EXCHANGE RATE PASS-THROUGH IN INDIA:
AN EXPLORATION WITH SECTORAL IMPORT PRICES

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***Abstract*:** This paper investigates into the degree of exchange rate pass-through to prices of non-oil imports in India during reforms. Exchange rate pass-through (ERPT) is the responsiveness of trade prices (expressed in local currency) to unit change in exchange rate. ERPT is complete if the response in prices is proportional to exchange rate changes and is incomplete if the change in price is less than proportional. The existing empirical literature on the subject provides ample evidence on incomplete pass-through to import prices. Theoretically, incomplete pass-through to import prices is explained in terms of exporters adjusting their mark-ups in order to maintain market shares following currency depreciation. Even though the studies on India have sound theoretical basis, the empirical estimates are weak based on single equation models. In sharp contrast to earlier attempts, a simultaneous equation model incorporating both demand and supply sides is set up for estimation. The reduced form equation for import prices is estimated for disaggregated imports using panel data estimation technique. The empirical results, which are robust, show incomplete exchange rate pass-through to import prices in India. The degree of pass-through is found to vary across commodity groups, the coefficient is found to be insignificant in case of most import sub-sectors with the only exception of chemicals. Further, the estimates show acceptance of fixed effect over random effect indicating sector-specific factors like market concentration and related conduct in determining the degree of exchange rate pass-through to import prices.

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1.   Introduction

This paper investigates into the degree of exchange rate pass-through to prices of aggregate as well as disaggregated imports in India during reforms. Exchange rate pass-through (ERPT) is the responsiveness of trade prices (expressed in local currency) to unit change in exchange rate. Accordingly, a pass-through coefficient measures the degree of responsiveness. ERPT is complete if there is a proportional change in prices on account of a unit change in exchange rate and is incomplete if the change in price is less than proportional. The responsiveness of prices of internationally traded goods and services to exchange rate movements has, of late, assumed importance in open economy macroeconomic analysis of developing countries.

Theoretically, devaluation of home currency leads to an increase in import prices in terms of home currency. Following home country currency depreciation, price of imports in home country currency rises which in turn reduces the domestic demand for imports and results in lowering of exporters' market share. In order to maintain the existing market shares, especially in the short run, exporters generally adjust their mark-ups. The higher the price elasticity of demand of a country lower will be the mark-up over production cost. This explains why exchange rate movements often do not bring about proportional change in import prices and pass-through is incomplete. Market segmentation is one of the possible reasons for incomplete pass-through, which allows imperfectly competitive firms to charge different prices for the same product in different export market. Pricing-to-market (PTM), thus, depends on the market power of the respective firm in the export market to a large extent. For instance, as Halpern and Koren (2007), find import prices are higher for products of firms with greater market power. However, in the long run permanent change in nominal exchange rate may lead to complete adjustment in import prices, with pass-through being complete in the long run.

In the context of trade and exchange rate reforms in India and depreciation/appreciation of the Indian during the period that followed, a study of exchange

rate pass-through to sectoral import prices becomes necessary. A review of existing literature will identify the issues that are important in determining the extent of exchange rate pass-through.

1.1 Review of Literature

Earlier studies on the subject find out, in general, evidence of incomplete exchange rate pass-through. For instance, Feenstra (1987) finds that the pass-through coefficient for US import prices of Japanese exports varying across products in the range from about 0.6 to unity. Campa and Goldberg (2002) show that OECD import prices in local currencies, on the average, reflect 60 percent of exchange rate fluctuations in the short run, and nearly 80 percent over the long run. A number of recent papers have shown that the degree of pass-through has declined substantially since the 1990s. For instance, Marazzi et al. (2005) have found a steady dcline in the exchange rate pass-through into US import prices during the 1990s. Krugman (1986) shows that PTM is a real phenomenon, but not universal; in particular, evidence on German export prices suggest stickiness being confined to machinery and transport equipment prices. The aggregate estimates in this paper suggest that 35 to 40 percent of the real appreciation of the dollar since 1980 has been absorbed by foreign exporters thus lessening the extent of import price rise in the US than in other markets.

