# REVIEW ON MEASUREMENT OF EXCHANGE RATE PASS-THROUGH IN INDIA

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## ABSTRACT

Once the increasing openness of an economy is taken into account, the role of foreign exchange rate becomes critical in determining its macroeconomic behaviour and outcomes. Among the various channels through which foreign exchange rate can affect an economy, the process by which it can impact domestic inflation including the degree, scope, feedbacks and lags in this process, has been broadly called Exchange Rate Pass Through. The literature on this issue is vast in the international context and is also growing continuously in the Indian context. In particular, the dimension of measurement of Exchange Rate Pass Through plays a critical role in the empirical analysis in this area primarily because of the high-degree of sensitivity of the final results to the ways in which the major variables were conceptualized and measured in the first place. Thus, this paper undertakes a review of the major evidences on Exchange Rate Pass Through in the Indian context with a special emphasis on the definitional and applied theoretical issues that emerge through this survey. It was found that the measurement strategies in this area are diverse, complex and context-specific and that despite disagreements on the best way to measure Exchange Rate Pass Through, there are several broad patterns of analysis that are common to all the major studies in this area of research.

**Keywords:** Exchange Rate, Exchange Rate Pass Through, Inflation, Open Economy Macroeconomics.

## 1. INTRODUCTORY NOTE

An important outcome of the Keynesian revolution of the 1930s was the recognition of the fact that the presumption of strict theoretical independence between the real and nominal economic

systems might not always hold once the underlying assumptions of the classical macroeconomic system were relaxed. In particular, in the short run, when price and information rigidities might be prevalent, the real and nominal spheres of economic life could interact closely with each other both theoretically and empirically. Furthermore, when the increasing openness of economies was taken into account, macroeconomic research globally had to account for the international linkages for more meaningful interpretation of policies. Operation of foreign exchange markets and rates thereof were such important links and their impact on and relationships with the domestic economy continue to be matters of intense research and debates.

Among the various channels through which foreign exchange rate could affect domestic economy, the ways in which the international prices of a country were affected by nominal exchange rates received considerable attention in the international macroeconomic literature roughly beginning with the landmark works of Magee (1973), Dornbusch (1985), etc. With time this framework of analysis took into account several other dimensions of the interconnections between exchange rate variations and domestic inflation. Hence, the empirical relationship between exchange rate and inflation, and the degree, scope, feedbacks and lags in this process, have been broadly called the process of Exchange Rate Pass-Through (ERPT[1]). Historically, ERPT was associated with the inter-connections between the exchange rate and international prices and in particular with the import prices, but off-lately the chain of impact of exchange rate changes have been extended to the movements in domestic inflation via the variations in import prices as well to the impact of exchange rate movements on the pricing behaviour of domestic exporters. International literature has termed the earlier framework as Stage I pass-through while the impact of import price movements on domestic inflation has been called the Stage II pass-through[2]. Consequently, the combination of these two processes that links exchange rate changes with domestic inflation[3] has been called ERPT.

Operationalization of ERPT in applied macroeconomic research has been another area of concern and continuous refinement. While the theoretical framework linking exchange rate and domestic inflation appears to be well-established, the strategies deployed in quantifying this concept have been multi-fold and ever evolving. The nature, measurement, scope, lags, determinants and other such facets of ERPT have been an area of intense debate globally while the evidences in the Indian context are still probably in an early stage of development. Moreover, ERPT is also closely related to numerous other macroeconomic issues such as the Balance of Payments adjustment process, monetary policy conduct, etc. and hence poses a challenging and gigantic task for any researcher in locating those economic forces that are more important for the analysis of ERPT and which do not overlap with the factors determining other macroeconomic phenomena. Thus, it becomes critical to understand the conceptual and empirical dimensions of ERPT as applicable to a small open economy like India and evaluate the evidences that have

been accumulated so far. In particular, the dimension of measurement of ERPT requires special attention because not only is it the starting point for examining other related issues such as the determinants of pass-through, asymmetry and non-linearity in its response to various kinds of exchange rate changes, etc., but also because it is tightly anchored to the ways in which various macro policy measures are conducted.

The dimension of ERPT measurement poses at least two sets of closely inter-related issues. First, how have the various studies defined and measured exchange rate, import prices, export prices, domestic inflation, etc. and, what have been the period of analysis, frequency of data among other issues. Such concerns may be clubbed together as the "definitional considerations" in ERPT measurement; and second, what have been the theoretical and empirical links between these fundamental constituents of ERPT which may be called the "applied theoretical framework". These two frameworks are tightly linked because, for example, with a given conceptual framework, even a slight change in the definition of either of the constituents of ERPT can lead to sizeable differences in the estimated results. Thus the various approaches, issues and strategies utilized by the Indian evidences in conceptualizing and operationalizing ERPT provide the central organizing theme for this paper. After a brief introduction on this issue, Section 2 undertakes a detailed review of the various evidences on this matter in the Indian context. Thereafter, Section 3 examines the various conceptual and empirical dimensions that can be extracted from the review undertaken so far and finally the last Section concludes this paper.

