testing of sequential L versus L+1 approach. The third approach is called the sequential approach and it involves testing for n number of breaks versus n+1 breaks until the true number of discrete breaks is found. This approach seems to be the most systematic in the endogenous search for structural breaks in time series data. By employing this approach, the analyst avoids presuppositions on the nature of structural breaks underlying the economic variable in question. This can help reveal important dimensions of the data that may have been suppressed were the analyst to impose *a priori* breaks on the data. With this spirit, the Bai and Perron (1998) test in its modified sequential version as contained in Bai and Perron (2003) is employed in this chapter. The variables which provide conclusive results on the existence of structural breaks are corroborated with the *a priori* beliefs on the important years and the final number and location of structural breaks are estimated. Thereafter, stationarity tests are performed using different approaches for the series providing evidence of structural breaks versus those that do not display such characteristics.

The time series behavior of the key macroeconomic variables employed in this chapter is contained in Figures 4.1 to 4.3. Import price inflation has displayed considerable mean-reversion and this indicates stationarity in this series which is also corroborated by its test for non-stationarity contained in Table 4.4, wherein all the three tests – namely the ADF, Phillips-Perron and the KPSS tests conclusively indicate that the series is stationary. Moreover, there is no evidence of a structural break in this series as shown in Table 4.3. This variable is of

primary interest and it will be employed as a dependent variable in the import price pass-through equations. Hence, its stationary nature provides a sound econometric basis to investigate the issues further. Furthermore, the economics of pass-through analysis requires the import price variable in growth rate form[37], and thus it is plausible to employ the log-difference form of this variable across the equations estimated later in this chapter.

Attention is thereafter shifted to the key macroeconomic variables that are later utilized in the empirical estimations as regressors. WCPI displays a downward trend and the global inflationary pressure has fallen since 1991-92 which points towards not only slowing inflation but perhaps also improving cost conditions in major advanced economies that largely dominate the global trade flows. This fact is corroborated by the falling inflation rate for the OECD block, represented by OECDI, and perhaps the downward trajectory in global inflation has accentuated this behavior in the inflation rate of advanced economies. This is also evident from the high positive and significant correlation between WCPI and OECDI as shown in Table 4.2. WCPI and OECDI do not provide any evidence of a structural break as depicted in Table 4.3, and both of them are stationary in log difference form as shown in Table 4.4. These two variables are possible candidates to proxy the cost conditions of the major import suppliers of India and they seem to be trend stationary processes. The trend contained in these variables contains critical information on the nature of inflationary momentum in advanced economies and the possible changes in the aggregate cost conditions in these countries.

Oil price is another important element in the baseline model developed in this chapter and is hypothesized as a key determinant of import price behavior while also being used as a control variable in the estimation of import price pass-through. The two candidates for measuring oil price inflation are OILINDg and OILWBg, both of which represent the annual growth rate in the crude oil prices for the Indian basket and the average global crude oil price respectively. Both the variables appear to be fluctuating around the mean and it seems that there is a tendency of mean-reversion in these variables. Subsequently, both these variables do not portray evidence of structural breaks as depicted by Table 4.3 while also being stationary in log difference form as shown in Table 4.4. The lack of trend in these variables is perhaps a reflection of the independence of oil price fluctuations from global inflationary momentum and cost conditions of the advanced economies which are also corroborated by the low correlation between these WCPI and OECDI on the one hand and oil price variables on the other. The dominance of the OPEC bloc in oil price maneuvering is evident in the apparent incongruence of oil price inflation and global inflation momentums. The use of oil price inflation as another

regressor in the estimation of import price pass-through is thus warranted as WCPI and OILIND possess different information while representing the cost conditions of the two major blocs of nations that supply the bulk of India's aggregate imports.

RGDP represents the aggregate income growth of India and is employed as a measure of the mark-up variations in the macroeconomic theoretical model adopted in this chapter. Expansionary output can be linked with increased domestic inflationary momentum while also expanding the import demand of India. Under these circumstances, the variations in aggregate output can vary in positive correlation with the mark-ups maintained by the foreign suppliers. Robust output can indicate stronger import demand and may permit the foreign exporting nations to maintain their mark-ups constant while passing over the exchange rate variations to the import prices in local currency. It may perhaps also motivate the foreign suppliers to expand their mark-ups and thus increase the import prices exogenous to exchange rate changes. Under such circumstances, it is plausible to expect a more-than-full pass-through because the impact of exchange rate variations on import prices may be accentuated by the additional pass-through of mark-up variations which may occur independent of the exchange rate fluctuations. The role of this variable is thus critical in the import price pass-through analysis. In terms of its time-series properties, there are two structural breaks – viz. in 2008-09 and 2018-19[38]. The break in 2008-09 is largely on account of the Global Financial Crisis (GFC) while the break in 2018-19 may be ascribed to the global economic slowdown and the decreased momentum of international trade flows. It may also be the case the that introduction of the Flexible Inflation Targeting after 2016-17 caused a lagged impact on the aggregate output but this is more of a speculation at this juncture. RGDP has not shown any sign of a trend and perhaps the growth trajectory was largely anchored to the mean growth rate throughout the study period by prudent fiscal and monetary policy designs. More concretely, literature has found that the Global Financial Crisis has caused a structural shift in the import price pass-through itself (Rajan and Yanamandra, 2015; Patra et al., 2018). Accordingly, the year 2008-09 is incorporated into the estimation of import price pass-through by specifying an appropriate dummy variable. This is undertaken to not only address the structural break in the RGDP series which is used as a regressor in the estimation of import price pass-through equations but also to test the hypothesis of any fundamental change in import price inflation itself due to the GFC.

Table 4.3: Bai-Perron test for structural breaks in the key variables during the sample period

Sr. No.	Variable	Form	Regressors	Structural Break after
1	IPX	Log	Constant; Trend; AR(1)	1999; 2011
			Constant; Trend	1999; 2011; 2015
		Log Difference	Constant; AR(1)	*Not evident*
			Only Constant	*Not evident*
2	WCPI	Annual Growth Rate (%)	Constant; Trend; AR(1)	*Not evident*
3	OECDI	Log	Constant; Trend	1999; 2002; 2008
		Log Difference	Constant; Trend; AR(1)	*Not Evident*
			Constant; Trend	*Not Evident*
4	OILIND	Log	Constant; Trend; AR(1)	2015
			Constant; AR(1)	2015
		Log Difference	All variants	*Not Evident*
5	OILWB	Log	Constant; Trend; AR(1)	2015
			Constant; AR(1)	2000; 2015
			Constant; Trend	2000; 2006; 2015
		Log Difference	Constant; AR(1)	*Not Evident*
6	RGDP	Log	Constant; Trend; AR(1)	2018
			Constant; AR(1)	2018
			Constant; Trend	2001; 2018
		Log Difference	AR(1)	2018
			Trend	2008
7	BEX	Log	Constant; Trend; AR(1)	2003
			Constant; Trend	2003; 2004; 2012
			Constant; AR(1)	2012
			Constant	1998; 2012; 2013
		Log Difference	All variants	*Not Evident*
8	NEER	Log	Constant; Trend; AR(1)	2012
			Constant; Trend	1997; 2012
			Constant; AR(1)	2008; 2012
		Log Difference	All variants	*Not Evident*
9	REER	Log	Constant; Trend; AR(1)	*Not Evident*
			Constant; Trend	1998
			Constant; AR(1)	2009
			Trend	1995; 2001; 2011
			Constant	2007; 2010; 2015
		Log Difference	All variants	*Not Evident*

Table 4.3 *(continued)*				
10	WINF	Log	Constant; Trend; AR(1) Constant; Trend Constant; AR(1) Trend; AR(1) Trend	2015 1996; 1997; 2010; 2015 *Not Evident* 2015 2002
		Log Difference	Constant; Trend Trend	2014 1996; 2013
11	CINF	Log	Constant; Trend; AR(1) Constant; AR(1) Constant; Trend Trend; AR(1) Trend AR(1)	1999; 2008; 2010 1999; 2008; 2009 2000; 2001; 2010 2006 2002 1999
		Log Difference	Constant; Trend; AR(1) Constant; Trend Constant; AR(1) Trend	2000 1999; 2008; 2014 2000 1999; 2014
12	GDEF	Log	Constant; Trend; AR(1) Constant; Trend Constant; AR(1) Trend; AR(1)	2003; 2006; 2014 1997; 2000; 2005; 2010; 2014 2004; 2006; 2014 1999; 2004; 2014
		Log Difference	All variants	*Not Evident*
13	WINFVOL	Coefficient of Variation (%)[$]	Constant; Trend; AR(1)	2015
		Log of Standard Deviations[$]	Constant; Trend	2008; 2018
14	CINFVOL	Coefficient of Variation (%)[$]	Constant; Trend; AR(1)	2000; 2018
		Log of Standard Deviations[$]	Constant; Trend; AR(1) Trend	2000 2000
15	BEXVOL	Coefficient of Variation (%)[$]	Constant; Trend; AR(1) Constant; Trend	2018 2018
16	NEERVOL	Coefficient of Variation (%)[$]	All variants	*Not Evident*

(Table continued…)

Table 4.3 *(continued)*				
17	RTOPEN	Log	Constant; Trend; AR(1)	2009
			Constant; Trend	2011
			Constant; AR(1)	2011
			Constant	1999; 2005; 2013; 2015
		Log Difference	All variants	*Not Evident*
18	NTOPEN	Log	Constant; Trend; AR(1)	2011
			Constant; Trend	2004; 2011
			Constant; AR(1)	2013
			AR(1)	2013
			Trend	1997; 2009; 2012
		Log Difference	All variants	*Not Evident*

Notes: 1. The 'sequential L+1 breaks vs. L' version of the Bai-Perron test is employed[39]; 2. Detailed results are available from the author upon request along with the Bai-Perron (2003) critical values; 3. The periods represent financial years; 4. Regressor combinations that are not reported here did not provide evidence for structural breaks; 5. $ refers to the variables estimated using year-on-year growth rates. **Source**: Author's estimation.

The growth in the exchange rate has shown considerable variability but all the variables, namely BEXg, NEER, and REER, that signify exchange rate movements, seem to be reverting to the mean path during the study period. Subsequently, there is no evidence of any structural break in these series and all these variables are found to be stationary in log difference form. The mean-reverting behavior of these series is perhaps an indication of the persistent depreciating tendency of the Indian rupee and also possibly the proactive 'management' of the exchange rate fluctuations by the RBI. Since the adoption of LERMS, the RBI has moved towards a managed floating stance and it seems that it intervenes to largely stabilize the exchange rate volatility rather than maneuvering its value itself as indicated by the lack of any apparent trend in these variables. Domestic inflation, on the other hand, has shown important breaks as indicated by the variables WINF and CINF in Table 4.3. In log difference form, WINF, which represents wholesale price inflation, has shown breaks in 1996, 2013, and 2014. The year 1996 could be representing the financial market reforms that were underway after the structural adjustment programme began in 1991. As examined in chapter three, the inflationary momentum was strong during this phase and wholesale inflation entered into double digits. A sharp rise in monetary policy rates and a hard monetary policy stance was undertaken to contain inflation. In a short period, wholesale inflation felt down from more than a 12% rate to about 4%. The years 2013-14 and 2014-15 experienced stagflationary tendencies (Government of India, 2014). While the growth momentum slowed down, inflation did not and continued to remain on an elevated pitch. There was a large fiscal and monetary stimulus in 2011-12 and it

seems that “proved to be excessive and fostered high inflation” (Government of India, 2014, pp. 32). Perhaps these are the economic mechanisms that could explain the existence of structural breaks in these years for WINF. The variable CINF, representing consumer price inflation, has shown several breaks. The most evident ones are in the years 1999-2000 and 2008-09. The large fall in consumer price inflation after 2008 may have emerged from the GFC and the slowdown in the global economy which could have transmitted to the Indian markets causing a contraction of aggregate demand. Indeed, evidence has been found suggesting that both the trend inflation and inflation volatility changed fundamentally in India after the GFC (Alex, 2019). This fall in consumer inflation could have been led by the fall in aggregate demand due to weakening trade. Consumer inflation shifted in terms of its trend and intercept as evident from Figure 4.2. There was a reversal of trend and inflation picked up momentum after 1999-2000. The economic slowdown brought by the global trade slowdown could have resulted in a highly expansionary monetary policy by the RBI. Perhaps, the economic recovery and the monetary and fiscal stimuli pushed by the Government during this period may have contributed to this shift in the consumer price inflation data after 1999-2000.

Given the structural breaks in WINF and CINF, testing them with the traditional stationarity tests could result in incorrect inferences as ignoring structural breaks can result in confusing the breaks as unit roots (Enders 2015; Casini and Perron, 2018; Majune, 2018). Hence, the test for stationarity should be conducted while accounting for the structural breaks. Perron (1989) was one of the first studies to highlight the problems in employing the Dickey-Fuller test when the time series variables possess a structural break. The author concluded that the inability to account for such breaks in the unit root tests could result in mistaking breaks as unit roots and result in specification errors in the regression models. To overcome this, one of the popular approaches proposed in the econometric literature is the Zivot-Andrews test following Zivot and Andrews (1992). This test is capable of handling structural breaks while testing for unit roots and determines the breaks endogenously (Glynn et al., 2007). The search process for breaks by this test is based on looking for breaks wherever the t-statistic from the ADF unit root test is minimum. Thus, the dates which are least favorable for a unit root null in the ADF test are tested using separate dummies for each of these dates in the unit root testing process.

Table 4.4: Stationarity dimensions of selected variables across the sample period

Sr. No.	Variable	ADF test statistic	Phillips-Perron test statistic	KPSS test statistic	Final remark
1	ΔInIPX	-4.73***	-4.66***	0.17	Stationary
2	WCPI	-2.55	-2.44	0.51**	Non-Stationary
3	ΔWCPI	-5.9***	-6.87***	0.15	Stationary
4	ΔIn(OECDI)	-4.25***	-3.66**	0.07	Stationary
5	ΔInOILIND	-4.49***	-4.39***	0.10	Stationary
6	ΔIn(OILWB)	-4.46***	-3.49**	0.16	Stationary
7	ΔIn(BEX)	-6.37***	-6.27***	0.20	Stationary
8	ΔInNEER	-7.53***	-7.47***	0.13	Stationary
9	ΔIn(REER)	-5.99***	-10.47***	0.22	Stationary
10	ΔIn(GDEF)	-5.64***	-1.97	0.07	Stationary
11	BEXVOL	-5.46***	-5.46***	0.20	Stationary%
12	NEERVOL	-5.93***	-5.92***	0.08	Stationary
13	ΔIn(RTOPEN)	-5.8***	-6.84***	0.50***	Inconclusive

Notes: For the ADF test and Phillips-Perron test, p-values are one-sided and based on MacKinnon (1996). The critical values for the KPSS test statistic are based on Kwiatkowski et al. (1992). **Source**: Author's estimation.

Another advantage of this test is that, unlike other alternatives such as the Banerjee-Lumisdaine-Stock test or the Perron-Vogelsang test, it uses full information and thus has better statistical power compared to the other tests. Accordingly, the results from the Zivot-Andrews test are presented in Table 4.5. The variables WINF and CINF are stationary as per this test when the structural breaks are accounted for. Another variable that is considered for proxying aggregate inflation in India is the aggregate GDP deflator. This variable has a larger coverage compared to WPI or CPI and also accounts for non-tangibles while incorporating information on a much larger set of commodities whose combined price variations are represented in this variable. GDPDEF does not show any evidence of structural breaks and is stationary in log difference form as depicted in Tables 4.3 and 4.4. Despite its econometrically sound properties, the theory of ERPT warrants the use of 'explicit' price indexes rather than 'implicit' price indexes, primarily because the aggregate level movements of an aggregate implicit price index is a statistical construction and emerge from the ways in which the numerator and the denominator of the price index were estimated. WPI on the other hand captures actual price variations, emerging from the market behavior of agents, in the wholesale goods markets and provides information on actual market price signals rather than statistically constructed price

variations. Due to this reason, this chapter gives prime importance to WPI and CPI-based inflation variables but robustness tests are performed with GDPDEF also.

