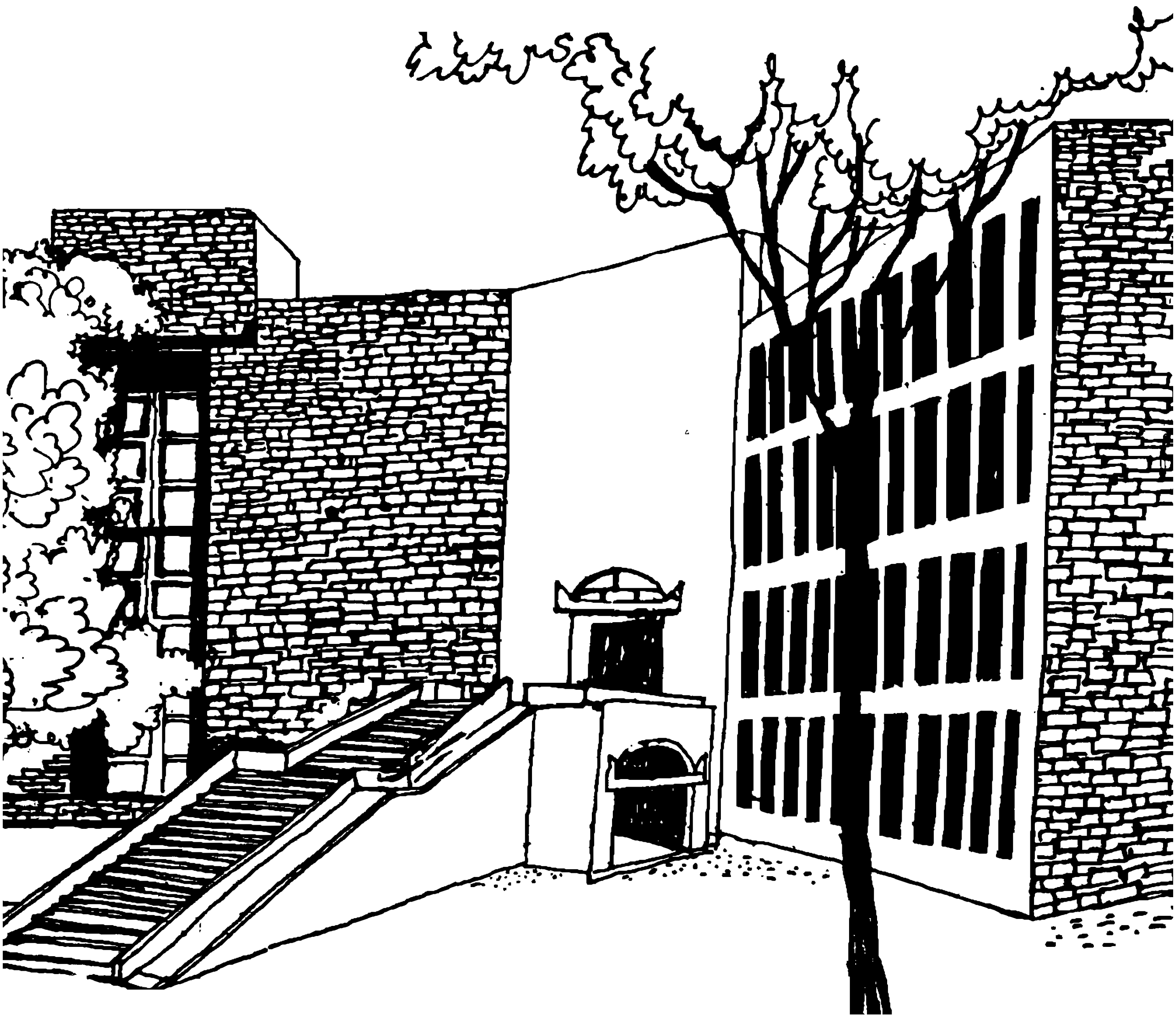
IIM
AHMEDABAD

Working Paper



IMPACT OF EXCHANGE RATE PASS-THROUGH
AND VOLATILITY ON INDIAN FOREIGN TRADE

By

Ravindra H. Dholakia
Ravindra Saradhi V.

W.P.No.2000-01-02
January 2000 1572

The main objective of the working paper series of the IIMA is to help faculty members to test out their research findings at the pre-publication stage.

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380 015
INDIA

Impact of Exchange Rate Pass-Through and Volatility on Indian Foreign Trade

Ravindra H. Dholakia
and
Raveendra Saradhi V.

Abstract

The exchange rate Pass-through and exchange rate volatility, are two important issues that determine the effectiveness of the exchange rate depreciation in achieving the desired trade balance. The aggregate analysis of Indian imports and exports with quarterly data from 1980 to 1996 attempted in the present paper has shown that the exchange rate pass through is complete for the import prices before and after 1991 policy reforms. Export prices, on the other hand, exhibited near full pass-though only after 1991. The study also indicated that the export quantities respond positively to the changes in the exchange rates, while the import quantities show resistance to the changes in the exchange rates. The adverse impact of the exchange rate volatility on price realisation has not transmitted to the quantities traded in both the exports as well as imports in India. The study reveals India's lack of bargaining power in the international markets both as a buyer and as a seller. It is argued that the economic reforms have strengthened the market forces by making them more responsive to the price signals. The study also indicates that targeting REER in India may not satisfactorily address the concerns for the trade balance, though it may be useful for export promotion.

Impact of Exchange Rate Pass-Through and Volatility on Indian Foreign Trade

Ravindra H. Dholakia**
and
Raveendra Saradhi V. **

1. Introduction:

After devaluation in 1991, studies on Indian exchange rate and trade balance concentrated on the effectiveness of exchange rate devaluation as a policy to improve the trade balance [see, Rajaraman (1991), Sarkar (1992, 1994, 1995, 1997), Bahmani-Oskooee and Malixi (1992), Nag and Upadhya (1994), Patra and Patnaik, (1994), Ranjan (1995), Buluswar, Thompson and Upadhyaya (1996), Nachane and Ranade (1998), etc.]. Out of these, only Patra and Patnaik (1994) and Ranjan (1995) studied the impact of exchange rate transmission into export and import prices. This transmission is an important determinant of the success of the exchange rate policy in bringing the desired changes in the trade balance. The other determinant is the extent and duration of adjustment of the quantities to the changes in the export and import prices. Since the classical small country assumption is not always valid as shown by Menon (1996) for Australian imports, we need to consider the import-export price sensitivity to exchange rates in India for determining the effectiveness of the exchange rate policy. Another important aspect of exchange rate not figuring in any of these studies is the exchange rate volatility. It is studied separately by Paul and Harish (1993) and Samantha (1998). Most of these studies are based on annual observations and ignore the time series properties of the data. As a result, the questions of timing of adjustments and seasonality are not properly addressed. Similarly, the issues of exchange rate volatility and its transmission to prices and quantity response are not simultaneously examined in any of these studies so

** The authors are respectively Professor and Doctoral Student at the Indian Institute of Management, Ahmedabad.

far. Moreover, it is also relevant to examine whether these behavioural relationships substantially shifted after the 1991 policy reforms.