## 2. EVIDENCES OF ERPT MEASUREMENT AND RELATED DIMENSIONS

What follows is a brief survey of the two major issues related to ERPT measurement as mentioned above namely the definitional and conceptual frameworks used for the estimation of ERPT. *Prima-facie* it can be noted that ERPT has basically been interpreted as an Elasticity measure showing the responsiveness of domestic prices to exchange rate variations. However, the use of different methods such as Vector Auto Regression (VAR), Simultaneous Equation Models, etc. make it difficult to strictly interpret the observed coefficients as measures of simple elasticities as is the case with traditional single-equation-based OLS regressions. Such concerns have primarily motivated the following review.

One of the earliest studies examining the phenomenon of ERPT was Krishnamurty and Pandit (1996). Within their larger aim of building a macroeconometric model for examining the determinants of international trade flows of India at a disaggregate level, the effects of the links between exchange rate, international prices and domestic prices, on trade deficit were investigated. The explicit inclusion of this inter-linkage, which was termed as ERPT in the paper, also signified a marked break from the trend of underplaying the importance of ERPT in the

context of Indian trade flow analysis that had persisted so far. They measured exchange rate as a nominal bilateral exchange rate index with base year 1980-81. Domestic prices were measured by the Wholesale Price Index (WPI). Import and Export prices were measured by unit value indexes. The study period was from 1970-71 up to 1990-91. Various simulations were undertaken to understand the alternative scenarios of trade flow behaviour in India. It was found that devaluation of exchange rate decreased the trade deficit in domestic currency.

Dholakia and Saradhi (2000) investigated the extent of ERPT in both import and export sectors of India using quarterly data from 1980 to 1996 and analyzed the extent of ERPT to India's export and import volumes, export and import prices, and trade balance. In order to pursue these empirical objectives, the study analyzed the impact of exchange rate changes on the import price and export price separately. The coefficient of the logarithm of exchange rate with respect to import price index as a dependent variable signified the extent of direct-pass through to the importing country. Similarly, the coefficient of the logarithm of exchange rate with respect to export price as a dependent variable measured the extent of pass-through to the exporting country. The authors used unit value index as a measure for import and export prices respectively which were collected from official published data and was frequency of data was quarterly. For measuring the exchange rate variable, the study had constructed two different Nominal Effective Exchange Rate indexes using separate weights for each. The shares of the top four trading countries, namely the U.S., the U.K., Germany and Japan, in the total import and total export of India were used as weights to construct two series of NEER, namely one for aggregate export and the second for aggregate import. The index was based on geometric mean of bilateral exchange rates of Indian currency with the trading countries. It should however be kept under notice that the measure of ERPT in this study was a part of a larger equation consisting of many other determinants of Import and Export prices. A single equation framework was used with four separate equations for price of import, quantity of imports, price of export, and quantity of exports. Hence, the coefficient of interest here contained only partial information of the impact of exchange rate changes on the international prices while ignoring the effects of other variables. The extent of ERPT might have shown considerable divergence from achieved results were a simultaneous system to be used. On account of ERPT to import price, the study found that there was full pass-through with the concerned coefficient being 1.29 and not being significantly different from unity. Thus the authors concluded that at the aggregate level, Indian import sector was a price taker characterized by lack of any market power or 'pricing to market' phenomenon. However, exchange rate changes were found to have had no significant impact on import quantities. In case of export prices, the estimated pass-through was found to be 0.30 which worked out to be significantly less than unity but it increased to 0.7 after 1991. As the post-1991 value of ERPT to export prices was found to be not significantly different than 0.9 (with 0.1 being the adjustments in import intensity of exports and hence in total being full pass-through at

1), the hypothesis of complete ERPT to export prices could not be rejected. Lastly, export quantities were found to be positively and significantly affected by exchange rate changes. The study thus focused on the Stage-I ERPT while ignoring the impact of international prices on domestic inflation and the direct effects of exchange rate changes on domestic inflation. This probably weakened the conclusiveness of the results obtained in the study though its findings were appreciable in the light of the then-prevailing data and methodological environments.