Volatility is another important dimension in the ERPT process and both the inflation and exchange rate volatilities are taken into account by WINFVOL, CINFVOL, BEXVOL, and NEERVOL. Their descriptive estimates can be seen in table 4.1 and their correlations with other important macroeconomic variables in table 4.2.

Table 4.5: Zivot-Andrews stationarity test for variables with structural breaks

Sr. No.	Variable	Variant	Test Statistic	Conclusion
1	ΔInRGDP	Both trend and intercept	-6.43*	Stationary
2	ΔIn(WINF)	Only intercept	-3.39***	Stationary
3	ΔInCINF	Only trend Both trend and intercept	-3.08 -4.16**	Non-stationary Stationary
4	CV of WINF	Only intercept	-12.36***	Stationary
5	$\text{In}(\text{WINF}_{\text{SD}})$	Only intercept	-5.48***	Stationary
6	$\text{In}(\text{CINF}_{\text{SD}})$	Only intercept	-3.75**	Stationary
7	CV of CINF	Only intercept	1.16	Non-stationary and has a structural break at 2004
8	In(RTOPEN)	Both intercept and trend	-3.71*	Stationary
9	In(NTOPEN)	Both intercept and trend	-3.09$	Stationary

Notes: Underlying p-values are based on the standard t-distribution and do not take into the breakpoint selection process. Maximum lags were specified to be 4. $ implies significant at 13% level. **Source**: Author's estimation.

Each of these variables was estimated using the standard deviations for twelve-month data of each financial year, by using the information on the year-on-year growth for each month. Hence, monthly information is incorporated into annual terms via these variables. WINFVOL represents the year-wise standard deviations in the WPI inflation rate. CINFVOL, BEXVOL, and NEERVOL represent the same in CPI inflation rate, bilateral exchange rate, and nominal effective exchange rate respectively. Theoretically, inflation and exchange volatility can be considered inversely associated with inflation persistence (Aron et al., 2014). Larger instability in inflation implies that the prevailing inflation rate may not hold its pace and is subject to larger swings, thus diverging from the mean path. Such behavior is in direct

contrast to a persistent inflation momentum where the prevailing inflation rate is expected to hold ground for a lengthier time frame (Gil-Alana and Gupta, 2019).

A similar argument applies to exchange rate volatility and thus a more persistent exchange rate cannot behave equally volatile as this would imply continuous deviations from the mean which is inconsistent with time-persistence[40]. Given this background, the inflation volatility variables are employed for proxying not only the level of volatility but also to reflect, inversely, the persistence of these variables. WINFVOL shows evidence of a structural break in 2008-09 and 2018-19. There was a sharp fall in the level of instability in wholesale price inflation immediately after 2008-09. Concurrently, WINF also saw a sharp fall after 2008-09. It seems that both the level and volatility of inflation felt down following the GFC which could have emerged from the large fiscal and monetary stimuli by the Government to help navigate the economy from the global recession. The year 2018-19 saw a shift in the behavior of wholesale inflation volatility perhaps due to the changing nature of global inflation, a lurking global recession, and possibly from the after-effects of the adoption of the Flexible Inflation Target regime since 2016-17. Another possible source could have been the volatile nature of food inflation and the volatile crude oil prices whose impact might have been passed-through to the instability in domestic prices (Government of India, 2019). CINFVOL, on the other hand, saw a structural break after the year 2000-01 which also coincides with one of the key structural breaks in CINF. Figures 4.2 and 4.3 make it amply clear that the time-path of both these variables changed fundamentally after 2000-01 whereby CINF began rising again after the sharp fall of the late 1990s and its volatility also assumed an expansionary path. This could have been a result of the pick-up in aggregate demand at home and due to the growth-inducing impact of the monetary expansion undertaken in the late 1990s to wither the looming global crisis and trade slowdown. WINFVOL is concluded to be stationary as reported in Table 4.5 using the unit root test that accounts for the break determined endogenously. The break may still very well define the time-series nature of this variable but it does not contribute to the unit root problem. A similar conclusion is drawn for CINFVOL.

Lastly, the measures of trade openness as captured in real terms by RTOPEN and in nominal terms by NTOPEN show that there has been a fundamental shift in trade openness after 2011-12 as portrayed in Figure 4.3 and further corroborated in Table 4.4. This change in the behavior of trade openness is a matter of serious concern as it indicates that the Indian economy, at least concerning trade integration, has become an increasingly closed economy. While not ruling out increasing openness on the financial front, the change in the trend of trade

openness shows a structural change as the Indian economy experienced continued trade integration since the early 1970s. The primary factor contributing to this is the slowdown in Global trade since 2011-12 (Aslam et al., 2017). Literature has found that the structural shift in global demand towards non-tradable and "within tradables toward nondurable manufactured goods" (Aslam et al., 2017, pp. 18) could be the key explanations for the generalized slowdown in trade across the economies cutting across both the advanced and emerging nations alike[41]. Both the measures of trade openness are stationary when tested for unit root with a structural break as depicted in Table 4.5.

This concludes the examination of the fundamental time-series properties of the variables which are now ready to be employed in the empirical estimations of import price pass-through and the host of related matters to be debated thereto.

4.7. Methodological considerations

Exchange rate pass-through to import prices has been an active area of debate in the international domain, with a particularly large number of studies studying the PTM behavior of exporters involved in trade among the Global-North countries. The relative dominance of advanced economies in the literature resulted in strong empirical presuppositions on how the ERPT coefficient should behave even for emerging nations, and the major factors that could explain the observed behavior of pass-through relationship. The early traces of active research on the pass-through issue can be traced to the observation of Japanese firms practicing differential pricing strategies which ignited the interest in import price pass-through (Feenstra, 1987; Marston, 1989; Feenstra et al. 1993). The shift from advanced economies to emerging economies began in the early 2000s when panel data-based studies began incorporating emerging economies into their samples and examined how pass-through dynamics underwent a change when attention was shifted from the advanced large open economies to emerging small open economies. The incompleteness of pass-through to import prices in advanced economies was largely justified by Taylor's hypothesis proposed by Taylor (2000) which also marked the beginning of an active macroeconomic approach to pass-through analysis. The findings from advanced economies served as a benchmark to build the expected inferences from emerging economies. Given that large open economies experienced incomplete pass-through, the emerging small economies should experience complete or even more-than-complete pass-through, at least to the trade prices. The findings from emerging economies

largely testified to this notion though some discrepancies were found but were later rationalized using Taylor's hypothesis.

Pass-through analysis for emerging economies raised fresh new hypotheses that required further examination and this warranted the need for high-quality long-run time series data which posed a serious challenge in these economies (Aron et al., 2014). Thus, the methodological apparatus that was so well-suited for samples using data from advanced economies could not be simply 'extended' to emerging economies. Innovations in econometric methodologies were needed that could handle the data constraints in emerging economies while allowing robust inferences. There are different methods that have been employed across studies that use different samples with heterogeneous data sources. While there can be different ways of categorizing these methods, the framework of Aron et al. (2014) can be useful at this point. Econometric methodologies in the import price pass-through analysis can be categorized into two major approaches: the first is the methods that use the single equation models where an import price function can be estimated through the new open economy macro models, such as the one found in Obstfeld (2002), or from partial adjustment models such as the one used in Webber (1999), or perhaps from reduced form equations of a simultaneous equation system such as the one proposed by Goldberg and Hellerstein (2008). These methods have proven to be powerful tools in exploring the nature of pass-through to trade prices while maintaining parsimony of variables, data, and econometric inferences. A key advantage of these methods is their ability to handle several nested hypotheses on the factors affecting the pass-through relationship while being suitable for samples with lower degrees of freedom. The fundamental feature of these models is that they "are based on reduced-form regressions from a partial equilibrium model" (Aron et al., 2014, pp. 121), and treat the changes in exchange rate variables as exogenous shocks. A major limitation of this approach is that structural breaks or changes including regime shifts can cause challenges in estimation and thus it is necessary to establish if such issues exist before estimation, and if they do, appropriate treatment should be adopted to avoid specification errors. Another concern with this method is that it warrants the use of stationary variables which implies differencing and possible loss of long-run information.

Given the concerns with the first set of methods, the second approach has emerged to estimating pass-through which is broadly termed as the systems approach which, in the context of import price pass-through, includes the VAR approaches and the DSGE models in the tradition of the new open economy approach to pass-through analysis. VAR models are capable

of tracing the dynamic path of import prices following an exogenous shock in the exchange rate and can also handle the feedback effects. VECM approach is another frequently employed approach and these methods have provided may useful insights into the dynamics of import price behavior regarding exchange rate variations. Rajan and Yanamandra (2015) are an application of these methods in the Indian context during recent times. The DSGE model has not been explored actively in the area of import price pass-through in India but has been applied in several studies focusing on the pass-through to domestic inflation. Systems methods are capable of handling the endogeneity of exchange rate shocks which is not feasible with the single equation approach. However, one needs to justify theoretically in advance if the observed exchange rate variations are purely exogenous or emerge from the pass-through process itself. Such concerns, it seems, are generally not examined before the time-series methods are employed in the pass-through analysis. An important advantage of the single equation models is their ability to accommodate varying theoretical models of pass-through mechanisms, thereby allowing structural estimation of the pass-through coefficient.

Given this brief background, the methodological choices in this study are driven by the following concerns: first, data constraints are a serious concern as far as the import price variable is concerned. As explained earlier, the variable used in proxying import prices is the Import Unit Value index whose data on monthly basis is available only from April 2013 onwards. The old Fisher index based on the year 1999-2000 is unavailable from the Directorate General of Commercial Intelligence and Statistics (DGCIS). Thus, one is faced with two choices: the first is to opt for the Import Price Index of the International Monetary Fund (IMF), or the second is to center the analysis on Annual data for which consistent and continuous time series on import unit value index are available. The data of the import price index for India by the IMF are problematic as their coverage, weighting pattern and construction methodology do not seem to represent the imports market of India and thus could provide a biased picture of the price variations in aggregate imports if used in pass-through estimation[42]. Thus, the decision was made to examine pass-through issues in the domain of annual data to incorporate continuous, consistent, and reliable time series information. However, the issue of short-run versus long-run pass-through necessitates monthly data as the definition of short and long runs have largely been captured in terms of months needed for the complete pass-over of exchange rate shocks into the aggregate import prices in local currency. Thus, the use of annual data implies that the instantaneous impact of exchange rate variations on import price inflation may very well be a composite coefficient incorporating the short-run impact, conceptualized as the

coefficient in the first month, and the long-run impact, conceptualized by the coefficients from the second to the twelfth month. It is difficult to rationalize the pass-through effects beyond the twelve-month horizon and literature too has not been able to find much evidence of a strong degree of import price pass-through after twelve months have passed since the exchange rate shock. Thus, the current period pass-through coefficient in the estimations to be examined shortly, should correctly be interpreted as a composite pass-through coefficient incorporating both the immediate and lagged response of import prices to exchange rate changes.

Hence, this study employs a single equation approach by incorporating the features of the ERPT process in a partial equilibrium reduced form approach derived from the pricing behavior of foreign countries supplying India's bulk of imports within the mark-up model for a small open economy. As documented earlier, the theoretical framework adopted in this study can be traced to the seminal works of Dornbusch (1987), Campa and Goldberg (2005), Bussiere (2013), Rajan and Yanamandra (2013), and Aron et al. (2014). Firstly, the estimation of the import price pass-through coefficient is undertaken using the baseline model as delineated in the previous sections. Each of the variables in the baseline model emerges from the underlying macroeconomic model developed earlier. Due care is taken to specify the model as parsimoniously as feasible. The estimation of the baseline model is undertaken using a partial equilibrium framework with Ordinary Least Squares (OLS) after duly ensuring that the time-series information is suitable for being captured via the OLS route. The strength of this econometric framework is its simplicity and ability for direct economic interpretation of the coefficients. The baseline model represents the core structure of the pass-through mechanism that is tested in this chapter. The primary concern is with how costs, mark-ups, and exchange rates together shape the import price function and how the import price pass-through coefficient has behaved during the sample period. The disaggregated feedback mechanisms that might be at work are presumed under the ceteris paribus condition. This is inevitable given that the fundamental concern of this chapter is to capture the aggregate relationships between different prices. The baseline model provides the basis for further estimations and all other estimations are specified around this baseline equation and are reported in section 5.1.

After estimating the import price pass-through coefficient in the baseline model, the analysis is expanded to account for additional macroeconomic variables that are strongly considered as possible determinants of the import price inflation itself. Incorporating these factors into the import price function helps to examine the pass-through coefficient while controlling for additional variables and thus the estimate of the pass-through coefficient is

further refined. Key hypotheses on the determinants of import price inflation are tested in this expanded model reported in section 5.2. The analysis is undertaken within the partial adjustment framework on the lines developed by Koyck (1954) and Nerlove (1958). The lagged impact of import prices, the dependent variable, is incorporated into the baseline model with additional factors other than the factors accounted for in the baseline model. A stock adjustment, or the partial adjustment model, postulates a long-run equilibrium relationship and derives its short-run counterpart by allowing the dependent variable to adjust to its past values, which is generally presumed to be incomplete due to nominal or real rigidities, "inertia, contractual obligations" (Gujarati and Porter, 2008, pp. 632), including contractual rigidities in the price setting due to menu costs, switching costs or other such factors. The advantage of the partial adjustment model is its ability to account for adaptive expectations in the determination of import price inflation and its ability to provide estimates for both the short-run and the long-run impacts of exchange rate variations on import price inflation. This is undertaken in section 5.2.

After undertaking the estimation of the determinants of import price inflation while refining the estimate of the pass-through coefficient, the issue of the factors shaping the behavior of the import price pass-through coefficient is examined. There are at least three approaches to this matter. The first approach is to estimate a time-varying coefficient of pass-through using methods such as the Kalman filter, a Time-Varying VAR model, or a linear Time-Varying Coefficient model such as the one adopted in this chapter later on. This time-varying coefficient can serve as a dependent variable to capture the variables that may impact the pass-through coefficient in an OLS framework.

The second approach to this issue is to employ interaction terms between the exchange rate and the possible determinants of the pass-through coefficient itself. One can locate this approach in Goldfajn and Werlang (2000), and in the Indian context in Patra et al. (2018) in recent times. The idea behind using interaction terms in the import price function itself is that the coefficient of the interaction terms would reflect the extent to which the additional information of the determinant factor inflates or deflates the impact of exchange rate variations on import prices. While pass-through is defined in terms of the unilateral effects of exchange rate variables on import prices within the import price function, an interaction term would imply the extent to which the interacting factor can increase or decrease the impact of exchange rate on import prices. A high and positive coefficient would imply that the factor being interacted with the exchange rate is enabling a larger pass-through of exchange rate changes to

import prices and in case of a high but negative coefficient, vice versa. The coefficients of the interaction terms may be interpreted as modified ERPT coefficients which signify the combined impact of the exchange rate and the hypothesized determinant rather than the unilateral impact of the exchange rate on import prices.

The third approach possible in this regard is to build a dependent variable through the ratio of import price changes to exchange rate changes and utilize it to model the possible determinants of the ERPT coefficient. Put simply, the ERPT coefficient is defined as the average effect of exchange rate variations on import prices without controlling for other possible intermediating factors. Theoretically, pass-through is an elasticity coefficient derived after the impact of other intermediating factors is controlled for within a regression framework. Using a simple ratio would bias the nature of the pass-through coefficient and such a variable ceases to be a coefficient in the first place. Hence, this chapter undertakes the analysis on this account by using both the first and the second approaches and is perhaps the first study to investigate the issue of import price pass-through at such an analytical depth[43]. Thus, in section 5.3, the relationship between exchange rate variations and various macroeconomic factors affecting the import price pass-through coefficient is investigated while expanding the scope of the models estimated in the previous sub-sections.