Incomplete pass-through is generally explained in the existing literature by the existence of trade barriers, transaction and transportation costs, market power and imperfect substitutability between domestic substitute and foreign products. To find out why exchange rate pass-through is incomplete, Dornbusch (1987) explains the adjustment of relative prices to exchange rate movements in an industrial organization approach by using various models. The approach is to explain price adjustment in terms of market concentration, product homogeneity and substitutability, and relative market shares of domestic and foreign firms. All the models in this analysis predict that appreciation leads to a decline in the price of imports. While in the case of homogenous goods domestic firms fully match the decline in price, the extent of decline in the relative price of differentiated imported brands depends on competition and on the relative number of home and foreign firms. In contrast, Feenstra, Gagnon and Knetter (1993) find that pass-through tends to be highest for high market shares

with firms facing less competition and not experiencing a similar change in costs. However, Krugman (1986) stresses that dynamic models of imperfect competition are the best to explain exchange rate pass-through. The study explains the phenomenon in terms of supply dynamics resulting from the costs of rapidly adjusting the marketing and distribution infrastructure, and the demand dynamics resulting from the need of firms to invest in reputation.

Choice of currency in invoicing prices of commodities plays a major role in exchange rate pass through. Firms generally set the prices by examining the nature of fluctuations of prices in both home and destination market currencies. If the variance of export prices in firm's own currency is comparatively less than in local currency, then the firm opts for producer currency pricing. On the other hand if the opposite relationship holds, then firm's price exhibits 'local currency stability' (LCS). In the event of similar environments for both producers' currency and local currency prices it is optimal for the firm to set its price in its own currency – 'Producer Currency Pricing' (PCP). Bacchetta and van Wincoop (2002) argue that if prices are set in exporters' currency then the exchange rate pass through is necessarily complete. However, if prices are set in importers' currency then exchange rate fluctuations have no impact on import prices.[1] Engel (2005) shows that firms prefer to invoice in the importer's currency when optimal price is stable in the importer's currency.

Campa, Goldberg and Minguez (2005), empirically estimating exchange rate pass through to import prices across countries and products in the Euro area, emphasize the importance of currency invoicing of the prices of traded commodities. The results also show that in the short run exchange rate pass through to import price is high but incomplete and close to complete in the long run. There are the variations in the degree of pass through across countries and products and introduction of euro is not found to have changed this transmission rate. Campa and Goldberg (2002) explain the estimated result of incomplete pass-through in terms of vital but limited role of macroeconomic variables among industries. Campa and Minguez (2006) explain unequal and incomplete short run exchange rate pass-through across commodities and countries in terms of the degree of openness among the countries.

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[1] Goldberg and Knetter (1997) also find that the local currency prices of foreign products do not respond fully to exchange rate.

Apart from market structure, international market segmentation, (non) homogeneity of products, trade openness, and currency of trade invoicing, inflation plays a very crucial role to the nature of pass-through. Taylor (2000), Choudhuri and Hakura (2001), and Zorzi et al. (2007) provide evidence on existence of a positive association between inflation and the exchange rate pass-through. In an attempt to explain lower pass-through across countries since the 1990s, Taylor (2000) establishes the decline in the level and volatility of inflation as one of the primary factors. Choudhuri and Hakura (2001), using general equilibrium framework based on open economy macro models, find a positive and significant relationship between inflation and exchange rate pass—through to domestic prices across regimes. Zorzi, Hahn, and Sanchez (2007) also found that the degree of exchange rate pass-through to prices for a number of emerging markets of Asia, Latin America, and Central and Eastern Europe depends on inflation in addition to import openness.