Patnaik, Kapoor and Dhal (2003) undertook an examination of the macro-interactions between output gap, inflation rate, interest rate, exchange rate depreciation, food-grain inflation and fuel price inflation for the period April 1993 up to March 2002 on monthly data. Within their broader Structural Vector Auto Regression (SVAR) framework, the study also focused upon the relationship between exchange rate and domestic inflation. Here, exchange rate was measured by nominal bilateral exchange rate between the Indian rupee and U.S. Dollar and the inflation rate as the year-on-year and seasonally adjusted monthly Wholesale Price Index. The analysis based on the initial impulse in exchange rate, i.e. a depreciation of nominal exchange rate, produced interesting results. The inflation rate actually declined for the initial few months. However, after around 6 months of lag, the inflation rate showed an increase and stabilized at a higher level than the initial level of inflation after around 34 months since the exchange rate depreciation. The analysis however did not examine the transmission channel via which exchange rate changes translated into inflationary movements. Import prices are generally considered to be the key channel for this transmission but its role in the process of ERPT was not examined. It is also important to point out that the study conducted an analysis of ERPT in a VAR framework and hence deriving a reliable measure of the elasticity of current domestic inflation to current exchange rate changes was not possible.

Mallick and Marques (2006) examined the extent of ERPT to import prices and export prices at sector specific levels. The analysis was focused on the Stage-I pass-through only, i.e. that of exchange rate changes to international prices and not to domestic inflation. This paper modified the traditional pricing-to-market models into a pricing-to-products variety with the variation of mark-ups embodied in export prices for each major sector of country's export industry being analysed. The study used panel regression model on annual data for two time periods, namely, 1980-1990 and 1991-2001. This was done to analyze any structural breaks after the package of economic reforms in 1991 and existence of differences between the extents of ERPT in the two time-periods. Further, ERPT to export prices was defined as the elasticity of export price (measured in domestic currency) to exchange rate changes, while ERPT to import price was measured as the elasticity of import price (measured in domestic currency) to exchange rate changes. The mark-up coefficient that was assumed to be embodied in the export price was expressed in terms of the local currency and was proxied by the constant term in the export

equation. Exchange rate was defined as the nominal bilateral Rupee/Dollar exchange rate. Import and export prices were measured as Unit Value indexes of imports and exports. The study justified the use of bilateral exchange rate on account of dominance of U.S. as the trading partner particularly on the export side. On account of pass-through to import prices, the analysis found that there was no conclusive evidence on whether the pass-through to import prices was full or absent, but there was a decline in it in the 1990s compared to the 1980s. Moreover, the analysis at sectoral level for the 1980s revealed that there was full or more-than-full pass-through in three import sectors namely, Crude Materials, Inedible, Except Fuels (SITC 2), Food & Live Animals (SITC 0), and Animals and Vegetable Oils, Fats, & Waxes. This was so only for one sector i.e. the Crude Oils (SITC 2) sector for the 1990s. In case of the export price, the investigation revealed that pass-through to foreign currency export price was more-than-than-full for the 1980s while it was partial for the 1990s. The sectoral analysis of pass-through to export prices showed that India was increasingly tending towards a price-making player in all the major export sectors except in case of Beverages & Tobacco (SITC 1), Chemicals and Related Products (SITC 5) and Crude Materials, Inedible, Except Fuels where it was probably evident that India was still a price-taker. The study could have utilized the NEER and the differences in the ERPT in both the cases, with the nominal bilateral exchange rate and NEER, could have been compared to see if statistically significant differences existed between them.

Ghosh and Rajan (2007) estimated the aggregate pass-through of exchange rate changes to aggregate domestic inflation for the period 1980 up to 2005 using quarterly data. Exchange rate was measured by both the nominal bilateral US dollar exchange rate as well as the NEER. Domestic inflation was defined as the quarterly aggregate Consumer Price Index for India. All the data were seasonally adjusted using the Census X-12 methodology. Regression analysis in double logarithmic form was employed with the first equation linking the logarithm of India's CPI with bilateral Rupee/U.S. Dollar exchange rate and the second equation linking the logarithm of India's CPI with NEER while both took into account other possible determinants of CPI too. ERPT was thus defined as the coefficient expressing the relationship between the logarithm of exchange rate variable and the CPI. Estimation of ERPT was done for three different periods in time. Primarily, it investigated for the whole period under consideration from 1980 up to 2005 and then the period was subdivided into 1980Q1 to 1990Q4 and 1992Q1 to 2005Q4. Long-run ERPT was estimated using regression in level form data despite evidences of non-stationarity. This was justified on the basis of the Johansen co-integration method which showed the existence of a stable linear relationship among the variables in level form itself. Error Correction Model (ECM) was used to estimate short-run ERPT to CPI. Estimated long-run pass-through of the bilateral exchange rate to CPI was 43 percent when US PPI was used to measure foreign cost while it reduced to 41 percent when US CPI was used instead. In case of NEER, statistically insignificant coefficients were found in all specifications and hence no evidence of

pass-through was visible. Short-run pass-through in case of bilateral exchange rate with US PPI and US CPI respectively was found to be 10 percent and 9 percent respectively.