Lastly, a fundamental concern in the macroeconomic analysis is the temporal stability of the structural relationship hypothesized in a linear[44] model. A voluminous literature has emerged on this issue following the classic critique of aggregative macro models expounded by Lucas (1976) who criticized the "stable-parameter view" of macroeconometric research and raised the concern that the very causal relationships between aggregate variables being captured by econometric models may be time-variant, thereby causing the underlying relationship itself to shift across time. Such a 'changing-structure' view caused an uproar among macroeconomists and empirical studies began testing the Lucas Critique on different issues such as monetary policy, trade balance adjustments, growth models, and also the matter of ERPT. Macroeconomists have been very much open to the prescriptive implications of the Lucas Critique – a sound macroeconomic model must ensure that the structural parameters of the model are broadly stable across time so that the inferences can be applied to the entire sample period and possibly utilize the estimated model for forecasting (Goutsmedt et al., 2015). In other words, the identification of the true model must account for the temporal behavior of the underlying economic model (Sims, 1980). However, the empirical prescription that policy

changes can cause the true parameters to change following the policy change has been put to test and the evidence has been at best mixed (Linde, 2001).

The hypothesis of a time-variant versus a time-invariant ERPT coefficient is examined in this chapter by using a Time-Varying Coefficient (TVC) model that allows the estimation of a time-varying ERPT coefficient within the linear framework itself. The model is developed in the works of Schlicht (2020), Schlicht (2021), and thereafter in Schlicht (2022). There are several other approaches in this perspective, such as the use of the Kalman filtering technique as applied in Pizzinga (2012), other state-space models, non-linear time-varying models, Flexible Least Squares-based models such as the one proposed in Kalaba and Tesfatsion (1989) and the framework adopted in this study. Across all these approaches, the most suitable time-varying model should be able to accommodate a linearly specified model while posing lesser data requirements and more robust inferences.

A time-varying parametric model must estimate the time path of an economic relationship using the sample information by calibrating its expected behavior through some kind of iteration. Some approaches use bootstrapping, while others use recursive methods. The Schlicht (2021) framework estimates a 'method of moments' estimator within the state-space model where coefficients are presumed to be generated by a random walk process. The time-variant estimates for the coefficient of interest are estimated as conditional expectations of the coefficients given the sample data. Thereafter the time-average estimates of the coefficient for each point in time are estimated via the Generalised Least Squares (GLS) estimates of the corresponding regression with time-invariant coefficients. This method has various strengths against the other alternatives mentioned above. First, this approach does not warrant initial values for the initial state and the initial variances but estimates endogenously. This may be considered as its strength against the Kalman filter approach (Schlicht, 2021). Second, given that the estimates are based on the 'method of moments', the assumption of Gaussian disturbances is not imposed *a priori*. Third, this method allows the analyst to vary only one coefficient or multiple coefficients across time, thereby allowing the testing of a range of economic models where not all coefficients may be time-variant. Thus structural modeling of a wide variety of economic theories can be undertaken in this approach. Fourth, the fundamental property of this approach is the selection of estimates that minimize the sum of squared disturbances in the specified equation and a weighted sum of squared disturbances in the coefficients where the weights are estimated as the inverse of the variance ratios estimated

by the algorithm. This allows the algorithm to balance between the goodness of fit and parameter stability simultaneously.

The most important limitation of this approach is the assumption of the coefficients being generated by a random walk process and more general stochastic processes are not considered in this algorithm. However, the assumption of coefficients being generated by a random walk process may not be completely unrealistic with regards to the ERPT coefficient and this assumption can serve as a working assumption to derive the time-varying estimates rather than as a theoretical imposition on the underlying Data Generating Process (DGP). Moreover, the strengths of this approach far outweighs its limitation and thus this chapter employs the Schlicht (2021) time-varying coefficient approach to estimate the ERPT coefficient across the period 1991-92 to 2021-22. After estimating the same, the chapter examines the time-series properties of the estimated coefficient while comparing it to the alternative estimates which were arrived at by using a Rolling Regression approach. The rolling regression coefficient estimates are contrasted to the time-variant estimates of the ERPT coefficient and inferences are drawn on the nature of the pass-through process in India pertaining to import prices. The analysis is not constrained only to the estimation of the study of the stability of the pass-through coefficient but the determinants of the stability or instability in the pass-through coefficient as investigated by testing hypotheses that are supported by both the underlying theory and the literature. Thereafter, chapter four is concluded.

4.8. Empirical Analysis

This section provides the estimates of the ERPT coefficient derived from the aggregate import price function along with the determinants of the import price itself, the impact of the interactions between exchange rate and key macroeconomic variables on import prices, the estimation of time-varying ERPT to import prices and finally the determinants of the stability in the pass-through coefficient.

4.8.1. Estimation of the extent of import price pass-through

Equation 13 expresses the baseline model for estimating the extent of pass-through from exchange rate variations to import prices. All the variables are specified in log-difference form, which is not only standard practice in literature but also allows direct interpretation of the pass-through coefficient as an elasticity measure. Aggregate import price inflation is hypothesized to be determined by OILIND which represents the oil price inflation for the Indian crude basket

and is used for resenting the oil price shocks as well as the cost condition prevailing in the OPEC bloc which supplies almost 1/3rd of India's total imports.

$$\Delta InIPX = \beta_0 + \beta_1 \Delta InOILIND + \beta_2 \Delta InNEER + \beta_3 \Delta InWCPI + \beta_4 \Delta InRGDP + \beta_5 D_{GFC} + \varepsilon \quad \text{....(13)}$$

Note: ε is the error term.

Another motivation is to account for the oil price pass-through which can have adverse effects not only on import prices but on the larger trade balance adjustments via its unfavorable price impact. One of the channels in the oil price pass-through mechanism is the import channel (Bhanumurthy et al., 2012). This channel is captured by the coefficient of the oil price variable in this equation. Thereafter, NEER is included which represents the exchange rate variations[45]. WCPI in equation 13 represents both the cost conditions in the advanced economies including the OECD bloc following Yanamandra (2015), as well as the global inflation momentum which causes import prices to vary due to inflation differentials between the domestic inflation rate and the inflation rate in the foreign suppliers of India. It is also plausible to consider WCPI as a rough approximation of the mark-up variations in the pricing process set by the foreign suppliers under the assumption that India's imports market represents a small open economy with limited market power and price-taking behavior. Increasing inflation in the economies of foreign suppliers can cause the mark-ups to shrink following a cost shock that shifts the marginal cost of production upwards. Under such circumstances, the only way in which the mark-ups can persist at the earlier level is through a larger pass-through to the import prices in Indian currency. Thus, WCPI can capture three dimensions – first, it can explain the cost conditions in the OECD bloc; second, it can explain the effects of global competitive pressure on Indian import prices (Menon, 1995); and third, it can represent the mark-up variations caused by changes in the global competitive pressure, particularly in the economies supplying India's imports (Dash and Narasimhan, 2011).

It is well-established in the literature that the mark-up is a function of the real exchange rate and other macro-variables (Aron et al., 2014). Hence, the variable RGDP is taken into account to represent two important factors that can affect import price behavior at the aggregate level. Firstly, aggregate real GDP represents the level of domestic demand conditions in the economy which is expected to positively impact import prices as increased domestic income can shift the imports demand upwards, causing the import prices to rise. However, underlying this presumption is the belief that the substitutability between domestic production and imports

is low, and thus at least some portion of the increased domestic aggregate demand would shift towards imports, causing its demand to rise. This approach can also be located in Khundrakpam (2007), Khundrakpam (2008), Dash and Narasimham (2011), Junttila and Korhonen (2012), Rajan and Yanamandra (2015), and Forbes et al. (2018), among some others. Moreover, the domestic demand pressure represented by RGDP can itself explain the mark-up variations as higher demand locally could allow the foreign firms exporting to India, to increase their mark-ups over the marginal cost due to robust demand conditions locally (Menon, 1995; Dash and Narasimham, 2011). Thus, RGDP is expected to put upwards pressure on import prices both directly by increasing the demand pressure and indirectly by allowing the exporting countries to expand their mark-ups on account of buoyant demand conditions[46].

Lastly, the baseline model accounts for the impact of the 2008 GFC on the import price behavior to account for the possible implications of the financial crisis for the aggregate import price inflation in India. The mechanism through which the financial crisis has impacted India's import prices is contained in Khundrakpam (2008), and Patra et al. (2018) among others. The financial crisis brought a substantial slowdown in global trade, thereby impacting the import demand in India negatively. Given this background, it is expected that the 2008 crisis has negatively affected India's import prices by contracting the domestic output and thereby the demand for imports. This hypothesis is also put to test within the baseline model itself. Furthermore, evidence has been found for the year 2008 and its neighborhood years as causing structural breaks in several variables included in this chapter as shown in Table 4.3. Furthermore, the pass-through coefficient itself may have undergone a structural shift since the 2008 GFC (Patra et al., 2018). Thus, accounting for the impact of a financial crisis helps to handle these issues while allowing the pass-through coefficient to be estimated after removing the direct impact of the crisis on import prices. In this sense, the estimated pass-through coefficient in the baseline model represents the pure impact of exchange rate variations on import prices without the interference of other macroeconomic determinants of import prices.

Given the analytical underpinnings of the baseline model presented above, table 4.6 presents the expected signs of the coefficients as narrated above. OILIND is expected to impact the import prices positively given that it represents the cost conditions of the OPEC nations and also represents a large bulk of India's aggregate imports. Increased oil price inflation represents the worsening cost conditions of the oil exporting bloc. It is assumed that the increase in oil price emerges from the cost build-up in the oil-exporting nations and given that India is a price-taker against the OPEC bloc, the adverse cost conditions are passed over into

India's import prices so that the mark-ups of the oil sellers are maintained constant[47]. It also seems that the oil-exporting nations largely utilize non-rupee currencies in invoicing their contracts whereby they display PCP behavior, thus justifying the positive expected sign of this coefficient. Furthermore, oil price inflation can have a price impact in terms of an increase in the aggregate import prices of India while also possibly inducing a negative quantity impact in the form of lowering oil imports. The Indian economy has a large dependency on crude oil and due to the continuously expanding real economy, the trend in oil demand has been on the rise, thereby causing the price impact of oil price inflation to overpower its quantity impact. Hence, the expected sign is positive on this variable.

Table 4.6: Expected behavior of the coefficients from Equation 13

Sr. No.	Variable	Expected Sign
1	ΔInOILIND	+
2	ΔInNEER	-
3	ΔInWCPI	+
4	ΔInRGDP	+
5	D_{GFC}	-

NEER is expected to impact import prices negatively given that it is defined in terms of the number of foreign currency units per Indian rupee. The negative sign implies that the pass-through effect of the exchange rate on import price inflation is expected to behave as per the theory of ERPT. Depreciation in NEER is expected to increase import price inflation while appreciation is expected to reduce it. The extent to which this happens will be revealed by the empirical estimates reported hereafter[48]. WCPI is expected to impact the aggregate import prices of India positively, implying that the advanced economies tend to pass over the increased cost pressures in their country to Indian import prices to avoid affecting their mark-ups from contracting. Thus, a positive sign of OILIND and WCPI would imply PCP behavior while a negative sign would be theoretically perverse as it would indicate that in the wake of worsening cost conditions in the exporting nations, their mark-ups absorb the increased costs more than proportionally by further reducing the prices of their commodities for Indian consumers. Highly variable mark-up, such as in this case, implies that India is not a price-taker in the global commodity markets which violates the actual nature of India's import sector as examined in section 4.2.

RGDP is expected to impact import prices positively given that it allows increases in the mark-ups of import suppliers of India given the robust domestic demand and also because

increased aggregate income at home implies increased demand for imports. Thus, both the price and quantity channels through which domestic expansion can impact imports are accounted for through this variable. Lastly, the Dummy variable signifying the impact of the 2008 GFC is expected to impact import prices negatively. It may affect import prices negatively implying that the financial crisis caused a fall in import price inflation. The rationale for this belief has already been explained above.

Table 4.7 presents the estimated model specified in equation 13. The signs of all the coefficients except RGDP are as per the prior theoretical expectations indicating that the model depicts the true underlying process fairly well. The oil price pass-through via the import price channel is positive at the value 0.29 and implies that oil prices tend to build inflationary momentum in aggregate import prices. The extent of pass-through is, however, less than unity implying that either the pass-over from the OPEC nations is incomplete or perhaps, the Government is undertaking some form of absorption to normalize the oil prices in the domestic markets. It is well-known that oil prices feed into food prices and the oil-food price nexus can cause an inflation spiral which the Government would try its best to avoid. Furthermore, the oil exporting countries are practicing PCP behavior by passing over the oil price variations to India's import prices. The extent of this behavior is however limited and perhaps the oil importing firms in India could be bearing the brunt of the oil price pass-through. WCPI also shows the expected sign and its coefficient is estimated to be 0.17 which implies that advanced economies are possibly passing over their domestic cost pressures to Indian buyers, though the extent of this is incomplete. This is understandable as the OECD economies tend to practice PTM behavior and not all of the cost pressure may be passed into a single market. They might be distributing the increased costs to different markets depending on their underlying objectives for each of the markets. DUM shows the expected sign but is significant at the 12% level. While being significant at the borderline, the negative sign confirms the hypothesis that the GFC contracted global trade flows while also causing a contraction of Indian import demand which could explain the negative coefficient.

Table 4.7: Empirical estimates of import price pass-through in India based on Equation 13

The dependent variable is ΔInIPX					
Variable	**Coefficient Value**	**Standard Error**	**t-ratio**	**Expected Sign**	**Actual Sign**
Intercept	0.09**	0.045	2.078	NA	+
ΔInOILIND	0.29***	0.101	2.908	+	+
ΔInNEER	-1.25***	0.375	-3.340	-	-
ΔInWCPI	0.17**	0.074	2.366	+	+
ΔInRGDP	-1.04	0.704	-1.473	+	-
D_{GFC}	-0.20#	0.124	-1.623	-	-
R^2	0.63	***F-statistic***	8.13***	***D-W statistic***	1.60

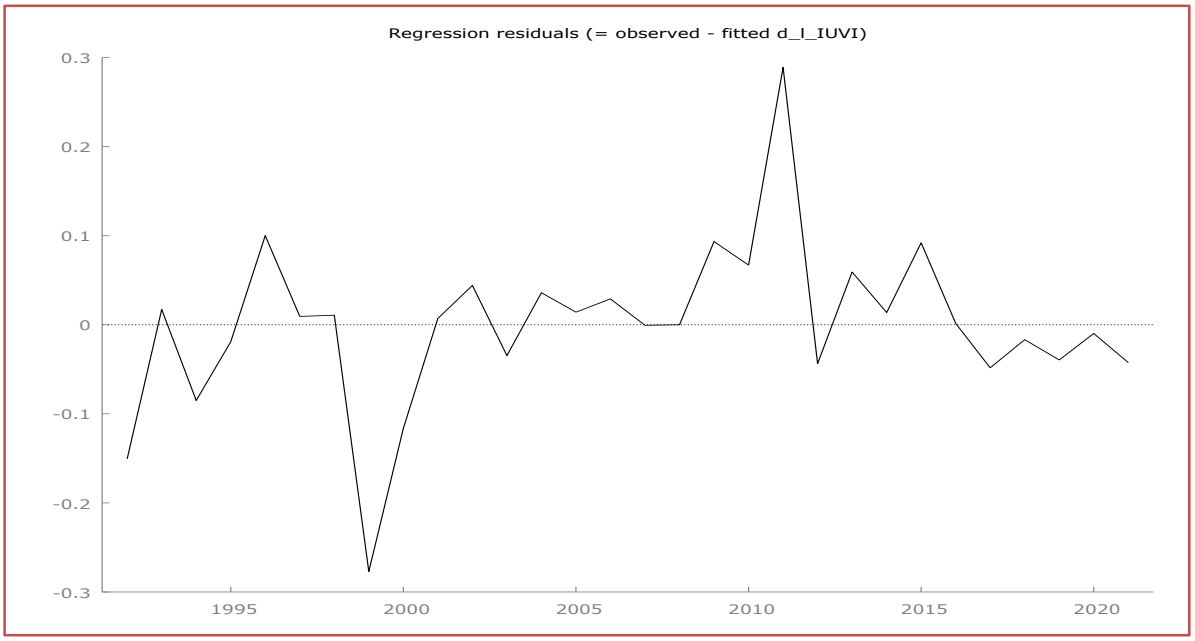
Notes: 1. ***, **, and * indicate that the given estimate is statistically significant at 1%, 5%, and 10% levels of significance respectively; 2. # indicates significance at 12% level; 3. The number of observations is 30; 4. Data are in annual terms. **Source**: Author's estimation.