In this paper, we examine the impact of exchange rate and exchange rate volatility on export-import prices and quantities using quarterly data for the period 1980-96. As the year 1991 is a major dividing line not only in terms of exchange rate devaluation but also other economic reforms in India, we tested the hypothesis about any behavioural change in the relationship in the post-1991 period. We have also taken care of the time series properties by conducting unit root and co-integration tests and derived the long run elasticities by estimating dynamic log-linear regressions.

2. The Background:

The standard IMF reform package includes maxi devaluation of the currency of the country to improve the trade balance. This prescription depends upon the elasticity approach to the balance of trade. Elasticity approach focuses on the exchange rate as the major determinant of the trade balance. The devaluation lowers the foreign currency price of exports and raises the rupee price of imports, and consequently the quantities respond to reduce the trade deficit. According to elasticity approach, devaluation improves the trade balance if it meets the criteria of Marshall-Lerner condition.[1] The era of floating exchange rates, which unfolded after the breakdown of Bretton Woods system, was perceived to be an efficient system to correct the balance of payments disequilibria. It also allows the governments to concentrate on achieving internal balance and other economic objectives since the external balance would be ensured automatically through exchange rate flexibility. Although many countries fulfilled the Marshal-Lerner condition, the trade account of several industrialised

[1] Simple Marshall-Lerner condition indicates an improvement in trade balance if the sum of the price elasticities of the demand for imports and the demand for exports, in absolute terms, is greater than 1. More complicated conditions in terms of the elasticities of demand and supply in the home country and foreign country for exports and imports can also be similarly stated. (See, Chacoliades (1990), P. 557- 61.)

countries showed persistence of the trade imbalances even after the devaluations. Such observations led to the critical assessment of the underlying assumptions of the elasticity approach to the balance of trade. Magee (1974) argued that the impact of the exchange rate changes on the trade flow is lagged due to contractual obligations. There is an initial deterioration of the trade balance, because it takes time for quantities to respond to changes in the price. Over a period of time, elasticities of exports and imports increase and the trade balance is expected to improve. This pattern of adjustment is referred to as the *J-curve* effect in the literature. It lays more emphasis on the lagged quantity response than on the lagged price response, and assumes that the exchange rate changes are fully transmitted into prices almost instantaneously.

The assumption of full and instantaneous transmission of exchange rate changes into prices is critical in the ultimate success of exchange rate policies to affect the trade-balance. If the exchange rate changes take time and do not get fully transmitted into prices, their effect on trade balance would be necessarily limited. Similarly, the changes in the exchange rate under the floating exchange rate system are generally not found to be in the same direction throughout. They usually fluctuate in practice. Exchange rate *overshooting* is a common occurrence. This brings to the focus another issue of the exchange rate volatility which by itself can hamper the quantity response and hence reduce the effectiveness of the exchange rate policy on the trade balance of the country.

The phenomenon of exchange rate pass through (ERPT) is measured as the extent to which exchange rate changes get transmitted to the destination currency prices of traded goods. Under perfect competition among the suppliers, it is natural to expect that the pass through will be complete, i.e., when the rupee depreciates by 10%, the price of Indian imports in rupees would increase by 10% and the dollar price of Indian exports would fall by 10%. However, the phenomenon of the import intensity of exports being positive and imperfect competition due to segmented markets and product differentiation can lead to less than complete pass through.

It has often been observed that some exporters with market power adjust their profit margins rather than fully adjust their export prices to the exchange rate changes. As a result, the local currency import prices change by less than what would otherwise be expected. Such "pricing to market" (Krugman, 1987) could be on account of: the input costs not being dependent on exchange rates; irreversible nature of the initial investments to develop the foreign market and get the access to it; strategy to protect the market share; cost of creating additional capacity and hence the extent of perceived permanency of the exchange rate changes on the part of the suppliers; consumers' resistance in switching over to the substitutes immediately; presence of the multi-nationals and their transfer-pricing practices; presence of the non-tariff barriers as pointed out by Bhagwati (1988); and the menu costs and time lag involved between the order and payment.

The empirical evidence for the large economies (predominantly U.S.A.) mostly reported incomplete ERPT and it was thought that the small economies would exhibit full pass through because they are likely to be the price takers internationally. Studies by Khosla and Teranishi (1989) challenged this assumption by reporting incomplete ERPT for small countries such as Indonesia, and the Philiphines. Mereno (1989) for Taiwanese and Korean export and import prices, and Menon (1992) for Australian exports also report incomplete pass through. Menon (1996) in a disaggregated study of Australian manufactured imports dispelled the notion of small country assumption more convincingly. Subsequently, Lee (1997) for Korea also suggests incomplete pass through of change in exchange rate to import prices. In contradiction to the above, Clark (1991) for Botswana, and Kenny and McGettigan (1998) for Ireland find the pass through to be close to full. Patra and Patnaik (1994) and Ranjan (1995) report a considerably incomplete ERPT ranging from 40% to 90% in the case of Indian exports. Their methodology was indirect in the sense that exchange rate did not figure as an explanatory variable in their equations. They derived the pass-through coefficient on the basis of the estimates of elasticities of demand and supply for exports and imports. Their results were also not very convincing because of the perverse sign of the price elasticity of supply.

The implication of exchange rate volatility (ERV) on the trade volume can be examined in terms of the uncertainty in the exchange rates leading to the uncertainty of the effective price and costs applicable to the exporters and importers. They ultimately result in uncertain profits. If the profits are more risky, it may be expected that the risk averse trader will reduce his volume of trade to minimise adverse impact on his profits. There are also arguments in favour of positive effect of exchange rate volatility on trade flows. Cabllero and Corba (1989) conclude that under the perfect competition, convexity in profit function, symmetric costs of capital adjustment, and risk neutrality, increases in exchange rate volatility will increase exports. But the authors also point out that exports can decline with increasing exchange rate volatility if the assumptions of risk neutrality and symmetric costs are relaxed. Though the negative effect of exchange rate volatility on trade flows finds favour in the theoretical literature, the empirical evidence is rather inconclusive. Most of the studies relating to overall levels of international trade suggest that exchange rate variability has had no significant effect on the overall volume of international trade. While some of the studies using bilateral data found negative relationship between ERV and trade, Ying and Varangis (1992) in a study of six countries found contradictory results. Kishore, et al. (1988) found positive link between Indian export instability and exchange rate variability. Paul and Harish (1993) using both the OLS and VAR models studied six developing countries including India. In case of India, they found that the variability of real exchange rate had negative effect on export volumes. Their results further suggest that the relationship is likely to be more pronounced in the short run than in the long run. Samanta (1998), on the other hand, using error correction mechanism did not find statistically significant relationship between the exchange rate volatility and India's trade during 1960-

1986. Thus, the empirical evidence both at the international level and in the case of India on the relationship between ERV and trade flows is inconclusive.