The analysis of the extent of ERPT to both WPI and CPI in India, within their larger aim of understanding the macro-connections between oil prices, output gap, exchange rate, monetary policy and domestic inflation, was undertaken by Bhattacharya, Pattnaik, Shah (2008) for the period September 1997 up to October 2007. The lags and the duration of the impact were also empirically scrutinized along with a focus on the long-run relationship between exchange rate movements and domestic inflation. A recursive VAR approach in the first difference form was utilized to investigate the above issues. The long-run relationship between the variables was accounted for by using Vector Error Correction Mechanism (VECM). Exchange rate was measured as the nominal rupee/Dollar bilateral exchange rate domestic inflation by WPI and CPI monthly data. ERPT was measured as the elasticity of domestic prices to the log of exchange rate. Seasonal adjustments in the relevant variables were undertaken by using X-11 ARIMA method. The authors found moderate pass-through to CPI and WPI both. Long-run ERPT to CPI was 3.7-17 percent while for WPI it was 28.6 percent. Not accounting for monetary policy in the VAR framework showed that a larger proportion of a 100 percent exchange rate shock was transmitted to CPI within a lag of two years. In case of WPI, only 1.3 percent of the 100 percent exchange rate shock was passed into after a lag of two years. Incomplete pass-through was thus found.

The advent of economic reforms marked a critical juncture in the international environment facing the Indian economy. It thus became important to understand the extent to which reforms affected the degree of ERPT and Khundrakpram (2008) focused on the analysis of the same. Exchange rate was defined as NEER and domestic inflation as WPI. Monthly data from January 1990 up to March 2005 were used. The author stressed that the data frequency of WPI, its popularity as the headline inflation, etc. motivated them to employ the same to measure domestic inflation. All the data were seasonally adjusted. There were four models employed with different combinations of the sum of current and lagged values of variables such as inflation rate, exchange rate, marginal cost of the exporting firm (measured as trade weighted foreign price), domestic demand conditions, food price shock, and money stock. The fourth model consisted of all the above variables. Both the short and long run pass-though coefficients were estimated. All variables were tested for non-stationarity and were found to be stationary in first difference form. Incomplete pass-through of exchange rate changes was observed to domestic inflation in all the models used. Short-run pass-through was in general found to be lower than long-run pass-through. The long-run pass-through was particularly found to have increased during the study period.

While most of the above studies have focused on the extent of ERPT into import prices and domestic prices, Mallick and Marques (2008) investigated the extent of pass-through into export prices quoted in foreign currency by the Indian exporters. This analysis was undertaken at both aggregate and sectoral levels with 34 sectors being covered based on the Standard International Trade Classification (SITC). Annual (financial year) data from 1980-81 to 2001-02 were employed. Deriving their measure of coefficient of ERPT from a typical profit-maximizing function of a representative exporting firm, a value of zero for this coefficient indicated full pass-through in foreign currency terms while vice versa if the value were found to be one. A critical assumption underlying their construction of the coefficient of ERPT was that exchange rate changes did not affect the domestic exporters' cost of production. Exchange rate was measured as 36-currencies weighted NEER (weights being the relative shares of these currencies in India's total external trade) and export prices as unit value indexes of exports, both aggregate and sector-wise. For domestic inflation rate, WPI was utilized. Export data were free on board (f.o.b.) while import data was cost, insurance and freight (c.i.f.) based. The analysis used a panel regression framework. The final equation regressed the change in the log of export prices (in rupees) against the change in log of NEER, Marginal Cost and sectoral export shares, as well as against a macroeconomic policy index that was constructed using information on fiscal deficit, inflation and trade openness. Differentials in ERPT coefficient between 1980s and 1990s were also analyzed. The authors found incomplete pass-through of exchange rate changes into India's export prices quoted in foreign currencies. In terms of the disaggregated behaviour of ERPT, the results varied for different industries and for the two time-periods namely 1980s and 1990s, with many sectors showing incomplete to no pass-through, though some displayed evidence of full pass-through into foreign prices of Indian exports. This was found to be particularly true for the 1980s.