Of special interest is the ERPT coefficient captured by the coefficient of NEER which is estimated at -1.25 indicating that a 1 percentage point depreciation in NEER causes a 1.25 percentage point increase in the aggregate import price inflation. Put differently, a 1 percent depreciation is inducing a 1.25% increase in import price inflation[49]. The pass-through is more-than-complete and corroborates the hypothesis that as a buyer, India is largely a price-taker in the global commodity markets. These findings, i.e. of more-than-proportional reaction of import price inflation to exchange rate variations in consistent with the findings in the literature on the Indian context such as in Pyne and Roy (2008), Yanamandra (2015), and Rajan and Yanamandra (2015) to quote the few studies that have investigated the issue of pass-through to import prices in India at the aggregate level. These studies have employed the single equation as well as systems approaches and have concluded larger-than-proportional pass-through to Indian import prices. While the direction of the pass-through is consistent with the expectations, the extent of the pass-through requires further exploration. What is the mechanism behind this empirical finding? Why does import price inflation react more than proportionately to exchange rate shocks? Is exchange rate overshooting possibly responsible for this? Or is it that the feedback effects from import prices to exchange rate is causing this 'overshooting' pass-through? One possible reason for this observation may be that the baseline model needs to incorporate larger information on the determinants of import price inflation, after which the pass-through coefficient may reduce. The baseline model is thus improved upon in the next section. Lastly, the negative sign of RGDP may be indicative of increasing import substitution along with an expanding economy thereby causing lower demand pressure on imports and thus perhaps causing a reduction in import price inflation[50]. Successive Indian Governments have stressed improving domestic production capabilities, though with different

degrees of seriousness. Perchance, this may explain the negative sign of the coefficient of RGDP.

From an econometric point of view, the model shows a fairly good fit in terms of R^2 being 0.63 and the model as a whole is also statistically significant given the value and significance of the F-statistic. The model was tested for multicollinearity through Variance Inflation Factors, and for autocorrelation using the Breusch-Godfrey test. In both cases, there was no evidence of these problems in the estimated mode while the DW-statistic also provided inconclusive results, indicating a lack of evidence on the existence of either positive or negative autocorrelation. The time series plot of residuals estimated from equation 13 is presented in Figure 4.4. The residuals seem to be mean-reverting and there does not seem to be any systematic pattern in the temporal behavior of the residuals.

Figure 4.8: Time series plot of residuals estimated from equation 13



Source: Author's estimation.

The estimated model above is then tested for heteroskedasticity using White's test for heteroskedasticity and the evidence implied that there might be considerable scope for incorporating more information into the baseline model. This motivates the empirical estimations in the next section.

4.8.2. Determinants of the import price variations

Import price inflation can emerge from factors beyond those captured by the baseline model reported in the previous section. The factors included in the earlier model represent the

fundamental building blocks of import price behavior but there exist additional issues that need to be accounted for to explain the import price variations more coherently. The literature on import price pass-through in the Indian context has confined itself to a bare minimum framework accounting for the traditional factors already incorporated into the baseline model reported earlier. However, there remain several issues that have been unexplored in the Indian context concerning the determinants of import price inflation. It is necessary to understand the mechanics of import price behavior well before contextualizing ERPT to import prices. The pass-through relationship emerges from the import price function itself; hence, theoretical improvements in the import price function can allow refinement of the pass-through estimate itself as a larger set of information is controlled within the ceteris-paribus condition. Consequently, this section moves beyond the traditional model of import price inflation which encompasses factors limited to the costs and mark-up components of equation six, and tests additional hypotheses about which macro factors could be playing a meaningful role in shaping the import price inflation itself.

As discussed in section 4.7, the analysis of the determinants for import price inflation is undertaken within the Partial Adjustment model on the lines of Koyck (1954) and Nerlove (1958). The fundamental motivation for the Koyck model was to handle the econometric issues in estimating the distributed lag model. These consisted of the determination of correct lag length, the issue of autocorrelation, and multicollinearity between lagged values of the same variable employed in the distributed lag model (Klein, 1958). To cut across these problems while maintaining the economic intuition behind the distributed lag models, Koyck (1954) provided a framework that assumed geometrically declining coefficients of the lagged variables and allowed the reduction of the infinite lag model into a model with only three unknowns – namely the coefficient of the current value of the regressor, the coefficient associated with the lagged value of the dependent variable and the adjustment coefficient of the error term. Nerlove (1958) expanded the Koyck model of partial adjustment and incorporated the adjustment of the dependent variable to its lagged value while allowing the estimation of both the immediate and the long-run coefficients associated with the regressors in the distributed lag model. This model allows a slow and gradual adjustment in the relationships being tested within the distributed lag framework and thus derives its name from the 'partial adjustment' model (Gujarati and Porter, 2008). Empirically, it is possible to estimate the short-run and the long-run adjustments in import price inflation to exchange rate shocks under this framework. This is possibly the

first study to have expanded the analysis of import price pass-through to factors beyond what has been largely employed in the literature while adopting the partial adjustment approach.

Four additional hypotheses are embodied in the specification of the determinants of import price inflation as depicted in equation 14. Expanding the basic model, the role of domestic inflation, inflation volatility, exchange rate volatility, and trade openness are examined in the expanded model. The literature on ERPT to domestic prices, the so-called complete pass-through, has accounted for several of these factors. However, it is yet to be debated if these factors are equally important in the determination of import price inflation itself. The prevailing inflationary environment in the country can feed back into the import prices through various channels. First, higher inflationary momentum can cause the pass-through of exchange rate changes to import prices to rise, given that local price adjustment is rapid and such an environment indicates higher tolerance of inflationary pressures by the monetary policy (Devereux and Yetman, 2010). Secondly, higher domestic prices may result in increased cost of production for Indian exporters who might be exporting important capital inputs such as metals, industrial chemicals, important components of automobiles and other industries, and other such commodities. The increased prices of these exported inputs to foreign sellers may result in increased costs for them, resulting in increased prices for Indian importers to cover the additional costs while maintaining the mark-ups constant. Thirdly, higher inflation at home can motivate foreign suppliers in varying their mark-ups upwards to capture larger profits given that under an inflationary environment, the tolerance to higher prices is prevailing and possibly the price elasticity of demand for imports may be low. Under these circumstances, it is probable that increased domestic prices would feed back into the import prices. However, the relationship between import prices and domestic prices should ideally be construed in lagged form; i.e. the lagged value of consumer prices should be linked with the current period value of import prices[51]. One may hypothesize current period import prices and domestic prices to be linked while recognizing that there may be a more dynamic two-way relationship between them and the single equation approach may not directly account for these feedback effects. Hence, separately examining them as regressors in the other price function within a single equation framework may be justified.

The inflationary environment also incorporates information on the volatility in prices which can induce uncertainties for foreign firms supplying the imports of the country Aron et al., 2014; Lopez-Villavicencio and Mignon, 2016). Increased uncertainty in the price environment can also induce cost uncertainties for foreign suppliers who may then be forced

to practice a larger degree of PCP and consequently pass over larger exchange rate variations to import prices. Independently of pass-through via the exchange rate, increased volatility of local prices could cross the threshold levels of tolerable menu costs and thus force the foreign firms to change the import prices in destination (local) currency causing import price inflation in India. Inflation volatility is also linked with the monetary policy stance (Taylor, 2000; Choudhri and Hakura, 2006; Balcilar et al., 2019). Higher volatility may indicate an accommodative monetary policy and foreign firms may see a larger scope in increasing the prices to expand their markups. Such changes in import prices are independent of the ERPT and rather emerge from factors other than exchange rate variations. Subsequently, the volatility in consumer price inflation is incorporated into this model.

Another volatility that can contribute to inflation in trade prices is exchange rate volatility. While the relationship between exchange rate volatility and import price pass-through from exchange rate changes has been debated in the Indian literature, whether exchange rate volatility can directly impact import price inflation is a matter not addressed satisfactorily so far. This matter is raised in the current section by incorporating the volatility of NEER into the import price function. The underlying idea is that higher volatility of exchange rates can result in an increased shift from the rupee to non-rupee currencies as the preferred invoicing currency. As more exporting firms shift to other currencies, naturally the negative exogenous shocks to the costs or mark-ups, independent of the exchange rate shock, could be passed over into India's import prices. This can explain one of the possible linkages between exchange rate volatility and import prices. Exchange rate volatility is one of the most important macroeconomic factors explaining the pass-through mechanism (Bussiere and Peltonen, 2008; Mendali and Das, 2017). However, the literature in the Indian context has confined the use of this variable for investigating the pass-through dynamics for domestic prices. This chapter extends this variable to explain the import price behavior itself through the volatility in the exchange rate. It is expected that the coefficient of this variable will be positive, indicating that increased volatility causes increased inflationary pressure on import prices, conceivably by increasing the degree of PCP among foreign exporters or perhaps by exogenous cost shocks or mark-up shocks that are passed over to Indian buyers to avoid the further negative impact of adverse exchange rate movements. Indeed, "if exogenous shocks to import prices are persistent, exporting firms are more likely to change prices… in response to exchange rate changes" (Junttila and Korhonen, 2012, pp. 90) thereby causing further inflationary pressure on import prices.

Lastly, the role of real trade openness is taken into account through RTOPEN. Increased trade openness lends the domestic economy much more exposure to external shocks, which may or may not emerge from exchange rate shocks. Increased openness in the importing nation can induce variations in the markups of exporting firms (Junttila and Korhonen, 2012) thereby inviting larger effects of cost, markup, or other shocks to the import prices. Increased openness also implies increased participation in international trade and possibly higher import demand due to dependency on foreign goods over time. Increased openness can thus increase the demand for imports and put upward pressure on import prices. It is thus possible that domestic shocks can translate into import price inflation and such dimensions are captured by the RTOPEN variable. It is expected that openness will impact import price inflation positively, indicating that higher trade dependency and integration can lead to higher inflationary pressure on trade prices that may emerge from both domestic and external shocks. Finally, the partial adjustment term, i.e. the lagged value of import price inflation itself, is expected to reduce the inflationary pressure in future periods by hopefully stabilizing the import prices to their long-run path. The proposed theoretical structure on this matter is captured by equation 14.

$$\begin{aligned}\Delta InIPX = {} & \beta_0 + \beta_1 \Delta InOILIND + \beta_2 \Delta InNEER + \beta_3 \Delta InWCPI + \beta_4 \Delta InRGDP \\ & + \beta_5 D_{GFC} + \beta_6 \Delta InCINF^{52} + \beta_7\, InCINF_{SD} + \beta_8\, InNEER_{SD} \\ & + \beta_9\, InRTOPEN_{t-1} + \beta_{10} \Delta InIPX_{t-1} + \varepsilon \qquad \text{...(14)}\end{aligned}$$

The variables used in equation 14 are in log-difference form to ensure both stationarity as well as avoid variables with structural breaks. The partial adjustment mechanism is captured by the β_{10}. The value of this coefficient will help to estimate the long-run impact of exchange rate variations on import prices. The estimated model is reported in Table 4.8.

Table 4.8: Empirical estimates of import price pass-through in India based on Equation 14

The dependent variable is ΔInIPX					
Variable	**Coefficient Value**	**Standard Error**	**t-ratio**	**Expected Sign**	**Actual Sign**
Intercept	-0.52**	0.182	-2.862	NA	
ΔInOILIND	0.23***	0.071	3.217	+	+
ΔInNEER	-1.21***	0.395	-3.070	-	-
ΔInWCPI	0.22***	0.050	4.478	+	+
ΔInRGDP	-2.57**	0.965	-2.661	+	-
D_{GFC}	-0.39***	0.095	-4.068	-	-
ΔInCINF	0.99	0.741	1.340	+/-	+
$InCINF_{SD}$	-0.08**	0.030	-2.728	+/-	-

Table 4.8 *(continued)*					
$InNEER_{SD}$	0.11**	0.049	2.236	+	+
$InRTOPEN_{t-1}$	0.16***	0.048	3.256	+	+
$\Delta InIPX_{t-1}$	-0.18*	0.098	-1.800	-	-
R^2	0.90			***F-statistic***	13.57***

Notes: 1. ***, **, and * indicate that the given estimate is statistically significant at 1%, 5%, and 10% levels of significance respectively; 2. # indicates significance at 12% level; 3. The number of observations is 30; 4. Data are in annual terms. 5. The period of analysis in this model is from 1994-95 to 2019-20 due to data constraints. 6. The Lagrange Multiplier (LM) test was performed to check for autocorrelation up to 5 lags and the null hypothesis of 'no autocorrelation' could not be rejected even at a 10% level. **Source**: Author's estimation.

Prima-facie, the results from the estimated model in Table 4.8 look excellent, given the highly significant overall model and high goodness of fit which is estimated at 90 percent. The signs of the additional hypotheses examined in this model are broad as expected. Firstly, it is clear that the level of domestic inflation does not play any significant role in the determination of import price inflation. This is evident from the statistically insignificant coefficient of CINF. Inflationary momentum as captured by the level of inflation may not be a major factor in the pricing decisions of foreign exporting firms and thus it has not shown any meaningful impact whatsoever. The Indian economy has generally experienced inflation which is mean-reverting and is generally well-anchored to a credible monetary policy. This may be the reason why the inflation rate in India is not having an impact on import price inflation, which was tested both in the current period and lagged terms.

Interestingly, inflation volatility has a slight but statistically significant negative impact on import price inflation as depicted by the coefficient of $CINF_{SD}$. While the coefficient is statistically significant, its magnitude is very small and this could imply that the role of inflation volatility is much more prevalent in explaining the empirical extent of ERPT to import prices rather than explaining the import prices themselves. The negative sign of the coefficient indicates that higher inflation volatility is inducing a fall in import prices. If foreign exporting firms are maintaining market shares and are engaged in active competition with other international players and if there exists higher substitutability with domestic output, then increased volatility in inflation may provide an opportunity to expand their presence in the domestic market. From a strategic competitive pricing perspective, during higher inflation volatility, foreign firms are expected to increase their prices in destination currency as uncertainties are higher and volatility may have crossed the tolerable level of menu costs. However, market share-maximizing firms may rather absorb these increased uncertainties and further reduce prices to maintain or expand their presence in the Indian market. It is a well-

accepted fact that the Indian market is a large and booming opportunity for international players given the freedom given by the Government to foreign players engaging in trade with Indian consumers and producers. Naturally, there may be a tendency to push further into the market by aggressive price competition with domestic competitors and perhaps with other international players in India. This could explain the negative sign of the inflation volatility variable.

Exchange rate volatility seems to have behaved as expected with the positive and significant sign of the coefficient of $NEER_{SD}$. While small in magnitude, it indicates that the belief of exchange rate uncertainty increasing inflationary pressure on import prices holds true in the Indian context after the reforms were initiated. Exporting nations seem to be indulging in PCP behavior and thus are letting import prices in Indian currency rise in the wake of an increase in variability of the exchange rate. Trade openness[53] shows the expected behavior and the hypothesis that higher openness renders import prices more exposed to external shocks and possibly even domestic shocks seem defensible.