From the above discussion, it is clear that ERPT and ERV are two important aspects that have bearing on the trade account of a nation particularly under the flexible exchange rate regime. In the empirical studies on these issues, ERPT tests are based on price series (mostly unit value index) as the dependent variable while the tests relating to ERV are based on trade volumes (mostly quantum index) as the dependent variable. The explanatory variables are more or less the same in most of the studies. Both these issues are, however, interconnected. The volatility affects the international trade volume through the increased prices of traded goods as the risk perceived by the player increases. The incomplete pass through limits this variability of the prices and hence reduces the adverse effects of fluctuating exchange rates on the quantities traded. Their simultaneous effect on the trade account has to be empirically determined by considering both the price and quantity equations incorporating both these aspects. Except Ying and Varangis (1992), there are hardly any serious efforts in this direction. We propose to make a modest attempt by considering Indian aggregate data on exports and imports on quarterly basis from Q2-1980 to Q1-1996.

3. The Model:

We propose a model of trade account of the balance of payments by considering the demand and supply equations for both exports as well as imports. We incorporate both exchange rate and exchange rate volatility as explanatory variables in these equations. A simple model for exports is developed as follows:

The structural form of the model consists of equations for the demand for exports (Qdx) and supply of exports (Qsx) as dependent variables and prices, incomes, exchange rates and exchange rate volatility as independent variables, besides the equilibrium condition; i.e.

$$Qdx = fx\ (Px, GDPf, ERx, ERVx, FPx) \quad (1)$$

$$Qsx = gx\ (Px, ERVx, DP) \quad (2)$$

$$Qdx = Qsx = Qx \quad (3)$$

Where Px is price of exports in rupee terms; Qx is the quantity exported; GDPf is the foreign income; ER is exchange rate of trading partners' currency in rupees; ERV is a measure of exchange rate volatility; DP is the index of domestic wholesale prices in rupee terms; and the FP is the index of foreign wholesale prices in foreign currency. Subscripts x implies variable specific to export. All the variables here are taken in their natural logarithms.

Solving the system, the reduced form of the model is obtained as:

$$Px = hx\ (GDPf, ERx, ERVx, FPx, DP) \quad (4)$$

$$Qx = ix\ (GDPf, ERx, ERVx, FPx, DP) \quad (5)$$

Similarly, we can consider the structural form of the model in terms of the demand for imports (Qdm), supply of imports (Qsm) and the equilibrium condition:

$$Qdm = fm\ (Pm, GDPm, ERVm, DP) \quad (6)$$

$$Qsm = gm\ (Pm, ERm, ERVm, FPm) \quad (7)$$

$$Qdm = Qsm = Qm \quad (8)$$

Where Pm is the price of imports in rupee terms, Qm is the quantity imported, GDPm is the Indian income, and subscript m implies variable specific to import. Solving the system of equations 6 to 8, the reduced form equations are:

Pm = hm (GDPm, ERm, ERVm, FPm, DP) (9)

Qm = im (GDPm, ERm, ERVm, FPm, DP) (10)

This way of modelling the phenomenon amounts to assuming that the equilibrium in the export-import markets has no appreciable impact on the exchange rate determination. The exchange rate and foreign price levels are included to account for the relative price effects on the supply and demand for exports and imports. Taking natural logarithms of all variables in the equation enables us to separate the exchange rate from the foreign prices. The GDP is included to take income effect into consideration. As we can see, these demand and supply equations are similar in form to the standard partial equilibrium elasticity approach with income effect.

4. Econometric Method:

Most of the earlier studies on the subject have not taken into consideration the possibility of nonstationarity of time series data. As it is well recognised by now, if the time series data are nonstationary, the regression on level variables may lead to spurious regression problem. However, even if the variables are nonstationary there exists a possibility that their linear combination might be stationary, i.e., the variables are cointegrated. When the variables are cointegrated, regression on the level variables will not be spurious and can be meaningful. In such cases, we do not have to lose any valuable long-term information, which we end up losing if we were to use first differences of the variables (Gujarati, 1995).

We test all the variables for stationarity and cointegration, using Augmented Dickey-Fuller and Philips-Perron tests. After finding the cointegration we specify the dynamic model to estimate the long-run parameters directly because as suggested by Maddala (1992), it is better to use a procedure of estimation that jointly estimates both long run parameters and shortrun dynamics than estimating longrun relationships through static equation. Notwithstanding the superconsistency property of I(1) variables, which assures that it is asymptotically valid to omit dynamic terms, the Monte Carlo works of Banerjee et al. (1993) and Inder (1993), show that this bias is often substantial.[2] As it is shown by Harris (1995), the Engle-Granger approach of estimating the static equation is equivalent to omitting the short-run elements of the underlying dynamic model. This is because, if more complicated dynamic models become necessary to capture the relationship between x and y, then estimating the static model to obtain an estimate of the long-run parameter β will push more complicated dynamic terms into the residual which, he argues, can show severe autocorrelation. Therefore, in order to take into account the lagged response of prices and quantities to the changes in the explanatory variables, we have included the lagged dependent variable in addition to the contemporaneous independent variables in the equations, wherever they turned out to be significant. This form of representation is called partial adjustment model which is a special case of autoregressive distributed lag models. [3] We also checked for autocorrelation and other traditional diagnostic tests to ensure that the estimated equations meet these criteria which are ignored in the Engle-Granger first stage estimation.

We have also introduced seasonal dummies to take into account the seasonality. The seasonal dummies were removed when they were not statistically significant. We have also considered the dummy variables for slope

---

[2] Banerjee, et al. (1993) has shown that this bias is less if the R^2 value is high.