Dash and Narasimha (2011) analyzed ERPT to both import and export prices with reference to India using quarterly data for the period 1993 (Q2) up to 2004 (Q3). Import and Export prices were measured by unit value indexes. The authors pointed out the inherent limitations of unit value indexes and noted that the changes in the underlying composition of the index, the problem of appropriate weighting factors, heterogeneity of the products, etc. were the major limitations of these indexes, but were used due to data constraints. Other variables such as the foreign cost of production (proxied by weighted average of Producer Price Index of major trading countries), domestic cost of production (WPI for India), domestic demand pressure (measured by the difference between trend level GDP and actual GDP), foreign demand pressure (measured by the weighted average of Index of Industrial Productions for seven major foreign countries with trade-based weights), price of import competing goods (India's WPI), were appropriately constructed by the authors. Finally, the exchange rate variable was measured as 36-currency trade-whetted NEER. Imperfect competition-based price-setting behaviour of exporting and

importing firms were used to derive the underlying theoretical specification of the estimated export and import price models. Regression models in double-logarithmic form were employed for estimating exchange rate pass-through to both import and export prices. Data were found to be stationary in their first difference form. Co-integration and error correction models were used to estimate the extent of both short-run and long-run ERPT coefficients. Evidences showed that ERPT to export prices was incomplete and positive in the long-run and its value was 0.36. Price of competing commodities and cost of production both, were found to have a positive impact on export price. Evidence on partial existence of bargaining power with Indian exporters was thus found. Based on the ECM estimations, export price index was found to have a faster response to foreign competitor's price (price of international substitutes) rather than NEER itself. Short-run estimates showed that ERPT was 0.30 to export prices and hence a larger proportion of exchange rate changes were absorbed by the profit margins of the Indian exporters. As far as import price pass-through was concerned, more than complete pass-through was found with the exchange rate coefficient's value being 1.76 in the long-run. In the short-run however, exchange rate was found to have had no significant effect on import prices. The coefficient of foreign cost of production showed that it significantly and positively affected import price and acted as an important variable in the import-price making process of foreign exporters to India. This also provided some evidence that import markets of India were not characterized by high competition to foreign exporters and hence changes in cost of production for foreign firms were largely pass over to import prices in Indian currency.

Roy and Pyne (2011) undertook an empirical evaluation of the extent of ERPT to aggregate and sectoral export prices of India for the period 1960-2000. The authors used a simultaneous equation model to estimate the ERPT relationship. Annual data was used to estimate ERPT coefficients. Export price and export volume functions were constructed taking into account variables such as export prices relative to world price, world demand, and domestic supply capability as measured by Gross Domestic Product among others. Exchange rate variable was defined as NEER as evident in their operational form of the theoretical model, while it was REER that was specified as a determinant of real export demand in the underlying real export demand function. Export prices were measured by unit value indexes in home currency. Pass-through of NEER to unit value indexes of exports both at aggregate and product-group levels were estimated. Three product-groups were covered by the study other than aggregate exports namely, manufactured exports, chemical and related products and engineering exports. They found evidence of incomplete pass-through to aggregate export prices with the value of the ERPT coefficient being 0.57. For the product-groups, all product-groups showed incomplete pass-through though there were differences in the extent of ERPT with chemical exports showing the highest pass-through (value of the coefficient being 0.95). The authors noted that their estimation did not account for the nature and structure of export markets as a source of

incomplete pass-through and that their results on structural breaks in the model could have changed if further time-periods were incorporated into the study.

Kapur and Behera (2012) took the empirical analysis of monetary policy transmission mechanism in India as its aim and, among other issues; they estimated ERPT, conceptualized as the impact of a one-unit change in exchange rate on domestic inflation, in order to investigate the efficacy of exchange rate channel for transmission of monetary policy shocks to output, demand and inflation in India. They undertook the empirical work within the New Keynesian framework by estimating backward-looking IS and Phillips relationships and a forward-looking monetary policy rule. The data period was from $2^{nd}$ Quarter of 1996 up to $1^{st}$ Quarter of 2011. Within their analytical framework, inflation was measured by year-on-year (y-o-y) changes in the WPI, exchange rate variable by y-o-y changes in bilateral nominal exchange rate of rupees against the U.S. Dollar. It must be noted that this variable entered as a determinant in two equations: first as a determinant of y-o-y changes in aggregate WPI of India and second as a determinant of y-o-y changes in WPI of Non-Food Manufactured (WPI-NFMP). They found that as far as aggregate WPI inflation was concerned, both the short-run and long-run pass-through coefficients were incomplete with their values being 0.06 (60 basis points) and 0.12 (120 basis points) respectively. The results were found broadly the same even if y-o-y- changes in the 36-currency trade-weighted NEER were employed instead. With reference to the y-o-y change in WPI-NFMP, NEER was found to have had significant effect while bilateral nominal exchange rate was found to be insignificant. A 10 percent change in NEER was found to have had 0.03 (30 basis points) and 0.08 (80 basis points) impact on changes in WPI-NFMP in the short and long runs respectively.