Finally, the partial adjustment coefficient has shown the expected behavior, indicating that the import prices tend to revert to their theoretically true level in the long run. Given the value of the partial adjustment coefficient, the long-run dynamics of the ERPT can be worked out using the framework developed by Koyck (1954) and extended by Nerlove (1958). Consequently, the long-run pass-through coefficient is worked out by dividing the short-run coefficient which is -1.21 by the adjustment parameter value which is worked out to be 1.18[54]. The long-run impact of exchange rate variations on the import price inflation rate is worked out to be -1.02 which indicates complete pass-through[55]. The finding of the complete pass-through, in the long run, is largely consistent with the evidence in the Indian context, even in recent times such as in Suryavanshi (2022) who finds a high but partial pass-through across the pricing chain in India. The estimated model was tested for heteroskedasticity, autocorrelation, multicollinearity, and normality of the residuals. The results of these tests indicated that none of these issues were distorting the estimated results. The residuals from the estimated model in Table 4.8 are reported in Figure 4.5. The residuals behave as expected and show a mean-reverting tendency. It is evident that the estimated model captures the major dimensions of import price behavior coherently and that most of the theoretically necessary information is incorporated into the model.

Figure 4.9: Residuals from the estimated equation for the determinants of import price inflation

Note: d_l_IUVI is the log difference of the IPX variable. Residuals are obtained from the estimated equation in Table 4.7. **Source**: Author's estimation.

The above estimation incorporated inflation and its volatility in terms of their current period relationship. Theoretically, the ERPT relationship presumes import price variations as the transmission channel for exchange rate changes to impact domestic inflation. Hence, strictly from the perspective of economic theory, it is implausible to hypothesize current-period domestic inflation as a determinant of current-period import price inflation which could be against the nature of causality embodied in the ERPT process. Hence, such a specification may cause mistaking a determinant of domestic inflation variations, which is the import price variable in this context, as a factor being determined by domestic inflation. Specification error may be committed in this case and thus, this model is modified by also estimating it while incorporating the lagged term of the level of domestic inflation and also the lagged term of inflation volatility, which is presented in Table 4.9.

Table 4.9: Alternative empirical specification of import price pass-through in India based on Equation 14

The dependent variable is ΔlnIPX					
Variable	**Coefficient Value**	**Standard Error**	**t-ratio**	**Expected Sign**	**Actual Sign**
Intercept	-0.54**	0.193	-2.774	NA	
ΔlnOILIND	0.21**	0.076	2.717	+	+
ΔlnNEER	-1.76***	0.385	-4.563	-	-
ΔlnWCPI	0.25***	0.054	4.515	+	+
ΔlnRGDP	-3.27***	1.095	-2.988	+	-
D_{GFC}	-0.53***	0.107	-4.926	+/-	-
$\Delta lnCINF_{t-1}$	0.46	0.803	0.570	+/-	+
$lnCINF_{SD(t-1)}$	-0.08*	0.040	-2.074	+/-	-

Table 4.9 *(continued)*					
$InNEER_{SD}$	0.12**	0.054	2.268	+	+
$InRTOPEN_{t-1}$	0.18***	0.053	3.444	+	+
$\Delta InIPX_{t-1}$	-0.32**	0.125	-2.516	-	-
R^2	0.89			*F-statistic*	11.70***

Notes: 1. ***, **, and * indicate that the given estimate is statistically significant at 1%, 5%, and 10% levels of significance respectively; 2. # indicates significance at 12% level; 3. The number of observations is 30; 4. Data are in annual terms. **Source**: Author's estimation.

The estimated model in Table 4.9 reflects the fact that irrespective of whether the measures of the inflation environment are linked in the current period or lagged terms with aggregate import price, the dynamics at play remain the same, and the determinants of import price inflation as hypothesized in this chapter remain coherent. The next section investigates the issue of what factors may shape the interactions between exchange rate and import prices and thus allow testing the well-established hypotheses on the determinants of ERPT in India.

4.8.3. Interactions between import price variations and exchange rate changes, and the issue of ERPT

After having examined the nature of pass-through from exchange rate to import prices in section 5.1 and the determinants of import price inflation in section 5.2, this section reflects upon the issue of how import prices are affected by the cross-interactions between exchange rate and the hypothesized determinants of ERPT to import prices. The approach adopted in this section emanates from Goldfajn and Werlang (2000) who examined the determinants of the import price pass-through coefficient by using interaction terms between exchange rate and key macroeconomic variables such as inflation level, its volatility, trade openness, and other. To date, such an approach has not been utilized in the Indian context to examine the nature of import price pass-through for the entire post-reforms period[56]. Equation 15 shows the theoretical model proposed in this section.

$$\Delta InIPX = \beta_0 + \beta_1 \Delta InOILIND + \beta_2 \Delta InNEER + \beta_3 \Delta InWCPI + \beta_4 \Delta InRGDP + \beta_5 D_{GFC} + \beta_6 \Delta InCINF^{57} + \beta_7 InCINF_{SD} + \beta_8 InNEER_{SD} + \beta_9 InRTOPEN_{t-1} + \beta_{10} EINF_{t-1} + \beta_{11} EINVOL + \beta_{12} EEVOL + \beta_{13} EOPEN + \varepsilon \quad ....(15)$$

The model contained in equation 15 is an extension of equation fourteen with four additional regressors that capture the key factors shaping the behavior of import price pass-through itself[58]. Variable $EINF_{t-1}$ is defined as the product of the ΔInWINF and ΔInNEER. It captures the interaction of exchange rate variations with the level of inflation. The underlying concern embodied in this variable is that while NEER impacts import prices directly, how it impacts import price inflation when the level of domestic inflation is also taken into account? A positive coefficient of this account would imply that the impact of exchange rate variations, i.e. ΔInNEER, is enlarged by the prevailing level of domestic inflation. A negative coefficient would suggest that the higher levels of domestic inflation suppress the impact of exchange rate variations, indicating a stabilizing role of an inflationary environment. The expected sign on this account is positive on this account, indicating that the combined influence of exchange rate changes and domestic inflationary momentum is expected to further increase the ERPT to import prices. The second interaction variable is EINVOL which is the product of $InCINF_{SD}$ and ΔInNEER. This variable attempts to capture the combined effects of inflation volatility and exchange rate variations on aggregate import prices. A positive coefficient would imply that an increase in volatility can inflate the impact of exchange rate changes on import prices, indicating that local uncertainties produced by volatile inflation result in a larger price impact from exchange rate changes. Perhaps, the hypothesis is that higher local uncertainties, due to an unstable inflation rate, cause the imports supplying foreign firms to change the prices in order to maintain the stability of their mark-ups. This may occur when the volatility in inflation crosses the tolerable level of menu costs, making the excessive inflation volatility too costly to be absorbed into the mark-ups of the foreign firms, inducing them to pass over the impact of volatility to Indian buyers.

Alternatively, one may construe the positive coefficient as reflecting the effects of switching costs on ERPT to import prices. With excessive volatility in local prices, the importing buyers may face a high switching cost, i.e. a higher cost of substituting imported commodities for domestic goods. Under such a circumstance, the foreign firms may be motivated to expand their mark-ups by taking advantage of the fact that importers would likely avoid shifting to domestic goods due to high uncertainty about their prices, and would thus 'stick' to the imported commodities even if their prices were to increase. This implicitly assumes that higher switching costs reduce the price elasticity of demand for imports at the aggregate level. While this may not exactly be the mechanism at work, it does provide a plausible explanation if the sign of the coefficient is positive. With regards to a negative

coefficient, the inferences would exactly be the opposite of the ones laid above, indicating that higher inflation volatility reduces the impact of exchange rate variations on import prices. Such behavior would deviate from the theoretically expected nature of the pass-through process. Hence, the expected sign is positive for this coefficient.

The next interaction variable is EEVOL which represents the interaction of ΔInNEER and InBEX_{SD}. The decision to interact the variations in NEER with the volatility in the bilateral exchange rate emerged from the fact that the interaction of NEER and its volatility yielded statistically insignificant results, though the sign was as expected. By using this combination of the variables, a better statistical fit was achieved. It is not completely implausible to expect the volatility in the bilateral exchange rate to shape the behavior of pass-through relationships. Indian imports are dominantly invoiced in US Dollars and perhaps this is true for a large number of emerging market economies. Hence, the volatility in the Rupee-US Dollar rate may very well capture information that might be feeding into the pricing decisions of foreign firms who prefer the US dollar as the invoicing currency. There are two schools on this account. The first lineage of analysts believes that exchange rate volatility should have a positive effect on the impact of the exchange rate on import prices. Works of Goldfajn and Werlang (2000), Devereux and Yetman (2010), and Corsetti et al. (2005), among others, have hypothesized such a relationship between exchange rate volatility and pass-through. However, there is a second and divergent view on this subject. Authors such as Paul Krugman, Froot and Klemperer (1989), and Taylor (2000) have championed the idea that the impact of exchange rate volatility on ERPT should be negative because higher volatility implies "common and transitory" (Frankel et al., 2005, pp. 6) changes which would not be considered important by the foreign firms given the menu costs.

The underlying idea of this belief is that the persistence of exchange rate shocks and their volatility are inversely related. In cases where there is a large exchange rate shock that persists even in the wake of high volatility, such as an exchange rate shock that shifts the intercept of the volatility variable itself, the second approach would collapse. This is because an intercept-shifting shock to the volatility variable would imply an increase in volatility while also making the exchange rate shock persistent thereafter. Hence, the correct expectations on this variable boil down to the time series properties of the exchange rate and exchange rate volatility variables and given the background laid in section 5.6, the expected sign on this account is positive on lines of Devereux and Yetman (2010).

The final variable in this context is EOPEN which depicts the interaction of InRTOPEN and ΔInNEER. The literature has a well-established empirical consensus that increased openness results in an increased impact of exchange rate variations on import price inflation, as discussed in the previous sub-sections. Thus, the expected sign on this coefficient is positive. In summary, the four interaction variables embody the four key hypotheses about which factors shape the impact of the exchange rate on import price inflation. It is expected that each of these hypothesized factors will show a positive effect on the interaction between the exchange rate and aggregate import price. Accordingly, the results are presented in Table 4.10. The sign of the coefficients of the interaction terms are positive and are on expected lines. It is important to note that the variable EINF was used in its first lag to avoid the endogeneity problem as the aggregate import price variable is juxtaposed as a determinant of domestic inflation in chapter five. Furthermore, the theory of ERPT permits hypothesizing lagged domestic inflation as a determinant of current import price inflation rather than associating them in current period terms within the import price function.

Table 4.10: Empirical estimates of the interactions between exchange rate and macroeconomic factors affecting pass-through

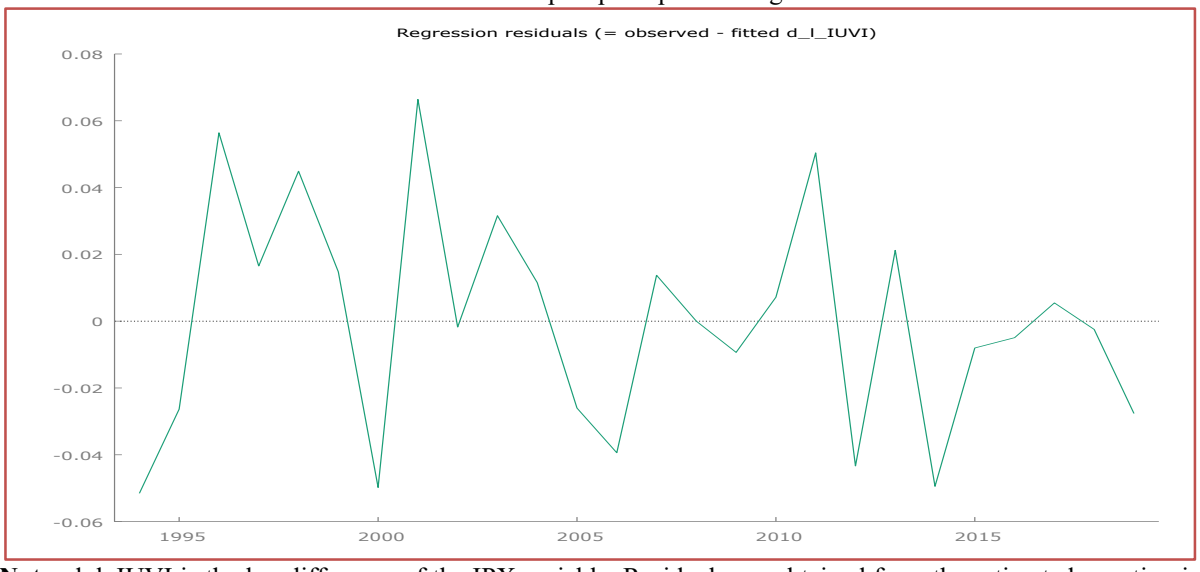
The dependent variable is ΔInIPX					
Variable	**Coefficient Value**	**Standard Error**	**t-ratio**	**Expected Sign**	**Actual Sign**
Intercept	-0.89***	0.167	-5.366	NA	
ΔInOILIND	0.34***	0.058	5.875	+	+
ΔInNEER	-2.11*	0.987	-2.136	-	-
ΔInWCPI	0.14**	0.052	2.763	+	+
ΔInRGDP	-2.29**	0.812	-2.825	+	-
D_{GFC}	-0.25***	0.080	-3.104	+/-	-
ΔInCINF	1.51**	0.600	2.517	+/-	+
$InCINF_{SD}$	-0.08**	0.028	-3.025	+/-	-
$InNEER_{SD}$	0.18***	0.045	3.894	+	+
$InRTOPEN_{t-1}$	0.23***	0.041	5.659	+	+
$EINF_{t-1}$	13.65***	4.304	3.172	+	+
EINVOL	1.35*	0.664	2.028	+	+
EEVOL	1.35**	0.575	2.342	+	+
EOPEN	0.20*	0.109	1.806	+	+
R^2	0.96	***F-statistic***	20.44***	***D-W statistic***	2.23

Notes: 1. ***, **, and * indicate that the given estimate is statistically significant at 1%, 5%, and 10% levels of significance respectively; 2. # indicates significance at 12% level; 3. The number of observations is 30; 4. Data are in annual terms. **Source**: Author's estimation.

The coefficient of $EINF_{t-1}$ represents the impact of a squared variable on import price inflation and thus its square root, which is worked out to be 3.69 represents the linear unit

impact of the interaction term on the dependent variable. The direct impact of inflation and exchange rate on the aggregate import price variable is given by their respective coefficients. The inflation rate has a positive direct impact on import prices. However, when combined with the exchange rate, the sign is still positive indicating that an inflationary environment increases the price impact of exchange rate changes. While the sign of the exchange rate variable should be negative for its direct individual impact on import price, the positive sign of this interaction term is a reflection that the inflation level dominates the direct impact of the exchange rate producing the positive sign of the interaction coefficient. Similarly, EINVOL shows a positive coefficient, indicating that higher inflation volatility swells the effects of exchange rate on import price inflation, implying that the pass-through effects are higher when local inflation is more unstable. EEVOL also shows the expected behavior and it seems that the line of thought developed in Goldfajn and Werlang (2000), and Devereux and Yetman (2010). Higher volatility in the exchange rate seems to be inducing a larger pass-through from the exchange rate to the import price in India during the sample period. Lastly, increased trade openness contributes to increasing the ERPT possibly through higher exposure to external shocks and a more inelastic demand for imports, which may allow foreign firms to expand their mark-ups without the fear of losing market share.

Figure 4.10: Residuals from the estimated equation of interactions between exchange rate and macroeconomic sources of import price pass-through



Note: d_l_IUVI is the log difference of the IPX variable. Residuals are obtained from the estimated equation in Table 4.7. **Source**: Author's estimation.

The model as a whole shows an excellent fit in terms of the highly significant F-statistic and a high R^2. The D-W statistic indicates a lack of evidence of autocorrelation problem in the

residuals and the model was tested for multicollinearity and heteroskedasticity also. Results were positive and indicated that these econometric issues were not prevalent. Furthermore, the time series plot of the estimated residuals from equation 15 is presented in Figure 4.6. The residuals were found to be normally distributed through the normality test and the model as a whole seems to be explaining the underlying pass-through mechanism quite well. This concludes the examination of the factors shaping the price impact of exchange rate via the key macroeconomic hypotheses embodied in the interaction variables, and the next section now investigates the stability issues of the estimated pass-through coefficient.