[3] Two variable case autoregressive distributed lag model, (ARDL (p.q.), where p stands for number of lags of dependent variable while q stands for number of lags of the independent variable can be represented as $Yt = \alpha + \beta 1\ Xt + \beta 2\ Xt\text{-}1 + \beta 3\ Yt\text{-}1 + ut$. Partial adjustment model is represented as ARDL (1, 0)

coefficients of exchange rate and volatility therein to analyse whether they are significantly different before and after 1991 July since it is a well recognised threshold date for the regime-switch in India. The presence of these dummies in the reported estimated equations depends on their statistical significance. We define these dummy variables as follows:

Q1	=	1 for quarter 1 and 0 for other quarters, similarly for the other quarters.
D91	=	1 >= 1991 q3, 0 otherwise
DER_t	=	$D91^* (ER_t - ER_{1991q3})$
$DERV_t$	=	$D91^* (ERV_t - ERV_{1991q3})$

The final estimated equations are as follows:[4]

$$Px_t = \beta_0 + \beta_1 ER_{Xt} + \beta_2 ERV_{Xt} + \beta_3 FP_{Xt} + \beta_4 DP_t + \beta_5 GDP_{ft} + \beta_6 DERxt + \varepsilon_{Xt} \quad (9)$$

$$Qx_t = \delta_0 + \delta_1 ER_{Xt} + \delta_2 ERV_{Xt} + \delta_3 FP_{Xt} + \delta_4 DP_t + \delta_5 GDP_{ft} + \delta_6 DER_{Xt} + \delta_7 Q_{Xt-1} + \varepsilon_{Xqt} \quad (10)$$

$$P_{mt} = \alpha_0 + \alpha_1 ER_{mt} + \alpha_2 ERV_{mt} + \alpha_3 FP_{mt} + \alpha_4 DP_t + \alpha_5 GDP_{mt} + \alpha_6 Trend + \alpha_7 DERV_{Xt} + \alpha_8 P_{mt-1} + \varepsilon_{mt} \quad (11)$$

$$Q_{mt} = \gamma_0 + \gamma_1 ER_{mt} + \gamma_2 ERV_{mt} + \gamma_3 FP_{mt} + \gamma_4 DP_t + \gamma_5 GDP_{mt} + \gamma_6 DER_{mt} + \gamma_7 DERV_{mt} + \varepsilon_{Mqt} \quad (12)$$

[4] Seasonal dummies are not shown here. We have also tried trend variable in the estimated equations and retained it only in the import price equation.

The coefficient of the logarithm of exchange rate in the case of import price (equation 11) measures the extent of pass through directly. When $\alpha 1 = 1$, it represents full pass through because the prices of imports expressed in rupees is fully reflecting the changes in the exchange rate. When $\alpha 1 = 0$, on the other extreme, the pass though is nil implying that the country has considerable market power in the import market. The coefficient of the logarithm of exchange rate in the case of export price (equation 9) measures the direct effect of exchange rate changes on the export prices measured in rupees. As the pass through is defined in terms of destination currency, we derive the proportion of the pass through by $1 - \beta 1$.[5] If India is a price taking country then $\beta 1 = 1$. It leaves the foreign currency price of exports untouched and in rupee terms the prices increase/decrease fully. When $\beta 1 = 0$, then, the changes in the exchange rate are fully passed on to the foreign currency price of exports i.e. pass through is 1.

5. Measurement of Variables and Data Sources:

Most of the studies have used unit value index as the measure of import and/or export prices. Their major limitations are that: (1) they are average realisations or expenditures during the period under consideration and not the price of the product; and (2) they are not fixed weight indices so any changes in the composition of products will affect the unit value though there is no change in the prices. However, there are no separate import or export price indices available in India. Only unit value indices for exports and imports are available officially on a quarterly basis obtained from the Monthly Abstract of Statistics, published by the CSO, Government of India (provided by DGCI&S). We have, therefore, used the same for the present study. Similarly, the quantum indices of exports and imports on quarterly basis as provided by DGCI&S are used for

[5] This can be easily seen from the equation (9). Consider all other variables as given. The equation (9), writing the logarithms explicitly, becomes $\ln Px = \beta + \beta 1 \ln ER$. But Px is in rupee terms. The foreign price of exports would be Px/ER. Therefore, $\ln Px - \ln ER = \beta + \beta 1 \ln ER - \ln ER$, i.e. $\ln (Px/ER) = \beta - (l - \beta 1) \ln ER$ where $(1 - \beta 1)$ is the proportion of the pass through.

measuring the quantities. In 1989, quantum and price data of exports and imports are missing for the second, third and fourth quarters. We have used the EMIs Algorithm to impute the missing data. Details on algorithm are available in King, et al. (1998). Amelia, a computer program, developed by Honaker, et al. (1999) is used for this purpose.

For exchange rate variable, nominal exchange rates for exports and imports are constructed separately using the export and import weights of the top 4 trading partner countries.[6] Thus, the exchange rate variable used in the export equations is different from the one used in the import equations. Nominal exchange rate of a foreign currency is expressed in terms of Indian rupees, so that an increase in the series means depreciation of the Indian rupee. The exchange rate index is computed as the weighted geometric mean of bilateral exchange rates. We derived the bilateral rates of rupee with other currencies by crossing rupee dollar rate and dollar and other currency rates obtained from Global Financial Data CD.[7] Volatility of exchange rate is measured as the standard deviation of monthly average exchange rates of past 12 months, and these monthly standard deviation in a quarter are averaged again to get quarterly standard deviations.

Foreign price is measured as the weighted wholesale price index of four major trading partners and oil prices. The foreign prices in the export equation have the same weights as the ones used for exchange rates in export equation. The foreign prices in the import equation include weight for oil. These weights are given in *Table 1*. Domestic price variable is proxied by wholesale price index in India. Data for these variables are obtained from Global Financial Data CD.

In the case of exports, the four countries GDP series are used to construct

---

[6] The formulae for calculating the nominal effective exchange rate:
$NEERt = EXP. \sum_i W_i \ln(100{*}Eit/Eio)$. Where Eit, Eio are current and base period exchange rates; W_i are trade weights, such that $\sum_i W_i = 1$; exp = exponential. The weights are given in *Table 1*.

the combined series of the foreign income as the weighted average. These are obtained from 1. Bureau of Labor Statistics for USA for the entire period;[8] 2. The UK office for National Statistics (ONS) for the UK for the period 1985-96;[9] 3. Sophia University website for the Japan for the period 1980 to 1995;[10] and 4. IMF, International Financial Statistics for the Germany and the remaining data for UK and Japan. The Indian GDP on quarterly basis is not available for the whole period. It is, therefore, proxied by the Index of Industrial Production (IIP). Monthly IIP index is used for calculating the quarterly average. It is obtained from the Monthly Abstract of Statistics, published by the CSO, Government of India.