Kumar (2014) was an analysis of ERPT relationship within a VAR framework for the period June 1995 up to February 2013 using Monthly data. ERPT was modelled as the relationship between exchange rate movements on the one hand and changes in WPI and CPI on the other. Exchange rate was defined as the bilateral Rupee/USD rate. WPI and CPI as published by the RBI were used as measurements of domestic inflation. The study found that ERPT was positive for both WPI and CPI with an exchange rate shock having relatively more impact on CPI. Interestingly, energy prices were found to have had a cumulatively larger impact on WPI and CPI than exchange rate. ERPT coefficients were found to be insignificant.

Yanamandra (2014) was a detailed analysis of several macroeconomic pass-through phenomena including ERPT. ERPT was conceptualized as the relationship between exchange rate changes and import prices. Empirical investigation was done both at the aggregate and disaggregate levels. Monthly data was employed for the period January 2003 up to March 2013. Exchange rate was measured using both the nominal bilateral USD/Rupee exchange rate and 36-currency

Trade-weighted NEER[4]. Import prices were measured by the Import Unit Value Index. The author estimated both the short-run and long-run estimates of ERPT to import price inflation. Using a Vector Error Correction Model (VECM) with import price inflation being a function of world CPI, IIP and NEER, short-run ERPT coefficient was found to be -1.16 (given that NEER was defined as number of foreign currency units per rupee), while long-run ERPT was -2.29. The author justified the existence of more than complete pass-through to aggregate Indian import price inflation in the long-run on the basis of the possibility of high inflationary expectations. Alternative specifications with National Stock Exchange (NSE) turnover, and both NSE turnover and IIP were also estimated. The short and long run coefficients in these cases were found to be broadly the same with similar signs of the coefficients. Alternatively, an index of nominal bilateral exchange rate was also used instead of NEER and the results were found to be robust to changes in the definition of exchange rate. The results were strikingly different at the one-digit SITC-based sectoral estimates of short run and long run ERPT coefficients. Sector specific import value indexes were employed while aggregate level cost and other variables were used. Except for the miscellaneous manufactured goods, coefficients were insignificant for all other sectors and some even had incorrect signs. Similar results were found even when the NEER was replaced by the bilateral exchange rate. Lack of use of sufficient sectoral information in the models and lack of inclusion of sector-specific mark-ups in the model were cited as possible causes of these results at the sectoral levels.

Mendali and Das (2016) undertook an empirical exercise of estimating ERPT to domestic prices in India using a VAR framework. The data used were monthly ranging from April 1992 up to November 2013. Domestic inflation for India was measured by WPI. Exchange rate was measured by the 36-currency trade-weight based NEER. The study used five variables and in the following order in the VAR model namely: oil price index as available from the *International Financial Statistics* of the International Monetary Fund (IMF), output gap as measured using the Hodrick-Prescott method, Broad money supply ($M_3$), NEER and finally WPI. All variables were used in logarithmic form. The study finds low degree of ERPT to WPI. The short run ERPT was found to be 0.011 per month following an exchange rate shock of 10 percent depreciation. The long-run value of ERPT was 0.6 which again substantiated the existence of incomplete pass-through. In terms of the Variance Decompostion undertaken to analyze the primary drivers of the observed impulse responses in WPI, domestic price shock and oil price shock were the major factors.

The following study was not undertaken in the Indian context but provided a glance of ERPT estimation in a non-linear framework and supplied considerable insights into how ERPT could be conceptualized in non-linear models. Soon, Baharumshah and Wohar (2017) was an empirical analysis of ERPT in six major Asian countries namely Thailand, South Korea, the Philippines,

Indonesia, Japan and China. It was based on a panel threshold regression model using Inflation Volatility as the threshold parameter to divide the sample into low inflation volatility and high inflation volatility countries. Basically, this allowed for the examination of ERPT when inflation is relatively stable and an inflation-targeting monetary policy was being pursued versus when inflation is considerably volatile and hence targeting of inflation was not practiced by the monetary authorities. Accordingly, ERPT was estimated for both low and high inflation volatilities. The study used Quarterly data ranging from Quarter 1 of 1980 up to Quarter 3 of 2014. The authors used CPI for measuring domestic inflations in the chosen countries, nominal bilateral US dollar rate for measuring exchange rate variable and US Producer Price Index for measuring foreign prices by basing it on the year 2005. All these data were obtained from International Monetary Fund's publications. The study found the existence of a single threshold with the value of threshold parameter being 4.17. They observed that ERPT was close to 1 (value being 0.91) if inflation volatility crossed the threshold value, but could not find any evidence of zero pass-through in case volatility of inflation was below the threshold value.