4.8.4. Stability of the pass-through coefficient within a time-invariant[59] framework

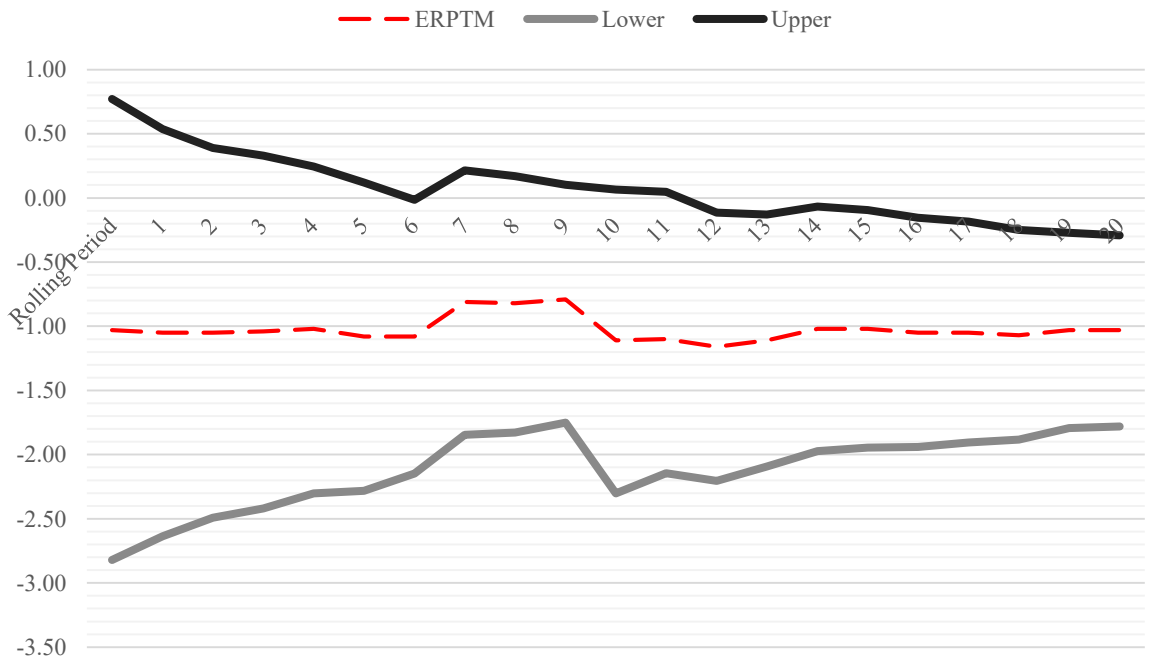
Economic relationships are assumed to be stable across time for the estimated models to be generalizable across periods and become useful in forecasting future periods. Economic dynamics attempt to account for leads and lags among the variables to model more complex relationships that may shift across time either discretely or continuously. When shifts in economic relationships are discrete in nature, single or multiple structural breaks might take care of such dynamics. Problems emerge when the structure of relationships changes continuously. In such cases, there may be structural changes or perhaps the regression coefficient may be varying over time. The debates on the time-varying coefficients can be traced to "the famous Keynes-Tinbergen controversy" (Schlicht, 2020, pp. 3) of the early 1940s where on the one hand Jan Tinbergen favored the time-invariant coefficients while allowing for small changes which may be handled through structural breaks, while on the other hand, Keynes asserted that long-run models cannot presume time-invariant relationships.

A popular approach to this issue has been to use rolling regression in estimating the time path of the ERPT coefficient. Well-known studies in this regard include Dwyer et al. (1993), Ihrig et al. (2006), Marazzi and Sheets (2007), Khundrakpam (2008), Aziz et al. (2013), Kabundi and Mbelu (2018), Kabundi and Mlachila (2019), and Balcilar and Usman (2021), among several others. The idea behind the rolling regression approach is to define a window that is of either a fixed period or an expanding period, and regress the variables for every window to trace the behavior of the ERPT coefficient across time. In advanced economies such as the US, Japan, and others, evidence of a fall in the pass-through to import prices as well as to domestic prices has been found. However, the findings on emerging economies are much more diverse. In the Indian case, there has been a broad consensus that the pass-through to aggregate import price is high but partial and that it has remained fairly stable except few years

when temporary structural breaks occurred such as in 2008 due to the GFC and in 2016 due to the adoption of the Flexible Inflation Target (FIT) regime as found in Patra et al. (2018). A fundamental limitation of the rolling regression approach is that the coefficient being traced across the rolling window is defined within a time-invariant framework. The changes in the coefficient across the rolling windows cannot be considered as emerging from time variability but may be on account of the sampling fluctuations as the sample is changed with every roll. However, it can allow a preliminary indication of how the time-invariant coefficient has behaved in terms of non-temporal variations that might cause the coefficient to change.

Thus, a rolling regression approach was adopted in this study and the baseline model estimated in Table 4.7 is rolled, beginning from 1991-92 with an additional year being added in every rolling window. Hence the initial point remained fixed. The estimated ERPT coefficient along with the upper and lower limits of the 95% confidence interval are reported in Figure 4.7.

Figure 4.11: Rolling regression estimates of the baseline model from Equation 14



Note: ERPTM is the coefficient of NEER in Equation 14 representing the import price pass-through from nominal effective exchange rate variations; Lower = Lower limit of the confidence interval of the coefficient; Upper = Upper limit of the confidence interval of the coefficient. **Source**: Author's estimation.

Clearly, Figure 4.7 shows that the price impact of exchange rate variations on imports has been complete and has remained largely stable across the sample period. The stability of the coefficient suggests that there has not been any secular decline or rise, i.e. any structural

change in the pass-through coefficient. Indian importers have continued to experience the full brunt of exchange rate uncertainties in the local currency prices and clearly, it may be inferred that Indian importers have been price-takers. It also seems that the foreign exporting firms have not been bothered much about market share and perhaps there are high switching costs along with a price inelastic aggregate imports demand that could have been allowing the pass-through to be consistently complete.

However, as noted earlier, the rolling regression framework can hide the time-inconsistencies or possibly be due to "spurious non-linear coefficients patterns" (Zanin and Mara, 2011, pp. 93). In either case, the rolling coefficients are inherently time-invariant coefficients estimated across a changing sample. Hence, each of the coefficients for each rolling period cannot be considered as a realization from a distribution of possible values which a time-varying model would be able to estimate. The insights from the rolling regression thus cannot be used to derive robust insights on the stability of the coefficient of pass-through and there is a need to examine the issue of coefficient stability within a more refined framework. This task is taken up in the next section.

4.8.5. Stability of the pass-through coefficient within a Time-Varying Coefficient framework

As discussed elaborately in section 4.7, this chapter undertakes the estimation of the import price function in a TVC framework on lines of Schlicht (2020), Schlicht (2021), and Schlicht (2022), which is a method of estimating time-varying coefficients within the standard state-space model and this approach allows the estimation of linear regression models. The properties of this method and its relative strengths and weaknesses along with its relative strengths against alternatives such as the Kalman filtering technique have been elaborated in section 4.7 itself. The baseline model[60] is now modified to allow each of the coefficients to vary across time. As shown in equation 16, except for the coefficient of the dummy variable, all other variables are permitted to vary across time[61].

$$\Delta InIPX = \beta_0^t + \beta_1^t \Delta InOILIND + \beta_2^t \Delta InNEER + \beta_3^t \Delta InWCPI + \beta_4^t \Delta InRGDP + \beta_5 D_{GFC} + \varepsilon^t \quad \ldots.(16)$$

The estimated time-varying ERPT coefficient to import prices is reported in Table 4.11 along with its descriptive statistics. The mean value of the coefficient is estimated at -1.31 with a relatively low variability of 26.64%[62]. The excess kurtosis is quite low while skewness

indicates a moderately skewed distribution of the variable. Figure 4.7 provides the time series plot of this coefficient and there is a structural break in the trend from around 2009-10 onwards wherein the pass-through began declining, i.e. moving towards zero. Perhaps, the GFC has been a fundamental driver in shifting the very nature of ERPT in India and thus it began declining in the aftermath of the global recession. What is clear is that the pass-through has not been stable across time and that it has begun declining in the post-crisis period which warrants further investigation on the determinants of this behavior of pass-through.

Table 4.11: Estimates of the time-varying ERPT coefficient for aggregate import prices in India

Year	ERPTM	Year	ERPTM
1992	-0.52	**2007**	-1.57
1993	-0.61	**2008**	-1.60
1994	-0.67	**2009**	-1.63
1995	-0.74	**2010**	-1.65
1996	-0.85	**2011**	-1.70
1997	-0.95	**2012**	-1.68
1998	-1.04	**2013**	-1.66
1999	-1.12	**2014**	-1.61
2000	-1.17	**2015**	-1.57
2001	-1.21	**2016**	-1.53
2002	-1.24	**2017**	-1.50
2003	-1.25	**2018**	-1.45
2004	-1.35	**2019**	-1.46
2005	-1.45	**2020**	-1.44
2006	-1.54	**2021**	-1.44
Descriptive Summary			
Mean	-1.31	SD	0.35
Median	-1.45	CV (%)	-26.64
Minimum	-1.70	Skewness	0.94
Maximum	-0.52	Excess Kurtosis	-0.24
Variance	0.12		

Notes: SD is Standard Deviation; CV is Coefficient of Variation. **Source**: Author's estimations.

Most importantly, the time-varying coefficient has behaved theoretically correctly across the period with the sign consistently being negative indicating that the pass-through relationship has not shown any perverse behavior during the sample period[63]. The basic time-series properties of the time-varying pass-through coefficient are reported in Table 4.12. Clearly, both from the non-stationarity tests as well from its behavior as depicted in Figure 4.7, the time-varying coefficient is not stationary while showing a structural break in the trend from 2009-10 onwards. The Bai-Perron test for a structural break in the trend of the time-varying

pass-through coefficient was undertaken and the test located the year 2010 as the year of break. Consequently, it is necessary to account for the structural break in unit root testing as warned earlier in section 4.7 to avoid conflating structural breaks with unit roots. Hence, the Zivot-Andrews test is undertaken and the evidence suggests that when the break in the year 2010 is accounted for, the pass-through coefficient behaves as a stationary variable.

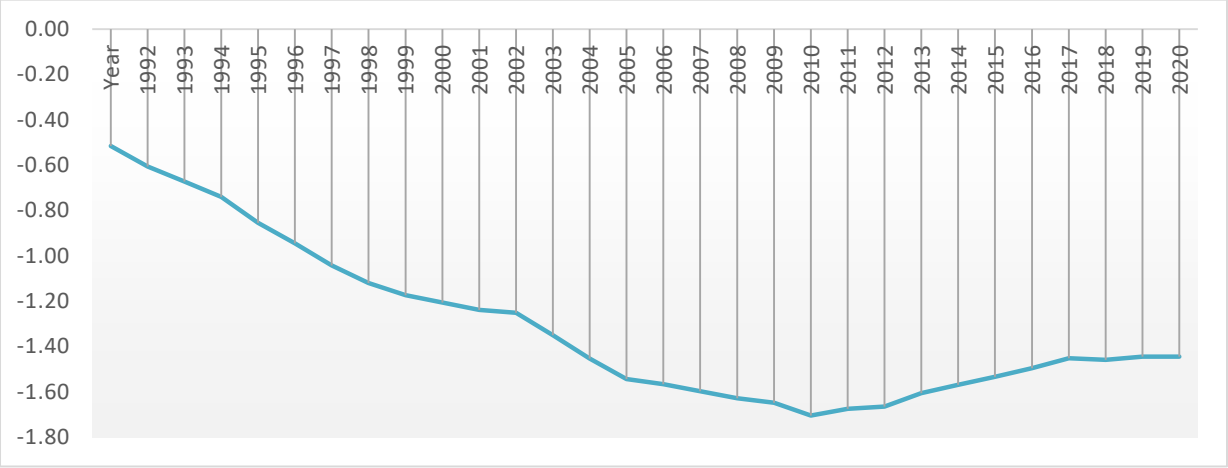
Table 4.12: Test for non-stationarity in the time-varying pass-through coefficient

Sr. No.	ADF Test	Phillips-Perron	KPSS	Zivot-Andrews
Test Statistic	-0.83	-0.38	0.27***	-3.54***
p-value	0.962	0.984	0.010	0.001

Source: Author's estimation.

Furthermore, it is also crucial to contrast the distributional characteristics of the behavior of the pass-through coefficient from the rolling regression and the time-varying coefficient model to understand the extent of instability that is revealed by the time-varying approach and the nature of this instability

Figure 4.12: Time-Varying coefficient of ERPT to import prices



Source: Author's estimation.

Subsequently, Table 4.13 provides the results of the test for equality of mean and equality of variance between the two estimates of pass-through coefficients. The results conclusively indicate that both the mean and the variance are statistically different between these two alternative perspectives of estimating the stability of the pass-through relationship. The level of pass-through estimates is statistically different and economically speaking shows slight divergence with the mean value of the rolling regression-based pass-through being -1.02 while that of the TVC being -1.31. The variances are also statistically different and thus the nature of stability itself has been different from both these perspectives. This paves way for

assessing the stability of pass-through coefficient from an econometric perspective that permits time-variation in the coefficients themselves. The same is conducted in the next section.

Table 4.13: Test for equality of mean and variance between the time-variant and time-invariant coefficients of import price pass-through

Statistic	ERPTM	$EPPTM_t$	Result
Mean	-1.02	-1.31	
Variance	0.01	0.12	
t-statistic	4.21***		Mean values are statistically unequal
F-statistic	12.57***		Variances are statistically unequal

Notes: 1. ERPTM represents the coefficient values estimated using the rolling regression approach, while $ERPTM_t$ represents the time-variant coefficient of import price pass-through; 2. For the t-test of equality of mean between the two samples, unequal unknown population variances are assumed; 3. The number of observations for ERPTM is 21 and for $ERPTM_t$ it is 30; 4. *** represents significance at a 1% level; 5. The underlying p-values are two-tailed. **Source**: Author's estimation.

Given the evidence on instability in the pass-through coefficient within the time-varying framework, a few questions naturally arise in this regard: Why is there instability in the pass-through relationship across the sample period? Can macroeconomic factors explain this instability? Which factors can explain this kind of behavior? The analysis on this account has not been conducted earlier in the Indian context and this provides an opportunity to freshly look into the mechanism at play behind the curtains of the apparent instability of the aggregate import price pass-through coefficient. This matter is taken up in the next section.

4.8.6. Determinants of the stability of exchange rate pass-through coefficient

The instability of the pass-through relationship reflects the forces that are constantly inducing variations in the extent to which exchange rate changes can vary aggregate import prices in India. The fact that the relationship between the currency and aggregate import price is changing with time raises the question of why this change may be occurring in the first place. A coherent answer to this question can emerge only when the determinants of the stability of the ERPT relationship are examined. Equation 17 expresses the theoretical model to study the macroeconomic foundations of the stability in the pass-through relationship in India and may perhaps be the first approach to systematically addressing this issue in the Indian context as far as import price pass-through is concerned.

$$ERPTM_t = \beta_0 + \beta_1 \Delta InWINF + \beta_2 \Delta InRGDP + \beta_3 InNEER_{SD} + \beta_4 InOPEN + \beta_5 D_{GFC} + \beta_6 D_{FIT} + \varepsilon \quad \ldots(17)$$

The dependent variable represents the time-varying pass-through coefficient estimated from equation 16. While this variable is found to be non-stationary using the traditional tests, it is clear that the structural break in 2009-10 has been the primary factor responsible for the alleged unit root in this variable. The Zivot-Andrews test result that tests the existence of non-stationarity with a structural break in the null hypothesis clarifies that after controlling for the structural break in the trend of the pass-through coefficient, the variable is very well stationary. The nature of non-stationarity in this variable is important information that cannot be sacrificed through mechanical differencing or other transformations. Any loss of information on this variable would result in a loss of the true nature of instability embodied in this variable. Not every OLS-based models with non-stationary variables produce spurious relationships. While econometric problems can be induced in such circumstances, the prudent handling of the structural break issue and careful specification of the theoretical structure of the model can help achieve reliable and robust inferences.