Table 1: Weights used for constructing Indices of Exchange Rate and Foreign Prices

Country	Import Weights		Export Weights
	Foreign Prices	Exchange rate*	GDP & Foreign Prices
USA	23.09%	47.02%	43.06%
UK	20.55%	20.55%	15.88%
Germany	16.75%	16.75%	18.18%
Japan	15.67%	15.67%	22.89%
OIL	23.93%		
	100%	100%	100%

* Oil weight is added to U.S. $.

Source: Monthly Statistics of Foreign Trade, DGCI&S. Period 1988-93.

[7] Available at http://www.globalfindata.com
[8] Available at http://stat.bls.gov/blshome.htm
[9] Available at http://bizednet.bris.ac.uk:8080/dataserv/ons/datasets/onsdatalist.htm
[10] Available at http://econom10.cc.sophia.ac.jp/needs/index.htm

6. Results:

All the variables (in logarithms) are tested for stationarity and cointegration. The Augmented Dickey-Fuller and Philips-Perron tests indicate that all except four variables were nonstationary in levels but stationary in first differences, i.e., variables are integrated of the order I(1).[11] These results are reported in *Appendix Table A1*. The Philips-Perron tests of cointegration based on residuals indicate that they are cointegrated (See *Appendix Table A2*). We also conducted three types of unit root tests (recursive, rolling, and sequential) as suggested by Banerjee, Lumsdaine and Stock (1992) on log-levels to check whether structural breaks are appropriately considered for the presence of the unit roots (See *Appendix Table A3*). Based on all these tests, we conclude that all the variables are nonstationary in levels but cointegrated.

As each of the equations tested shows that it is cointegrated, we performed the analysis on the level variables (in logarithms). We estimated several alternative models with different lags and dummy variables. All the models are then tested for Ramsay specification test, autocorrelation, heteroscedasticity, normality, etc. Among the models complying with all these tests satisfactorily, the final choice is made on the basis of the goodness of fit and statistical significance of coefficients.

In the case of the Indian imports, the estimates of our selected import prices and import quantities are presented in *Tables 2 and 3* respectively. From the selected model of import prices, we can derive the long run coefficients of the explanatory variables. These are presented as follows:

[11] The four variables are Qxt, Qmt, DP, GDPm (or IIP). There is an uncertainty about the I(1) property of these variables, as both the tests differ. For the purpose of cointegration tests we considered these variables as I(1), as one of the tests indicate them as I(1).

For the dependent variable Pm_t					
Independent Variables	ER_{Mt}	ERV_{Mt}	FP_{Mt}	DP_t	GDP_{Mt}
Long term Coefficient	1.29	-0.07	1.15	- 0.26	-0.09
Corresponding T-values	3.19	-6.3	5.38	-0.28	-0.62

Since the regime-switch dummy for the slope coefficient of the exchange rate volatility (ERV) is significant, the slope coefficient for the period after q2-1991 works out at 0.23 with the t-value at 26.2 which is statistically significant at 1% level.[12] Thus, if the volatility of exchange rate increases by 1%, the import prices would increase by 0.23% after 1991. Our results support the hypothesis of full pass through of exchange rate changes in the case of import prices.[13] Our aggregative study shows no evidence of "pricing to market" in the case of the Indian imports. It is expected, since a large portion of imports consists of petroleum products and internationally traded commodities. This relationship has not altered in the post 1991 period. On the whole, Indian imports behave as if India is a price-taker in the international market and lacks any market power as a buyer. Risk averse traders would, therefore, tend to raise the price in the face of excessive volatility of exchange rates which occurred after 1991.

The results of our selected model for the import quantities are presented in details in *Table 3* and are summarised as under:

For the dependent variable Qm_t					
Independent Variables	ER_{Mt}	ERV_{Mt}	FP_{Mt}	DP_t	GDP_{Mt}
Long term Coefficient	-0.38	0.019	- 0.79	0.46	1.06
Corresponding T-values	-0.82	0.23	-2.20	0.74	3.39

The long run estimates of the coefficients in the equation reported above suggest that the volume of the Indian imports gets determined to a large extent

[12] The t-value is calculated using the variance-covariance matrix of the coefficient estimates. The t-values of the long-run estimates of the coefficients are based on Kmenta (1971, p. 443-444)
[13] Exchange rate coefficient is 1.29 with the standard error of 0.40. Thus, it is not significantly different from unity.

by the domestic income (or IIP) and the foreign prices. Other variables do not appear to play any significant role. The exchange rate and volatility therein particularly do not show any significant relationship with the volume of imports. The regime-switch dummy for the exchange rate, however, shows positive and significant impact on volume of imports. This is not surprising because after 1991, export orientation and export intensity of the Indian industry has substantially increased and the import intensity of the exporting firms is higher (see, Dholakia and Kapur, 1999). Moreover, after 1991, there has been a substantial reduction in the tariff rates, which acts counter to depreciation of the exchange rate. On the whole, therefore, changes in the exchange rates after 1991 have not had any dampening effects on the volume of imports. As such, the long run elasticity of import volume with respect to the exchange rate works out to +0.72 after 1991 with the t-value to be just 1.05. The estimate is thus not statistically different from zero. Similarly, the long run coefficient of the exchange rate volatility after 1991 is -0.12 with the t value of -1.36, which is statistically insignificant. The import quantity in India as per our finding is highly resistant to the exchange rate and the volatility therein. It also does not show any marked seasonality or any significant relation to the domestic prices. All this shows the major weaknesses of India as a buyer in the international market.

Turning to the Indian exports, the results of our selected model of the export prices are reported in details in *Table 4* and is summarised as under:

For the dependent variable Px_t					
Independent Variables	ER_{Xt}	ERV_{Xt}	FP_{Xt}	DP_t	GDP_{ft}
Long term Coefficient	0.70	-0.05	1.34	0.35	-0.45
Corresponding T-values	4.23	-2.06	3.50	1.18	-1.12

The dummy on the slope of exchange rate is -0.40 with t-value (-2.39) which is significant at 5% level of significance. So the long run estimate after q2-1991 for the coefficient of logarithm of exchange rate (i.e. ER) is 0.30.