## 3. SOME ISSUES AND REFLECTIONS

ERPT continues to garner active attention of international economists primarily because of its criticality "for the conduct of monetary policy, choice of exchange regime and the transmission of external shocks" (Soon et al., 2017). The above review has pointed out some of the important works in this area and the extent of debate and disagreements are quite evident if one looks across the major conclusions of the studies in the Indian context. While some studies conclude that ERPT was more than complete in the recent past for India (e.g. Yamanadra, 2015); others conclude near-complete (e.g. Dholakia, 2000), incomplete (e.g. Bhattacharya, Pattnaik, Shah, 2008) or sometimes even near to zero pass-through (e.g. Kapoor and Behera, 2012). It is fascinating to see such diversity of empirical results and this fact motivates a closer examination of how ERPT was defined and conceptualized by various analysts. The following section attempts to organize the major issues and themes pertaining to ERPT measurement based on the review of evidences undertaken above.

### 3.1. Definitional issues

### 3.1.1. Exchange rate variables

Among the bilateral and effective varieties of exchange rate variables, NEER appears to be the most frequently employed measure in ERPT estimation. The construction of NEER by concentrating on factors such as basket of currencies, economically meaningful and dynamic weighting patterns, use of more economic information than bilateral rates, etc. seem to have been the possible reasons behind its popularity in the present context. However, several studies have

employed bilateral Rupee/U.S. Dollar exchange rate also, though, it is clear that NEER remains a variable of choice for ERPT to both international and domestic prices. Further, the divergence in the behaviour of bilateral nominal exchange rate and the NEER have been quite pronounced which make the final results of ERPT estimation particularly sensitive to how exchange rate was defined and measured in the first place.

### 3.1.2. International price variables

The measurement of import and export prices at aggregate levels has been undertaken mainly by using unit value indexes. The most critical source of information on unit value indexes of imports and exports in India is the trade indexes of goods as released by the Directorate General of Commercial Intelligence and Statistics (DGCIS), Government of India. The quality of measurement, coverage, weighting pattern, etc. of these data would determine how good the estimation of ERPT would be. These indexes are estimated using chain-base method and they employ fisher's ideal index number method for calculating the index values. The major limitations of these indexes emerge from not only the possible debates on methodological issues but also from the fact that they ignore services. Despite the non-inclusion of services, these indexes are the best available source of information on aggregate import and export prices. Another justification for using these indexes could be on account of difficulties in constructing a credible price index using disaggregated information for aggregate imports and exports. In the Indian scenario, there is a considerable lack of disaggregated price indexes for major internationally traded goods and services. Moreover the data that are available on this account too are limited in terms of their coverage and uniformity for macroeconomic aggregation. Interestingly, we could not find any study that attempted to construct its own measure of aggregate import and export prices in the Indian scenario as far as the analysis of ERPT is concerned.

### 3.1.3. Domestic inflation variables

Inflation measurement in India continues to be an issue of intense debate and research. With increasing sophistication of data collection agencies in India and the improvements in data collection mechanisms, considerable degree of coverage and improvements in accuracy of inflation data have been achieved in the recent past. However, owning to several limitations such as retention pricing, minimum support pricing, administered prices, very information on the changes in prices and weighting methodologies, price indexes used for measurement of inflation continue to be mere estimates which are to be carefully scrutinized before employing them. In case of ERPT, it is quite clear the WPI dominates the empirical landscape as far as the measurement of domestic inflation is concerned. However, some studies have also looked at CPI and also at the effects on both WPI and CPI of exchange rate variations. Barring few studies

however, most analysts have conceptualized ERPT to domestic inflation as the impact of exchange rate changes on WPI. The trickle down of the spread of exchange rate changes across the entire pricing chain has received limited attention in the Indian context. Furthermore, the ways in which variability in inflation can be linked to variability in exchange rates has also been an area that has considerable future scope.

## 3.2. Applied Theoretical issues

### 3.2.1. Links between exchange rate, international prices and domestic inflation

The theoretical connections between exchange rates and import and export prices have been primarily derived from various extensions of the basic pricing model of an imperfectly competitive exporting firm. With the advent of the new open economy macroeconomics literature, use of currency pricing models such as Local Currency Pricing (LCP) and Producer Currency Pricing (PCP) models to explain the degree of ERPT to major developed economies also became an important element of the international research in this context. Historically and even in the Indian scenario, the studies concentrating on measurement and impact of ERPT have varied between so-called Stage-I and Stage-II pass-throughs. An important issue that has repeatedly emerged in this context has been the estimation of short-run and long-run ERPT coefficients. The time-dimension inherent in this issue presumes critical importance not only for macroeconomic analysis in general but also for macroeconomic policies in particular for understanding micro-foundations. In India, RBI has been pursuing some measure of inflation targeting aiming for low and stable prices in the medium to long run. Such a policy goal, among other things, requires the knowledge of ERPT to domestic inflation across different time horizons. Information on ERPT to international prices is also a critical element of the complete ERPT process and hence the ways in which international prices react to exchange rate movements provide critical, though only partial, information on the impact of exchange rates on domestic inflation. Several studies have focused on this issue in the Indian context and have found that in general the long run ERPT is higher and near-complete compared to short-run ERPT. Supply side bottlenecks such as wage-rigidity in the short-run have contributed to the deviation between short-run and long-run elasticities. It is important to note that in the Indian context the monetary authority has been pursuing a discretionary intervention into the FOREX market to maintain price stability and this has probably complicated the impact of ERPT on inflation. Most of the findings on the account of lags in ERPT process seem to be suggesting that there are significant lags in the transmission of exchange rate movements to international prices in India. Analysts have also found that the length of these lags varies across time and space. A common finding in the Indian context has been that the aggregate ERPT shows lengthier lags than disaggregated measures of ERPT. Many of the studies have found that microeconomic