The first macroeconomic factor accounted for in this model is the level of domestic inflation measured by the variable ΔInWINF. The inflationary environment tends to increase ERPT as established in the seminal work of Taylor (2000). Thereafter a lineage of analysts has studied this matter that includes Goldfajn and Werlang (2000), Choudhari and Hakura (2001), Frankel et al. (2005), Zorzi et al. (2007), Ghosh and Rajan (2007), among several others. The mechanism behind this relationship has been examined earlier in the previous sections. The fundamental idea is that an inflationary environment should make it easier and less costly for foreign firms to pass over adverse exchange rate shocks to Indian importers as both switching costs and the price elasticity of aggregate import demand would be lower when inflation is already high. The importers would be more willing to 'tolerate' increased prices, and perhaps this can also explain the higher-than-proportional pass-through via the "inertial effects of rising prices" (Yanamandra, 2014, pp. 131). Accordingly, this variable is included in equation 17.

The next macroeconomic factor is the growth rate of real GDP which represents the demand pressure on imports and subsequently the inflationary pressure on import prices via domestic demand for imports. This conceptualization of RGDP implies that it reflects the effects of a domestic demand shock on ERPT. The expectation on this account is that a higher growth rate of GDP should result in robust demand for imports at home, allowing the foreign firms to pass over adverse exchange rate changes without the fear of losing market share when demand itself is high. This also presumes that increased GDP causes demand for imports to rise and suggests that the substitutability between domestic and imported goods is less.

Alternatively, another perspective can be put forward wherein under aggressive import substitution policies by the State, the elasticity of substitution between domestic and imported goods increases, and an expanding economy might experience a reduction in aggregate demand for imports. Under such circumstances, the ability of the foreign firms in passing over exchange rate shocks to Indian importers will be constrained by the fear of losing market share as importers can quickly 'switch' to domestic competing goods. Thus, both possibilities are expected *prior* concerning this variable.

Thereafter, exchange rate volatility – NEERSD, and trade openness – RTOPEN, are taken into account and the background to their role in the pass-through process was already laid in sections 5.3, 5.4, and 5.5. Two dummy variables are constructed for capturing two critical events pertaining to ERPT in India. First is the dummy variable representing the formal adoption of the Flexible Inflation Targeting (FIT) regime by the RBI, which occurred in October 2016[64]. This variable represents a test of the Taylor hypothesis (Patra et al., 2018). A negative sign of this coefficient would indicate that the RBI has been successful in reducing the inflationary impact of exchange rate variations on the Indian economy while a positive coefficient would imply otherwise. The dummy is defined in terms of the year 2016 as '1' while all the remaining years assume the value of '0'[65]. Lastly, following the works of Mendali and Das (2017), Patra et al. (2018), and Patra et al. (2020), among few others, the dummy variable for testing the impact of GFC on the pass-through coefficient is embodied in D_{GFC}. The expectations on the sign of this coefficient are dual. On the one hand, the financial crisis could have increased the instability in the pass-through relationship causing the coefficient to increase in its aftermath. Contrasted to this, it may have reduced the stability of the pass-through coefficient, causing it to fall in the aftermath of the crisis. Both these possibilities are plausible and hence the expectations are in both directions.

The estimated results are reported in Table 4.14. The coefficient of inflation has a positive and significant impact on the pass-through relationship and its stability. The results seem to confirm Taylor's hypothesis that pass-through is endogenous to the inflationary environment. Higher inflation in India contributes to increasing the inflationary impact of the exchange rate. The coefficient of RGDP shows a positively significant sign indicating that an expansionary economy is exposed to a larger inflationary impact from the exchange rate, perhaps due to the underlying mechanisms delineated in the previous paragraphs. Substitutability between domestic and imported goods, as well as the price elasticity of aggregate import demand, may be considerably weakened when the economy is expanding,

allowing the foreign firms to 'afford' increasing the prices following an adverse exchange rate change. Data seem to suggest that such a process may very well be at work in the Indian setting.

Table 4.14: Empirical estimates of the factors affecting the stability of the time-varying import pass-through coefficient

The dependent variable is $ERPTM_t$					
Variable	**Coefficient Value**	**Standard Error**	**t-ratio**	**Expected Sign**	**Actual Sign**
Intercept	2.42***	0.294	8.243	NA	
ΔIn(WINF)	1.70**	0.705	2.407	+	+
ΔInRGDP	2.71*	1.424	1.900	+/-	+
$In(NEER_{SD})$	-0.17***	0.053	-3.183	+/-	-
In(OPEN)	-1.05***	0.080	-13.08	+	-
D_{GFC}	0.23*	0.123	1.855	+	+
D_{FIT}	-0.21***	0.058	-3.645	-	-
R^2	0.92	***F-statistic***	36.13***	***D-W statistic***	1.76

Notes: 1. ***, **, and * indicate that the given estimate is statistically significant at 1%, 5%, and 10% levels of significance respectively; 2. # indicates significance at 12% level; 3. The number of observations is 26; 4. Data are in annual terms; 5. D_{FIT} represents the dummy variable for the year 2016 when the Flexible Inflation Targeting framework was formally adopted by the RBI. Alternative specifications of the Dummy variable, such as treating 2014 as the year of introduction of FIT as done by Patra et al. (2018), produced similar results. **Source**: Author's estimation.

The coefficient of exchange rate volatility is negative. Given that the dependent variable represents not only the level of ERPT but also its stability across time, it seems that increased volatility in the exchange rate allows the pass-through to stabilize. As debated earlier, there are two lines of thought on how exchange rate volatility impacts the pass-through coefficient. The analysts who propose that pass-through is reduced due to higher volatility in exchange rate appeal to the inverse relationship between volatility and the persistence of the changes in that variable (Lopez-Villavicencio and Mignon, 2016)[66]. If the currency is indeed volatile, the changes occurring in the currency's price may very well be short-lived and temporary rather than permanent. It appears that this is the case in the Indian context and the volatility in the exchange rate may not be inducing permanent shifts in the exchange rate's behavior, thereby preventing the foreign firms from frequently changing their prices, perhaps to avoid menu costs. This result should be contrasted to the findings in Table 4.10 where volatility was found to be increasing the inflationary impact of the exchange rate. This goes to show the gains in understanding the issue of pass-through when a time-varying framework is adopted versus when a time-invariant model is used.

The estimates presented in Table 4.14 can explain a large proportion of mechanisms at work given the high R^2 and the highly significant F-statistic. The estimated model was tested for multicollinearity, autocorrelation, heteroskedasticity, and normality of the residuals, and

the results indicated that the estimated model was not plagued by these econometric problems. The analysis presented in this and the previous sections is an attempt to uncover newer dimensions of import price pass-through and enhance the existing stock of wisdom on this subject. While the results have been presented and delineated through the prisms of both economic theory and the ideas built through the extant literature, contextualizing these results is necessary to make a deeper sense of the findings obtained in this chapter. This is the task of the next and the last section.

4.9. Summarizing the findings

Chapter four has examined various dimensions of the pass-through mechanism linking exchange rate variations and aggregate import price. Section 4.2 laid bare the key issues to be investigated. Section 4.3 examined the nature of the aggregate import basket of India, suggesting some stylized facts. First, the advanced economies broadly captured by the OECD bloc and also the OPEC bloc, have dominated as the key foreign suppliers of India's imports. Their share has persisted between 50% and 55% in the aggregate imports of India. Second, the share of the developing economies in India's import basket has consistently increased since 1991-92 and has reached about 45% in 2021-22. Third, oil imports as a proportion of the aggregate imports have hovered at around 30% since 1991-92 and this signifies the stable demand for oil in India. Clearly, ignoring crude oil in the pass-through estimation would bias the results. Fourth and last, it was found that India's direction of trade with advanced economies has been tilted towards imports relative to what India exports them and interestingly, similar behavior was encountered with the developing economies. This implies that India has been a heavily imports-dependent country and perhaps considerable scope remains open to exploit the export potential of the country.

Thereafter, Section 4.4 laid the foundations of the theoretical model adopted in this chapter after examining the competing approaches available on this subject. The choice of the theoretical framework was contextualized and the baseline model was proposed which later on provided the foundation for the empirical analyses. Section 4.5 provided the background on the data environment of the study while explaining the nature of the key macroeconomic variables employed in this chapter. Section 4.6 provided a coherent picture of the time-series behavior of the variables and their distributional characteristics before examining the basic time-series properties of these variables. The temporal behavior of the selected variables, the issue of structural breaks in them, and stationarity-related matters was explored in this section.

Section 4.7 analyzed the methodological issues in ERPT analysis in both international and Indian contexts and laid the rationale for the key methodological choices made in this chapter. This section also summarized the key debates on methodological considerations in the Indian context on the pass-through issue while rationalizing the methods chosen for empirical analysis in this chapter.

Subsequently, Section 4.8 provided, examined, and contextualized the empirical estimates arrived in this chapter. Within this section, section 4.8.1 estimated the extent of price impact from the exchange rate in terms of aggregate import price in India during the period 1991-92 to 2021-22. The baseline model was estimated and the initial estimate of the pass-through coefficient was worked out to be slightly more than complete. Following it, section 4.8.2 analyzed the issue of macroeconomic determinants of aggregate import price inflation in India within a partial adjustment framework. NEER, Oil price inflation, world inflation, exchange rate volatility, and trade openness were found to be contributing to higher import prices in India. On the other hand, the growth rate of real GDP, the financial crisis of 2008-09, volatility of domestic inflation, and the partial adjustment mechanism was found to be reducing import prices. Both the short-run and the long-run pass-through coefficients were estimated in this section and in both cases, pass-through remained high, though, in the long run, there was slight incompleteness in the same. The impact of the interactions between exchange rate variations and key macroeconomic factors such as inflation level, volatility in inflation, exchange rate volatility, and trade openness, on the import price inflation, was studied in section 4.8.3. The framework in this section allowed examining how these macro factors shaped the price impact of the exchange rate in terms of their combined influence on import price inflation at the aggregate level. Each of these factors was found to be increasing the price impact of the exchange rate on import prices.

Section 4.8.4 took up the issue of stability of the pass-through relationship across time by adopting a rolling regression approach. The estimates of the pass-through coefficient across selected rolling windows were reported in this section. The estimated time path of the coefficient indicated that the pass-through was complete and remained fairly stable during the sample period. However, a caveat was raised that the issue of the time-varying coefficient could not be sufficiently handled by a simplistic approach such as the rolling regression method. Thus, section 4.8.5 elaborated on the issue of stability of the pass-through coefficient within a time-varying coefficient model that allowed the modeling of a linear model within a state-space framework. This approach was examined in detail and its relative strengths and pitfalls were

noted. The estimated time-varying pass-through coefficient displayed instability and structural change after 2009-10 possibly indicating the deep impact of the financial crisis on the exchange rate – import price nexus in India. The rationale was developed for these findings and an important question was raised: Why has the pass-through relationship been unstable across this study period? After examining the time-series properties of the estimated time-varying ERPT coefficient, section 4.8.6 proposed a theoretical model of the macroeconomic process through which the instability of the import price pass-through could be explained. Results showed that an inflationary environment contributed to increasing the extent of instability of pass-through, thereby confirming the Taylor hypothesis that pass-through is endogenous to the domestic inflation environment prevailing in the country. This was undertaken from the perspective of the import price pass-through. Similarly, an increased growth rate of real output and the financial crisis of 2008-09 were found to have increased the instability in the import price pass-through coefficient. However, exchange rate volatility, trade openness, and the introduction of the Flexible Inflation Targeting (FIT) regime in India were found to be stabilizing the pass-through coefficient. Again, the result on the impact of the FIT regime on pass-through vindicated the Taylor hypothesis.

This concludes chapter four and the next section provides a preliminary overview of the issues to be studied in the next chapter where the scope of pass-through analysis is expanded to cover domestic inflation.

4.10. Precursor to the next chapter

Chapter five undertakes a detailed empirical assessment of the pass-through mechanism regarding the exchange rate – domestic inflation nexus in India at the aggregate level by using annual and higher frequency data. Firstly, the extent of pass-through from exchange rate variations to domestic inflation is examined. This is undertaken utilizing two baseline models reflecting two alternative approaches to capturing the complex behavior of aggregate inflation in India. Secondly, after establishing the basic nature of this nexus, the extent of pass-through is examined under different variations of the two baseline models. This is undertaken to check the sensitivity and robustness of the price impact of exchange rate when different related specifications are adopted. Thirdly, the issue of stability of the pass-through coefficient for domestic inflation is addressed using appropriate econometric frameworks. Fourth and last, the dynamic price impact of exchange rate on domestic prices is delineated within a Structural

Vector Auto Regression (SVAR) framework to unearth richer dimensions of the pass-through mechanism in India.

Notes

[1] The broad consensus in the Indian context is that the immediate import price pass-through is considerably closer to unity, implying almost complete pass-through. This finding has been largely robust to variations in empirical strategies. However, no *a priori* theoretical presumptions can be made on this account as this matter is equally empirical in nature.

[2] Defining the short-run and long-run pass-through is itself a matter of debate. Depending on the frequency of data and the underlying economic framework, shorter and longer horizons of pass-through behavior can be conceptualized in a drastically different ways. However, there needs to be consistency between the definitions of the short-run and long-run within the framework adopted in an empirical study. These debates are addressed in the section on empirical analysis of this chapter.

[3] A regression-based pass-through coefficient is a partial coefficient reflecting the quantum of currency variations on imports while holding other regressors constant. Hence, larger the number of parameters incorporated into the model, the larger will the factors whose direct effects on import prices are filtered to reflect the 'purer' effects on import prices emanating from exchange rate changes.

[4] The ideal requirement for such an exercise is to generate consistent and continuous time series on pass-through elasticity. This can emerge from a time-variant coefficients model, or can be examined from alternative methodological angles. Such concerns are examined in the empirical section of this chapter.

[5] The author would like to thank Dr. Hersch Sahay, Assistant Professor, Puducherry University, for providing useful insights and perspective on the construction of a time variant dependent variable which can capture the exchange rate pass-through relationship meaningfully. The responsibility of errors, if any, is solely of the author.

[6] The analysis of market structure is essentially a microeconomic exercise. However, one can obtain indicative insights from aggregate data also, which are employed in this chapter. It is necessary to obtain a broad indication of what kind of market do the Indian buyers face in the imports segment because this has immediate implications for the pricing behavior of our foreign supplier and thus on the nature of the pass-through process that India faces on the imports front. A more detailed insight on the nature of imports market across commodity groupings and country groupings may be located in Shanmugan (2019).

[7] While the exchange rate used in individual transactions are determined by the market rate as reported by the FBIL, it is also plausible that different firms under different industries may employ their own exchange rate calculations, such as freezing the exchange rate of rupee above the market rate by certain margin to hedge against variability risks during the settlement of the contract. Hence, such micro level information are required to rationalize the import price function at commodity level.

[8] In the Indian context, very few studies have examined the issue of exchange rate pass-through, whether to import prices or domestic prices, within the simultaneous equations model. One of the studies in this

context is Pyne and Roy (2008) who adopt a reduced form specification of import price function as proposed in the previous work by Goldstein and Khan.

[9] The exporting country is the supplier of imports purchased by the destination country.

[10] This may not be suitable if a vehicle currency is being used between the trading countries. For example, if country A imports from country B, but the invoicing of the contract is undertaken in the currency of country C, a vehicle currency, then the suitable exchange rate variable would be a product of the exchange rates between countries C and A, and countries C and B.