Our results suggest that the exchange rate pass-through (i.e. ERPT) in the case of Indian exports before 1991 was only 0.30, which is significantly less than 1. It has increased to 0.70 after 1991, since the regime-switch dummy for the exchange rate slope (0.4) was statistically significant. When we consider the import intensity of the Indian exports, the changes in the exchange rates would not be transmitted fully to the export prices in the foreign currency. This is particularly so because we have seen above that ERPT is full for the import prices in India. Therefore, a 5% depreciation of the Indian rupee leads to an increase of 5% in the Indian price of imported materials, and as a result, the cost of production would increase for an exporter depending on his import intensity. If we take the average import intensity of exports to be about 10% for the whole period (see, Dholakia and Kapur, 1999), ERPT can be regarded as complete when it is 0.9 since 0.1 is the adjustment for the import intensity of exports. After1991, since ERPT for Indian exports is found to be 0.7, which is not statistically different from 0.9, we can not reject the hypothesis of complete pass through. Moreover, exchange rate volatility (ERV) has a negative impact on the export prices and is statistically significant. However, its coefficient is numerically very low at 0.05 which is stable over time. This result suggests that increased exchange rate volatility have a depressing effect on prices of Indian exports. ERPT and ERV coefficients clearly show that after 1991, the Indian exporters are facing greater competition and lacking any significant bargaining power as sellers.

From the selected model of the export quantities (See *Table 5*), long run estimates of the coefficients can be obtained as under:

For the dependent variable Qx_t					
Independent Variables	ER_{Xt}	ERV_{Xt}	FP_{Xt}	DP_t	GDP_{ft}
Long term Coefficient	0.95	0.007	2.55	- 1.68	1.95
Corresponding T-values	3.85	1.71	2.30	-1.964	1.75

The long run estimate of the coefficient of the logarithm of the exchange rate (i.e. ER) after the q2-1991 works out to 2.21 with the t-value of 5.32 which is significant at 5% level. It can be readily seen from these results that the export quantities respond positively and significantly to the exchange rate depreciation. The exchange rate slope dummy has positive and statistically significant coefficient (0.92 with t-value 2.71) implying that the exchange rate elasticity of export quantities after 1991 (i.e. 2.21) is considerably higher than the one before 1991 (i.e. 0.95).[14] The Indian exports in volume terms were elastic with respect to the exchange rate and have become more elastic after the policy reforms and globalization trends in the Indian economy. The exchange rate volatility (ERV) has a statistically significantly positive impact in the long-run. However, the coefficient is numerically very low (0.007) which only leads us to say that ERV is not likely to adversely affect the quantities exported from India. Among the traditional variables, the foreign prices as well as the foreign income have significant positive impact on the Indian exports, whereas the Indian prices have negative significant impact on the quantity of the exports. A relatively high cross elasticity of exports with respect to the domestic prices suggests that production for the domestic market is a close substitute for the exports. However, the same does not hold for Indian imports. Higher domestic inflation discourages Indian exports. In our export quantity equation, it is interesting to observe that all the three components of the real effective exchange rate (REER) are individually significant statistically.

The export quantities, moreover, show seasonal pattern as all the three seasonal dummies are statistically significant. On the other hand, only dummy on the quarter ending in December is significant in the case of export prices. Since all the seasonal dummies in both these equations are negative, the clear implication is that during the last quarter, i.e. the Christmas quarter, Indian exports suffer in terms of price as well as quantity when the markets everywhere are looking up including the Indian domestic market. This further corroborates

[14] The long run coefficient of the exchange rate dummy is 0.922/(1-0.27) = 1.26

our finding that domestic market is considered a close substitute for the Indian exports.

7. **Concluding Remarks:**

In this paper we have examined the impact of exchange rate pass through (ERPT) and exchange rate volatility (ERV) on the prices and quantities of Indian imports and exports. The study reveals that in the case of import prices the ERPT is full throughout the period, indicating the 'price taking' behaviour; whereas the export prices exhibit near complete ERPT only after 1991, which was considerably incomplete before 1991. This suggests that India does not have any significant bargaining power either as a buyer or as a seller in the international market. It is, therefore, not surprising to find that increased exchange rate volatility would have an adverse impact on the prices paid and realised by the Indian Importers and exporters respectively. It is, however, not likely to affect the quantum of the external trade for India negatively. The adjustment process of prices and quantities to exchange rate changes to a large extent seems to be completed in two quarters for both exports and imports. The 1991 liberalization and economic policy reforms in India seem to have resulted in strengthening the market forces by making them more responsive to the price signals and promoting greater competition. An interesting finding of our study is that only the Indian export quantity is sensitive to all the three component variables of the real effective exchange rate. Neither import quantities nor export-import prices are sensitive to all the three component variables of REER. Thus, targeting REER in India may not satisfactorily address the concerns for the trade balance, though it may be useful for export promotion. Separately targeting domestic inflation rate and aim to maintain the stability of nominal exchange rate appear to be a better option for achieving the desired trade balance and improving the terms of trade. However, if the objective is revival of the economy through export promotion, careful depreciation of rupee avoiding excessive fluctuation in the exchange rate could be beneficial to the country.

Table 2: Results for the Import Price equation			
Variable	Coefficient	t-statistic	P-value
ERmt	.823	1.960	.055
ERVmt	-.046	-.701	.487
FPmt	.731	2.192	.033
DPt	-.169	-.272	.787
GDPmt	-.059	-.240	.811
Constant	-3.82	-1.794	.078
Ln(trend)	-.069	-1.039	.303
DERVmt	.192	2.438	.018
Pmt-1	.367	3.145	.003

R^2 = .91, Adj R^2 = .897, F-stat = 68.5057, LM1=. 47[.491], LM2= .442[.802], LBQ 1= .16 [.68], LBQ 2 = .23 [.89], ARCH test = .00005 [.998], WH= 44.86 [.393], RESET2 (1, 53) = 0.224, JB=1.25[.533]

Table 3: Results for the Import quantity equation			
Variable	Coefficient	t-statistic	P-value
ERmt	-0.379	-0.82	0.417
ERVmt	0.019	0.23	0.817
FPmt	-0.796	-2.20	0.032
DPt	0.460	0.74	0.461
GDPmt	1.065	3.39	0.001
Constant	3.729	1.64	0.106
DERmt	1.095	2.31	0.025
DERVmt	-0.136	-1.24	0.219

R^2 = .9037, Adj R^2 = .891, F-stat = 75.13, LM1=.101[.750], LM2= 1.10[.577], LBQ 1= .114 [.735], LBQ 2 = 1.21 [.545], ARCH test = 1.152 [.998], WH= 32.004 [.417], RESET2 (1, 55)= 0.423, JB = 1.67[.432]

Table 4: Results for the Export Price equation			
Variable	Coefficient	t-statistic	P-value
Erxt	0.703	4.23	0.000
ERVxt	-0.053	-2.06	0.044
FPxt	1.340	3.50	0.001
DPt	0.345	1.18	0.245
GDPft	-0.445	-1.12	0.268
Constant	-5.907	-3.09	0.003
Q4	-0.049	-2.97	0.004
DERxt	-0.404	-2.39	0.020