forces such as wage-rigidities play a central role in explaining the existence of non-instantaneous response of international prices to exchange rate changes. Considerable scope remains open in analyzing the micro-market forces in conjunction with macroeconomic factors and their impact on ERPT in the Indian context.

### 3.2.2. Methodological patterns across studies

There are a host of methods that have been used in the Indian context for estimating ERPT to either international prices or domestic inflation. Considerations of data constraints, usage of popular models, underlying theoretical considerations, etc. seem to have been the major factors determining the kind of estimation methodology followed. Broadly, the methods used till now in the Indian context can be classified into three types namely, single-equation methods, VAR and related variants, and simultaneous equation models. VAR has been by far the most frequently employed method. Some studies have undertaken estimation in a Structural VAR framework, while others have used Recursive VAR approach. It is not readily evident whether the choice of such methods was dictated purely by statistical considerations or by a blend of both economic and econometric needs. In the case of single-equation based approaches, use of linear and non-linear regression models was found with non-linear regression models being mostly utilized for estimating the differential impact of large versus small exchange rate changes on international and domestic prices. The use of simultaneous equation models in estimating ERPT has been quite limited in the Indian context. An important implication of these findings is that the underlying concept of ERPT coefficient differs from method to method. For example an ERPT coefficient estimated using a single-equation OLS-framework will have different underlying economic interpretation than a simultaneous-equation-model based ERPT estimate. Such concerns require a more exhaustive comparative analysis of various approaches used in estimating ERPT both from economic and econometric points of view, and this remains to be investigated in a more detailed framework in the Indian context.

### 4. CONCLUSION

ERPT remains a critical element in the larger analysis of an open-economy macroeconomic system. In the international context, a large number of analytical insights ranging from individual-specific factors to larger macroeconomic issues have been unearthed and it continues to receive considerable priority from both analysts and policy-makers. In the Indian context also, ERPT has been a well-researched and debated issue. This survey of evidences has revealed the richness of insights that have been discovered by various studies. These insights include, among other things, the estimation of ERPT for varying time horizons, variations in ERPT across different methodologies, the determinants of ERPT and particularly the micro foundations of the same, and the role of ERPT in the inflation process and policies.

While taking full cognizance of these contributions of available studies, it seems that the depth and probably the coverage of empirical dimensions of ERPT continue to throw good amount of scope for future research. Among these dimensions, the analysis of macroeconomic determinants of ERPT, the differences in the degree of ERPT across low and high frequency data, the estimation and analysis of disaggregate ERPT, building large-scale simultaneous equation systems for understanding the nature of ERPT and investigation of aspects of the ERPT process such as asymmetry and non-linearity, continue to require more intense and exhaustive analysis in the future. It is hoped that the present study motivates more efforts and academic exercises in the direction that are narrated.

**NOTES**

1. In order to examine the issues of leads, lags and other dynamic matters in the transmission of exchange rate movements to international prices and domestic inflation, the empirical frameworks undertaken have mainly employed VAR models and simultaneous equation systems.

2. As far as the inter-connections between exchange rates and domestic inflation are concerned, export prices happen to play a relatively less significant role in acting as causal links in the process of importing inflation from the external sector. Hence, the studies that have focused on ERPT to export prices of Indian exporters must be differentiated from the studies focusing on ERPT to import prices, volumes, and domestic prices and inflation.

3. Domestic inflation has been measured across the pricing chain including "consumer prices, producer prices, import prices and sometimes the prices set by domestic exporters" (Bhattacharya, Patnaik and Shah, 2008). However, import prices have generally been treated as the link between the exchange rate changes and the domestic inflation.

4. RBI has changed its exchange rate measurement convention from Rupees/foreign currency unit to foreign currency unit/rupee. Studies before 2017 that used the official bilateral and effective exchange rates would have employed the earlier definition. Even though it is just a matter of elementary arithmetic to convert from one quoting method to another, the interpretation of the ERPT coefficients must be undertaken with this recent change in mind.

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