A set of studies also argues that exchange rate pass-through to import prices happens in the long run, and not necessarily a short run phenomenon. In this respect, Faruqee (2004) examines the extent of exchange rate pass-through in a set of euro area prices along the pricing chain by using VAR approach. In the short run the impact of exchange rate movement on trade prices is near about zero. However, over the long run, the extent of pass-through to import prices in the euro area is close to complete. Kim (1990) investigates time variation in ERPT of US non-oil import prices to exchange rate during 1968 to 1986 using a varying parameter model and finds a dollar appreciation during 1980s led to a smaller decline in import prices due to a larger associated increase in foreign costs. Goldberg and Knetter (1997) present the evidence of incomplete pass-through of exchange rates to goods prices especially to import prices, in particular it is estimated to be near about 60 percent for US imports of Japanese products.

For the Indian economy, there are some recent studies as well looking into exchange rate pass-through to general price level and inflation. For instance, Ghosh and Ranjan (2007) estimate the exchange rate pass-through to India's consumer prices at the aggregate level. The results show there was no significant impact of nominal effective exchange rate on consumer prices. The study is consistent with the general literature of lower exchange rate pass-through to consumer prices. Compared to the pre-liberalisation period, at the post liberalisation period the extent of exchange rate pass-through to consumer prices is slight

higher. Khundrakpam (2008) investigates the impact of economic reforms on exchange rate pass-through to domestic prices by using monthly data for Indian economy. This paper does not support the view of decline in the exchange rate pass-through after economic reforms. Further it also observes the asymmetric response to appreciation and depreciation and large and small exchange rate changes. The paper explains the non decline in pass-through in the first half of 1990s in spite of sharp fall in inflation rate in terms of factors associated with economic reforms such as rise in import penetration ratio, reduction of tariffs and removal of quantitative restrictions, change in import composition etc. The rise in inflation persistence could be one of the causes behind the non-decline in pass-through in the second half of 1990s.

However, studies investigating the nature of exchange rate pass-through to import prices are fewer. Using the profit maximisation framework, a recent paper by Mallik and Marques (2006) analyses the impact of India's policy reforms on the exchange rate pass-through to import and export prices at one-digit SITC level for the period 1980-2001. The empirical analysis could not reject the complete pass-through to import prices for crude material, food and oil sector during the 1980s and for crude imports alone for the 1990s. Further, the extent of pass-through to import prices during the 1990s declined compared to that in the 1980s, which is explained the presence currency controls and the existence of trade barriers in the 1980s. The extent of exchange rate pass-through also differs across sectors.

The above review would show that the applied literature on the subject for emerging economies, in particular India, is not well developed. Even though the study by Mallik and Marques (2006) on the specific subject is exhaustive, it is not based on a macroeconomic framework. As a result, the econometric model in the study is not comprehensive accounting for various macroeconomic factors that determine prices in an open economy. In that sense, the results thus arrived in the earlier study might be inappropriate. The present study derives its justification from such deficiencies in the existing literature.

The main objective of this paper is to estimate and analyse the responsiveness of India's import prices to exchange rate movements. The exercise is also to find out the differences in the degree of the exchange rate pass-through at the aggregate level as well as across some selected sectors. For the purpose, the analysis covers only non-oil imports into

India, which account for about 70 per cent of total imports in 2005-06[2]. In specific, the present study analyses ERPT for imports of disaggregated product group including chemicals, machinery, transport equipments, metal manufactures and food processing. Fuel and mineral oils are excluded from this study as demand for these products are often price inelastic and thus exchange rate movements do not seem to play a major role in determining import prices movements.[3]

The paper is organized as follows. Section 2 provides a descriptive analysis of India's trade, in particular merchandise imports, and some of its macro-economic indicators, which will build up the stylized facts on exchange rate pass-through to import prices in India. Section 3 estimates the extent of exchange rate pass-through to India's import prices across sectors. Finally, Section 4 concludes by putting together the major findings of the study along with their implications for policy.