[11] This statement is only valid up to the extent that aggregate imports are looked into. It is plausible that across different industries, the heterogeneities of firms may cause some industries or firms or even bloc of firms to behave in like a monopsony or with considerable market power as buyers. This could be argued for such Indian importers who buy key inputs in bulk from foreign markets. Given that the analysis in this chapter is aggregate in nature, the behavior of the aggregate imports sector is considered rather than examining the disaggregate dynamics of market structure which requires a much more granular analysis.

[12] The fulfillment of equation one for an individual commodity would imply the upholding or the law of one price, while for the imports sector as a whole, it implies that the purchasing power parity condition is presumed.

[13] LCP may also be practiced by exporters who obtain large scale Government subsidies and reliefs to improve their competitiveness in the international markets. In this case, the rationale of absorbing exchange rate shocks into the mark-ups of the exporting firms is provided by the policy design rather than the market behavior of the exporters or the degree of their market power.

[14] Assuming the existence of an aggregate price function along with the aggregate marginal costs requires a leap of faith as large number of price functions of individual firms are weighted to derive their aggregate counterparts. Unlike most of the studies that utilize the mark-up variations model, this chapter introduces aggregate pricing dynamics from the first stage itself and recognizes the limitations of this model in capturing aggregate relationships while also fully utilizing its conceptual advantages. Moreover, if aggregate data are to be employed, as is the case in this chapter, aggregation from micro level information can be subsumed into the aggregate data and assumed in the ceteris paribus condition. Such adjustments in this model are required to make it suitable for macroeconomic analysis. Most of the studies in the Indian context, such as Rajan and Yanamandra (2015), have not delved into these issues but have directly adopted the micro level pricing model into their macroeconomic analysis.

[15] Marginal costs already account for the normal rate of profit and the existence of mark-ups allows for profit levels higher than this normal rate. It is debatable as to what is the ‘normal rate of profit’ for a country as a whole, though industry specific ‘going rates’ can be averaged to get a rough estimate of the normal rate of profit for the country as whole. This information can be useful in disaggregated analyses to measure the threshold beyond which abnormal profits being accruing and thus actual degree of market power emerges.

[16] See Yanamandra (2014).

[17] As stated earlier, the aggregation of micro level pricing components into an aggregate component requires addressing the aggregation problems inherent in the use of macroeconomic data. The exact weighting structure and weighting factors need to be recognized and its possible that the aggregate export price function may require inclusion of additional factors such as cross-price elasticities, measures of market power and addressing issues such as endogenous exchange rate variations. However, literature has found that this model broadly captures the import price pass-through dynamics quite neatly even when the aggregation issues are assumed in the ceteris paribus condition.

[18] Chapter six investigates the issues of size and directional asymmetries.

[19] It is important to note the subtle difference in the definition of the bilateral exchange rate versus the NEER. The bilateral exchange rates in India are measured in terms of units of rupees per unit of foreign currency while the NEER is defined in terms of units of foreign currency per Indian rupee.

[20] The aggregate nature of analysis in this chapter implies that the key macroeconomic factors will be accounted for in the empirical import price function. The strength of the mark-up variations model is its flexibility to adapt to different levels of aggregations.

[21] Trade openness can also be conceptualized to represent the costs of monetary expansion in open economies and the subsequent disciplinary impact of the same on monetary authorities. However, this perspective of trade openness is valid when domestic inflation dynamics are being studied rather than import price inflation. See Romer (1993) for deliberations on this perspective. See Mohanty and Bhanumurthy (2014) for an empirical application on similar lines in the Indian context.

[22] The use of World inflation rate can also be considered as a representation of global commodity markets and the impact of the general global inflationary environment on India's import prices. This perspective has not been incorporated into the import price pass-through estimation in the Indian context.

[23] This variable is interpolated appropriately for estimate the missing data by importing the high positive correlation between OILIND and OILWB and thus information on global crude oil prices are utilized to forecast the past values of the price of the Indian oil basket. In any case, as shown in the empirical estimates, both OILIND and OILWB provide qualitatively similar inferences in the pass-through estimation models.

[24] Literature has favoured the use of real or nominal GDP to represent the imports demand in the import price function within the mark-up variations model. The use of this variable is to control for import demand movements and it is generally hypothesized that increased imports demand would put upwards pressure on import prices. However, it may also be argued that increased GDP may cause expenditure switching with domestic output-substituting imported commodities, thereby resulting in a fall in the import price inflation. Both the theoretical possibilities are acceptable in the Indian context. Moreover, the use of aggregate GDP to represent imports demand is problematic and GDP movements will be

driven by non-tradable output variations also and these may weaken the links between imports demand and the proxy variable used here.

[25] The analysis in this chapter recognizes the possibility of both short-run and long-run pass-through to import prices emerging from exchange rate changes. Thus, the lags of the exchange rate variable are employed within a Distributed Lags framework, to capture the immediate and the delayed response of import price inflation to exchange rate changes.

[26] Further details on the construction, nature and issues connected with these two exchange rate variables can be found in chapter one.

[27] The month-on-month growth rates could be marred in part by seasonal fluctuations. Hence, the year-on-year growth rates allow the seasonality to be relatively reduced in these variables.

[28] Mohanty and Bhanumurthy (2014) suggest that exchange rate volatility can be construed as a measure of the exchange rate regimes. The assumption is that the higher the variability of exchange rate, the more flexible that nation's exchange rate regime must be. Indeed, structural breaks and occasional devaluations are not considered in this argument. From this perspective, one may consider this variable as a proxy for the exchange rate regime. If this variable displays high variability and the sign of this coefficient is positive, one may infer that floating regimes have an inflationary impact on import prices. If the sign is negative, then vice versa.

[29] Data on the Crude Oil price in constant or real US dollar terms are also employed in this study which are available from the same source.

[30] Its use was recently undertaken in Yanamandra (2014) in the Indian context. Very few studies are available in the Indian context that examine import price pass-through and most of the studies focus on the domestic price pass-through in the Indian setting.

[31] The total trade variable deflated by WPI is employed as the first preference in the study and the other variable is used to check for any gains in the empirical inferences while maintaining the structure of the model.

[32] However, the time series data on these variables, depicted in the Appendix, indicate that since 2011-12, the openness of the Indian economy has fallen down consistently. The aftermath of the Global Financial Crises, the subsequent slowdown in the world economy and the broader slowdown in international trade could have been some possible factors behind the falling degree of openness of the Indian economy since 2011-12. This matter requires a more detailed examination and is beyond the scope of this chapter.

[33] One can trace the root of active debates on this issue in the works of Perron (1989) who criticized the inferences in Nelson and Plosser (1982) and gave impetus to the issue of addressing structural breaks before examining the unit root properties of time series variables.

[34] Within the pass-through literature, the adoption of the Flexible Inflation Targeting (FIT) in India has been recognized as a fundamental shift in the monetary policy environment of the country. This chapter examines its impact on import price pass-through in later sections.

[35] While the Chow test is extremely popular in applied macroeconomic research, it presupposes a sufficiently large sample to ensure fairly high degrees of freedom for each sub-period in the test. If the total period itself is small, then a split-sample strategy may not be suitable and rather the dummy variable approach could be employed. Alternatively, bootstrapping methods could be explored.

[36] Approaches in this regard can include the splitting of samples, break-point test and forecast tests. Due to the small-sample problem frequently encountered in applied macro research, bootstrapping approaches are proposed that can overcome this limitation. See Kočenda and Černý, 2015 for more details on the extensions of the Chow test for locating structural breaks.

[37] Strictly from a theoretical point of view, the pass-through mechanism works in the level of prices. But the aggregate nature of macroeconomic research prevents the use of such information due to lack of data on aggregate levels of prices and thus indexes are employed instead. The aggregate ERPT research has evolved accordingly and the log-difference form of the import price and domestic price inflation functions allow interpretation of the pass-through coefficient which is theoretically equivalent to their analysis using information of price levels instead.

[38] RGDP was regressed on the dummy variables signifying the structural change after 2008 and 2018 respectively and there was no evidence of the year 2008 as causing structural change either as a one-time event, wherein the dummy was defined as one for the year 2008 and zero otherwise, or in terms of a regime shift, whereby the dummy was defined as one for year 2008 and thereafter while zero for years before 2008. However, there was statistical evidence of a negative impact on RGDP in and after 2018.

[39] Bai and Perron (1998) initially proposed the theoretical structure for econometric examination of multiple structural breaks without *a priori* specification of the break years. Thereafter, Bai and Perron (2003) operationalized this methodology and provided the critical values for the distribution underlying the Bai-Perron test for locating multiple structural breaks. The genesis of the Bai-Perron test can, however, be located as early as in 1989 in Pierre Perron's paper on the empirical testing of the unit root hypothesis on oil price shock of the late 1980s.

[40] However, one may argue that a volatile inflation or exchange rate that does not portray any form of trend, may be mean-reverting and thus there might still be an element of persistence in such a time series. However, the idea of persistence centers around not only mean-reversion but 'mean-closeness', and a variable that remains consistently away from its mean cannot be strictly classified as persistent. With this background, the volatility variables are also utilized as proxies for persistence, and volatility and persistence are expected to vary inversely.

[41] The regression RTOPEN on the dummy variable for structural change since 2010-11 or 2011-12 shows a negative coefficient which is statistically significant at 1% level. The OLS results for this regression may be obtained from the author upon request.

[42] Monthly data from 1993 onwards are available for this measure of import price variable. However, the empirical estimations undertaken using this variable provided theoretically inconsistent coefficients and the degree of pass-through appeared to be perverse from the economic theory point of view. There

were several econometric problems encountered in employing this variable too. Thus, it was decided to not employ this measure and rather adhere to the annual data on unit value index from official sources in India.

[43] Further details on the methodological issues and related aspects are elaborated in the next section as and where necessary.

[44] Linearity in this context implies the linearity in parameters and not necessarily in the regressors.

[45] The choice of NEER is dictated by the fact that India's import basket is composed of commodities that are invoiced not only in US dollars but also in other currencies such as Euro, Pound Sterling and Japanese Yen. Moreover, the estimations with the bilateral Rupee-US Dollar exchange rate did not yield expected results, perhaps pointing towards the decreasing dominance of the American dollar as the preferred invoicing currency in India's aggregate imports basket.

[46] Naturally, this assumes that the exporting firms are profit-maximizing firms. If their objective is to maximize market share, under such circumstances, the pass-through would be low and import prices would not be impacted at all or rather be impacted negatively, implying that with improved demand conditions, prices are cut down to capture larger market share. The actual sign of the coefficient of RGDP will explain which of these underlying objectives is being practiced by the exporting nations.

[47] While one might argue that the construction of the import unit value index accounts for the implicit oil prices, and thus there is a purely definitional relationship between both, this argument fails to address the fact that the increased import prices following and oil price shock is only possible when the increased prices are allowed to be passed over to the buyers by the OPEC bloc. Thus, the relationship between oil price inflation and import price inflation is behavioral.

[48] It is necessary to be careful in not interpreting the completeness or incompleteness of ERPT as representing the "intensity of competition" (Goldberg and Hellerstein, 2008, pp. 425). While the degree of competition can explain the degree of pass-through and both are expected to vary inversely, there may be other factors such as market-share maximization that could motivate exporting firms in varying their mark-ups in the wake of adverse exchange rate changes and not passing over the negative impact from exchange rate variations to the import prices in local currency.

[49] This is under the assumption that there are no directional asymmetries and thus the pass-through coefficient remains the same whether there is a depreciation or an appreciation in the exchange rate.

[50] The nature of this relationship requires further examination and is perhaps outside the scope of present discussion.

[51] The rationale for this is explained in the next footnote.

[52] It may not be theoretically correct to hypothesize current inflation rate and its volatility as determinants of current import price inflation, as import price inflation is itself a determinant of the current inflation rate within the theory of ERPT. Accordingly, the model was estimated with lagged values of InCINF and $InCINF_{SD}$. The results did not bring any drastic change in the estimated coefficients but increased the value of the exchange rate coefficient from -1.21 to -1.75 while still being

statistically significant at 1% level. The coefficients for one year lagged values of InCINF and $InCINF_{SD}$ are worked out to be 0.46 and -0.08 respectively with the latter being significant at 10% level.

[53] Trade openness has been incorporated with one lag, as the value of its coefficient was both insignificant and inverse to the expected sign.

[54] This is obtained from the coefficient of the partial adjustment term which is -0.18. See Gujarati (2008) for more details on its derivation.

[55] Some studies have found long-run pass-through to be more than double the short-run pass-through and have suggested that perhaps the 'hysteresis induced impact' might be at work (Yanamandra, 2014). Evidence of such behaviour is not found in the present model.

[56] The use of interaction terms in the manner constructed here is pervasive in the studies on size and directional asymmetries both internationally as well as in the domestic contexts. However, this chapter undertakes the analysis of the factors shaping the behavior of exchange rate pass-through in terms of key macroeconomic hypotheses.

[57] It may not be theoretically correct to hypothesize current inflation rate and its volatility as determinants of current import price inflation, as import price inflation is itself a determinant of the current inflation rate within the theory of ERPT. Accordingly, the model was estimated with lagged values of InCINF and $InCINF_{SD}$. The results did not bring any drastic change in the estimated coefficients but increased the value of the exchange rate coefficient from -1.21 to -1.75 while still being statistically significant at 1% level. The coefficients for one year lagged values of InCINF and $InCINF_{SD}$ are worked out to be 0.46 and -0.08 respectively with the latter being significant at 10% level.

[58] While employing interaction terms, it is necessary to incorporate the interacting variable separately also to account for the direct and combined impact of that variable on the variable of interest (Goldfajn and Werlang, 2000; Lopez-Villavicencio and Mignon, 2016). Hence, both the variables in interaction term are incorporated separately also in the equation 15.

[59] While Rolling Regression approach is employed to estimate the temporal stability properties of regression coefficients, the coefficients within each rolling window are time-invariant. Thus, "strictly speaking, this means that in principle such an approach cannot produce reliable time-varying parameter estimates" (Zanin and Marra, 2011, pp. 94).

[60] A critical limitation of the TVC approach is that the number of parameters increase rapidly causing loss of degrees of freedom if data constraints are not taken into account. Given the annual nature of the data and the number of observations being 31 years of data, the baseline model provides the most parsimonious perspective of the aggregate import price function. Future research can enlarge this model and adopt the other models estimated in this chapter on higher frequency data or possibly in panel sets.

[61] The time-varying parameter estimated in this section was undertaken by allowing all the coefficients except the dummy coefficient to vary across time. The estimates reported here were alternatively undertaken by only allowing the NEER coefficient to vary. Under both the cases, the results largely remained the same.

[62] The value of CV is negative because the mean values are negative. Readers may ignore the sign.

[63] The time-varying coefficient of pass-through was estimated using monthly data where in the Import Price Index of the IMF was employed to measure the aggregate import price variable while the baseline model was modified by replacing the Index of Industrial Production instead of the GDP for which monthly data are not available. The estimated time-varying pass-through behaved erratically showing positive signs for a sizeable period while again returning to negative value.

[64] Patra et al. (2018) specify the dummy variable for FIT regime from 2014 onwards reflecting the fact that the "Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework" was formally submitted to the RBI in January 2014. The said author was also one of the members of this Committee. In this study, the dummy variable for the FIT regime is specified from the date of its formal adoption by the RBI. The specification of Patra et al. (2014) was also tested for and the results largely remained the same. However, it made much more sense to impose this structural change on pass-through from the time when it became a formal consideration for the RBI.

[65] Alternative specifications of the Dummy variable with year 2014 being assumed as the year of FIT, following Patra et al. (2018), were also tested in this model. The results remained largely the same. However, the proper speficaitions of the FIT regime seems to be year 2016 when the RBI formally adopted it and the dummy variable has been specified purely from this perspective.

[66] "If the variance of inflation declines, its persistence also decreases while high variance is associated with high inflation persistence" (Lopez-Villavicencio and Mignon, 2016, pp. 5).