R^2 = .988, Adj R^2 = .986, F-stat = 662.417, LM1= 3.86[.049], LM2= 4.12[.127], LBQ 1=3.70 [.054], LBQ 2 = 5.46[.065], ARCH test = 1.35[.244], WH= 34.0 [.419], RESET2 (1, 55)= 2.44, JB = 2.80 [.247]

Table 5: Results for the Export quantity equation			
Variable	Coefficient	t-statistic	P-value
ER_{Xt}	0.691	2.028	0.048
ERV_{Xt}	0.0057	0.116	0.908
FPX_{Xt}	1.858	2.318	0.024
DP_t	-1.227	-1.948	0.057
GDP_{ft}	1.425	1.829	0.073
Constant	-9.640	-2.326	0.024
Q2	-0.348	-7.936	0.000
Q3	-0.157	-3.375	0.001
Q4	-0.137	-3.410	0.001
DERxt	0.922	2.717	0.009
Qxt-1	0.270	2.189	0.033

R^2 = .956, Adj R^2 = .948, F-stat = 144.731, LM1= 1.78[.181], LM2= 2.95[.228], LBQ 1=. 934 [.334], LBQ 2 = 1.02[.600], ARCH test = 3.04 [.081], BPG (10df) = 10.435, RESET (1, 50 df)= 0.006, JB = .789 [.674]

Notes:

1. Figures in brackets, followed by test statistics, are P-values.
2. LM1= Breusch-Godfrey LM test for autocorrelation of order 1.
3. LBQ1= Ljung-Box Q statistic for autocorrelation of order 1.
4. ARCH= Test for ARCH (1) residuals
5. WH= White hetroskedasticity test. Whenever this test not possible to due to degrees of freedom we have used Breush Pagan Godfray (BPG) test.
6. RESET Ramsay specification tests, degrees of freedom in brackets.
7. JB = Jerque-Bera (LM) normality test.

Appendix

TABLE A1: Results of Unit Root Tests								
	Log Levels				Log First Difference			
Variable	**ADF**		**Phillips Perron**		**ADF**		**Phillips Perron**	
	Test Statistic	**P-value**	**Test Statistic**	**P-value**	**Test Statistic**	**P-value**	**Test Statistic**	**P-value**
$\mathbf{P_{xt}}$	-1.618	0.78	-7.47	0.62	-6.24	0.00000	-77.92	0.00000
$\mathbf{Q_{xt}}$	1.377	1.00	-27.08	**0.016**	-4.4	0.00029	-68.10	0.00000
$\mathbf{ER_{xt}}$	-1.277	0.89	-3.07	0.93	-4.1	0.00099	-81.53	0.00000
$\mathbf{ERV_{xt}}$	-2.735	0.22	-13.54	0.24	-3.64	0.00503	-53.92	0.00000
$\mathbf{FP_{xt}}$	-2.526	0.31	-12.10	0.31	-2.83	0.05440	-23.56	0.00480
$\mathbf{DP_t}$	-0.312	0.98	-0.14	0.99	-1.5	**0.53200**	-58.27	0.00000
$\mathbf{GDP_{ft}}$	-2.658	0.25	-8.93	0.51	-2.97	0.03760	-54.96	0.00000
$\mathbf{P_{mt}}$	-3.081	0.11	-26.45	**0.019**	-5.24	0.00001	-79.31	0.00000
$\mathbf{Q_{mt}}$	0.350	0.99	-21.52	0.052	-4.38	0.00032	-70.85	0.00000
$\mathbf{ER_{mt}}$	-1.331	0.88	-2.88	0.94	-3.93	0.00180	-75.35	0.00000
$\mathbf{ERV_{mt}}$	-2.794	0.19	-13.36	0.25	-3.48	0.00849	-51.82	0.00000
$\mathbf{FP_{mt}}$	-1.998	0.60	-11.66	0.33	-4.56	0.00015	-54.44	0.00000
$\mathbf{GDP_{mt}}$	-1.813	0.69	-52.45	**0.00006**	-1.8	**0.38000**	-58.71	0.00000

NOTE:
1. H0: Unit Root present
2. Tested equation for levels include constant and trend.
3. Tested equation for first difference includes only constant.

TABLE A2: Results of Cointegration Tests		
Variables Tested for Cointegration (in logs)	Z-TEST	T-TEST
P_{xt}, ER_{xt}, ERV_{xt}, FP_{xt}, DP_t, GDP_{ft}	-49.176 **	-6.3979 **
Qx_t, ER_{xt}, ERV_{xt}, FP_{xt}, DP_t, GDP_{ft}	-58.888**	-7.3057**
P_{mt}, ER_{mt}, ERV_{mt}, FP_{mt}, DP_t, GDP_{mt}	-41.461*	-5.5274**
Q_{mt}, ER_{mt}, ERV_{mt}, FP_{mt}, DP_t, GDP_{mt}	-45.984 **	-5.9273 **

Note:
1.H0: No Cointegration
2. Constant is included in each of the equations tested and not trend.
** Significant at 5% level, * significant at 10% level

Critical Values for Philips-Perron type Cointegration tests (Davidson and MacKinnon, 1993)

10%		5%	
Z-TEST	T-TEST	Z-TEST	T-TEST
-38.4	-4.42	-43.4	-4.71

Table A3: Results of Unit Roots Tests with Structural Breaks (log-level)								
	Test Statistics							
	Px	ERx	ERVx	FPx	DP	GDPf	Qx	Pm
RECURSIVE	-2.00	-2.91	-2.59	-2.42	-2.32	-2.46	-1.83	-2.30
ROLLING	-2.81	-4.89	-4.05	**-5.25**	-4.71	-2.42	-3.29	-2.40
MEAN SHIFT	-2.26	-3.95	-2.13	-1.98	-2.41	-2.34	-1.31	-2.11
TREND SHIFT	-1.96	-3.19	-2.27	-2.12	-2.68	-2.84	-1.37	-1.91
	Test statistics						Critical Values	
	ERm	ERVm	FPm	GDPm	Qm		**2.50%**	**5%**
RECURSIVE	-2.80	-2.58	-1.92	**-5.61****	-3.47		-4.62	-4.33
ROLLING	-4.89	-4.01	-4.89	-3.12	-2.49		-5.29	-5.01
MEAN SHIFT	-3.81	-2.12	-2.06	-3.39	-1.54		-5.07	-4.8
TREND SHIFT	-2.99	-2.28	-2.07	-3.24	-1.69		-4.76	-4.48

Note:
1. H0: Unit Root present.
2.Critical values are given by Banerjee, Lumsdaine and Stock (1992)
3. Only GDPm in recursive method rejects the hypothesis at 2.5% level.