2. India's Trade and Exchange Rate Reforms, Trade Performance and Exchange Rate Movements: Some Facts

Trade reforms, though in a piecemeal way, were initiated during the 1980s[4], whereas exchange rate reforms towards a market-determined exchange rate of the rupee started in the early 1990s. This is, however, not to say that there were no exchange rate reforms prior to the 1990s. The major trade policy changes in the post-1991 period included removal of quantitative restrictions and replacement of such restrictions by tariffs, substantial reduction in the tariff rates as also their dispersion and simplification of procedures relating to trade. The WTO in 1995 acted as a catalyst in this process of trade liberalization in India. With trade liberalisation, the level of protection to Indian industry declined significantly. Table 1 shows the decline in weighted average import tariff across various sectors during 1991-92 to 2004-05. At the aggregated level, weighted average customs tariff fell from 81.4 per cent to 17.7 per cent between 1991-92 and 2004-05. The average rate of import duty for the agricultural products declined from 47 per cent in 1991-92 to 28.7 per cent in 2004-05. The

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[2] The figures are calculated on basis of the data from RBI, *Handbook on Statistics on Indian Economy*, various years.
[3] This contention matches with the finding of Mallick and Marques (2006), which show that exchange rate pass-through is in the opposite direction for fuel imports.
[4] See Panagariya (2005) and Sinha Roy (2005) for the purpose

decline was the highest for capital goods from 94.8 per cent in 1991-92 to 17.8 per cent in 2004-05. The coefficient of variation for total duty rates however varied since then, despite significant rationalization of import duty structures. A further step towards rationalizing the incentive structure for a neutral trade regime involved the removal or restructuring of large number of tax benefits and exemptions. For instance, cash compensatory support for export promotion was done away with in 1991. Besides these, the policies also aimed to reduce transactions cost in trade through a number of measures bring about procedural simplifications. Trade policy reforms in India, on the whole, aimed at reducing distortions in relative prices, removing anti-export bias, improving competition thereby enhancing international competitiveness.

There has been a spurt in the growth of trade in the post reforms period. From the mid 1980s, India's exports grew at an increasing rate up to 1990.[5] The annual average growth rate of exports during 1990s is about 12.9 per cent, while imports experienced a higher average growth rate of 16.7 per cent during 1991 to 1996. The growth rate of Indian imports was 36.35 per cent in the year 1995-96. Subsequently, in the remainder of the 1990s, the average growth of imports more than halved to 8.0 per cent on account of a relative slowdown in economic activity[6]. After 2000, as evident from Figure 1, exports grew at a faster average rate of about 20 per cent per annum and import growth was even higher. The growth rate of merchandise imports peaked at 39.53 per cent in 2004-05 (see Table 2 as well). With high growth in exports and imports since the mid 1980's, India's share in world trade also increased to more than double. The share of India's imports increased from 0.90 per cent in 1984-85 to 1.45 per cent in 2005-06. The pattern of India's foreign trade, both merchandise exports and imports, has undergone substantial changes during trade reforms in terms of growth and diversification of markets and products.

Accompanying high growth, India's merchandise imports underwent changes in direction and composition. During the reforms period, India's imports are being sourced from a wider range of countries. Data from RBI sources show that the shares of India's traditional trading partners like Germany, Japan, UK and Australia have declined along with the emergence of new import partners from East Asia including China. In recent years, Belgium,

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[5] Sinha Roy (2005) provides similar evidence. However, the study does not attribute growth in post reforms exports to trade liberalization alone.
[6] RBI, Report on Currency and Finance, 2001-02

Table 1: Average Import Duty Rates in India, 1991-92 to 2004-05

Commodity Group	1991 - 92	1992 - 93	1993 - 94	1994 - 95	1995 - 96	1996 - 97	1997 - 98	1998 - 99	1999 - 00	2000 -01	2001 - 02	2002 - 03	2003 - 04	2004 - 05
Weighted average														
Agriculture	47.0	22.7	19.6	16.7	16.7	24.0	22.3	17.7	20.5	25.4	21.6	27.8	27.2	28.7
Consumer goods	97.8	72.4	60.5	47.8	36.1	38.6	28.9	30.1	30.5	58.2	45.1	42.9	43.5	49.6
Intermediate goods	69.5	54.9	39.8	30.6	34.8	33.0	30.0	22.8	26.4	31.0	31.0	27.7	24.1	19.3
Capital goods	94.8	75.0	50.2	37.4	29.1	27.3	21.9	20.9	24.0	23.6	23.1	20.9	20.9	17.8
All Commodities	**81.4**	**54.1**	**40.7**	**37.1**	**32.9**	**30.4**	**26.7**	**22.6**	**24.9**	**26.1**	**25.9**	**22.4**	**21.3**	**17.7**
Coefficient of Variation														
Agriculture	43.5	102.0	100.0	87.5	87.7	76.6	74.4	78.5	65.1	48.0	49.3	63.0	63.6	64.1
Consumer goods	25.5	42.7	47.4	56.9	58.9	62.0	58.5	56.0	50.8	45.1	45.1	48.1	62.3	64.7
Intermediate goods	31.8	22.3	28.6	31.6	27.9	33.9	33.0	34.1	27.1	25.7	25.9	26.5	27.3	33.3
Capital goods	31.4	29.8	41.4	44.2	37.3	36.2	34.1	37.1	28.6	25.4	42.8	42.4	43.8	55.5
All Commodities	**32.0**	**36.2**	**42.3**	**47.2**	**46.5**	**49.9**	**48.2**	**47.8**	**40.5**	**37.0**	**39.6**	**41.5**	**44.1**	**55.4**

Source: Mathur and Sachdeva (2005)

Figure 1: Post-reforms Growth of India's Exports and Imports
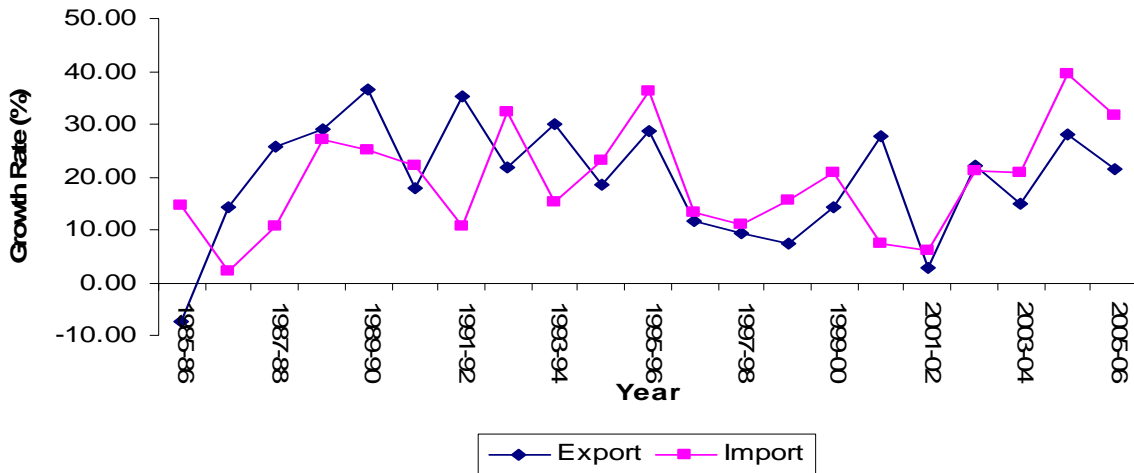
from where India imports raw gems, has emerged as one of the principal sources of imports. The share of India's imports from the OPEC region increased significantly from 16.3 percent in 1990-91 to 25.9 percent in 1999-2000[7]. India's share of imports from developing country increased during the 1990s. Another interesting feature has been the fall in the share of the Commonwealth of Independent States (CIS) countries as sources of India's imports.[8]