References:

1. Bahmani-Oskooee, M. and Malixi, M. (1992) " More Evidence on the J curve from LDCs", *Journal of Policy Modeling*, 14 (5), 641-53.
2. Banerjee, A., Lumsdaine, R.L. and Stock, J.H. (1992) "Recursive and Sequential Tests of the Unit Root and Trend Break Hypothesis: Theory and International Evidence", *Journal of Business and Economic Statistics*, 10, 271-87.
3. Banerjee, A., Dolado, J.J., Galbrith, J.W. and Hendry D.F. (1993) *Cointegration, Error Correction, and the Econometric Analysis of Nonstationary Data*, Oxford: Oxford University Press.
4. Bhagwati, J.N. (1988) "The Pass-Through Puzzle: The Missing Prince from Hamlet", *mimeo*, Columbia University.
5. Buluswar, M. D., Thomson, H. and Upadhyaya, K. P. (1996) "Devaluation and the Trade Balance in India", *Applied Economics*, 28(4), 429-32.
6. Caballero, R. J. and Corbo, V. (1989) "How Does Uncertainty About the Real Exchange Rate Affect Exports?" *Working Paper*, World Bank.
7. Chacholiades, M. (1990) *International Economics*, Intl. Edn. Singapore: McGraw-Hill Publishing Company.
8. Clark, L. J. (1991) "The Exchange Rate and the Price Level in a Small Open Economy", *Journal of Policy Modeling*, 13(2), 309-15.
9. Dholakia, R. H. and Kapur, D. (1999) "Trade, Technology and Wage effects of the Economic Policy Reforms on the Indian Private Corporate Sector", *The Indian Journal of Labour Economics*, 42(4), 981-91.
10. Davidson, R. and Mackinnon, J.G. (1993) *Estimation and Inference in Econometrics*, Oxford: Oxford University Press.
11. Gujarati, D. (1995) *Basic Econometrics*, 3rd edn. Singapore: McGraw- Hill Publishing Company.

12. Harris, R.I.D. (1995) *Using Cointegration Analysis in Econometric Modeling*, London: Prentice Hall/Harvester Wheatsheaf.

13. Honaker, J., et al. (1999) *Amelia: A Program for Missing Data (Gauss Version), Cambridge*, MA: Harvard University, http://GKing.Harvard.edu/.

14. Inder, B. (1993) "Estimating Long-run Relationship in Economics: A Comparison of Different Approaches", *Journal of Econometrics*, 57, 53-68.

15. Kenny, G. and Mc Gettigan, D. (1998) "Exchange Rates and import prices for a small open economy: the case of Ireland", *Applied Economics*, 30, 1147-1155.

16. Khosla, A. and Teranishi, J. (1989) "Exchange Rate Pass-through in Export Prices - An International Comparison" *Hiitotsubashi journal of Economics*, 30(1), 31-48.

17. King, G. et al. (1998) "List-wise Deletion is Evil: What to Do About Missing Data in Political Science", Paper presented at the Annual Meetings of the American Political Science Association, Boston.

18. Kishore, G.K., et al. (1988) "Export Instability revisited: The Link from Exchange Rate Variability", *Journal of Foreign Exchange and International Finance*, (3) 4, 341-53.

19. Kmenta, J. (1971) *Elements of Econometrics*, New York: Macmillan Publishers Co., Inc.

20. Krugman, P.R. (1987) " Pricing to Market when the Exchange Rate Changes", in S.W. Arndt and J.D. Richardson (eds.), *Real Financial Linkages Among Open Economies*, Cambridge, Massachusetts: Massachusetts Institute of Technology Press.

21. Lee, J. (1997) " The Response of Exchange Rate pass-Through to Market Concentration in a Small Economy: The Evidence from Korea", *Review of Economics and Statistics*; 79(1), 142-45.

22. Maddala, G. S. (1992) *Introduction to Econometrics*, 2nd edn. New York: Macmillan Publishing Company.

23. Magee, S.P. (1974) "US Import Prices in the Currency-Contract Period", *Brookings Papers on Economic Activity*, 1, 117-64.

24. Menon, J. (1992) "Exchange Rates and Prices of Australian Manufactured Exports" *Weltwirtschaftliches Archiv*, 128(4), 695-10.

25. Menon, J. (1996) *Exchange Rates and Prices: The Case of Australian Manufactured Imports*, Lecture Notes in Economics and Mathematical Systems, Berlin: Springer.

26. Moreno, R. (1989) "Exchange Rates and Trade Adjustment in Taiwan and Korea", *Federal Reserve Bank of San Francisco Economic Review*, 2, 30-48.

27. Nachane, D. M. and Ranade, P. P. (1998) "India's Trade Balance in the 1980s--An Econometric Analysis", *Applied Economics*, 30(6), 761-74

28. Nag, A. K. and Upadhya, G. (1994) "Exchange Rate and Trade Imbalance" *Economic and Political Weekly*, April 2, 819-20.

29. Patra, M.D. and Pattnaik, S. (1994) "Exchange Rate Pass Through and The Trade Balance The Indian Experience", *Reserve Bank of Indian Occasional Papers*, 15(4), 281-14.

30. Paul, M. T. and Harish, G. (1993) "Exchange Rate Volatility and Export Performance of Developing Countries", *Working Paper*, National Institute of Bank Management.

31. Rajararaman, I. (1991) "Impact of Real Exchange Rate Movements on Selected Indian Industrial Exports", *Economic and Political Weekly*, March (annual number), 669-78.

32. Ranjan, R. (1995) "Competitiveness of India's Exports: Some Aspects", *Reserve Bank of Indian Occasional Papers*, 16(4), 257-300.

33. Samanta, S. K. (1998) "Exchange Rate Uncertainty and Foreign Trade for a Developing Country: An Empirical Analysis", *Indian Economic Journal*, 45(3), Jan.-March, 51-65.

34. Sarkar, P. (1992) "Rupee Depreciation and India's External Trade and Payments since 1971", *Economic and Political Weekly*, June 13-20, 1259-66.

35. Sarkar, P. (1994) "India's Balance of Payments and Exchange Rate Behaviour since 1971 A New Approach", *Economic and Political Weekly*, June 1-8, 43-48.

36. Sarkar, P. (1995) "Trade, Price and Exchange Rate Behaviour", *Economic and Political Weekly*, May 20, 1197-201.

37. Sarkar, P. (1997) "Foreign Trade and Real Exchange Rate Behaviour; 1980-96", *Economic and Political Weekly*, May 17-24, 1133-36.

38. Ying, Q. and Varangis, P. (1992) "Does Exchange Rate Volatility Hinder Export Growth? Additional Evidence", *Working Paper*, World Bank, May.