With regards to commodity composition of imports, RBI data show that the share of capital goods in total imports recorded a higher increase compared to that of raw materials. Within capital goods, the rise in the share of imports for machine tools, electrical machinery was more pronounced. Manufacture of metals also grew at a high rate. While overall increase in the imports of industrial raw materials and intermediate goods was less pronounced, certain individual items like textile yarn, fabrics and chemicals recorded sharper increase. On the other hand, imports of petroleum showed wide fluctuations due to the movement of international prices. The imports of manufactured fertilizers also showed an increase during the post reforms period, although the annual average growth rate of its import remained at a lower level.

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[7] RBI, *Report on Currency and Finance*, 2001-02.
[8] RBI, *Report on Currency and Finance*, 2002-03.

Table 2: India's Foreign Trade Performance, 1984-85 – 2005-06

Year	Export Value (Rs. Crore)	Export Growth Rate (%)	Import Value (Rs. Crore)	Import Growth Rate (%)	TOI (%)	IOR	Export Share in World (%)	Import Share in World (%)
1984-85	11743.7	----	17134.2	----	12.68	0.075	0.53	0.90
1985-86	10894.6	-7.23	19657.7	14.73	12.01	0.077	0.53	0.81
1986-87	12452.0	14.30	20095.8	02.23	11.47	0.071	0.56	0.75
1987-88	15673.7	25.87	22243.7	10.69	11.79	0.069	0.56	0.74
1988-89	20231.5	29.08	28235.2	26.94	12.63	0.074	0.61	0.74
1989-90	27658.4	36.71	35328.4	25.12	14.25	0.080	0.56	0.72
1990-91	32557.6	17.71	43192.9	22.26	14.71	0.084	0.55	0.58
1991-92	44041.8	35.27	47850.8	10.78	15.47	0.081	0.58	0.66
1992-93	53688.3	21.90	63374.5	32.44	17.18	0.093	0.63	0.64
1993-94	69751.4	29.92	73101.0	15.35	18.03	0.092	0.65	0.69
1994-95	82674.1	18.53	89970.7	23.08	18.66	0.097	0.66	0.74
1995-96	106353.3	28.64	122678.1	36.35	21.14	0.113	0.65	0.74
1996-97	118817.1	11.72	138919.7	13.24	20.44	0.110	0.65	0.71
1997-98	130100.6	09.50	154176.3	10.98	20.28	0.110	0.63	0.71
1998-99	139753.1	07.42	178331.9	15.67	19.68	0.110	0.67	0.81
1999-00	159561.4	14.17	215236.5	20.69	20.98	0.120	0.73	0.74
2000-01	203571.0	27.58	230872.8	07.26	22.56	0.120	0.74	0.77
2001-02	209018.0	02.68	245199.7	06.21	21.63	0.117	0.84	0.90
2002-03	255137.3	22.06	297205.9	21.21	24.38	0.131	0.87	0.95
2003-04	293366.8	14.98	359107.7	20.83	25.59	0.141	0.91	1.08
2004-05	375339.5	27.94	501064.5	39.53	30.69	0.175	1.03	1.34
2005-06	456417.9	21.60	660408.9	31.80	34.35	0.203	1.10	1.45
Average		**19.54**		**19.40**			**0.69**	**0.83**

Note: Trade Openness Index (TOI) is calculated as a percentage of India's trade volumes on its GDP at current prices. Import Orientation Ratio (IOR) is the ratio of India's import and it's GDP. Shares are the percentage figures of India's exports and imports relative to the world's exports and imports.

Source: The export and import values are collected from the RBI, *Handbook of Statistics on Indian Economy,* various years.

## 2.1   Exchange Rate: Policy Changes and Movements

In 1991, following India's balance of payment crisis, a series of currency reform measures was undertaken in addition to other structural reform measures. A transition to a market determined exchange rate regime was felt necessary to deal effectively with different sectors to initial reform measures. Reserve Bank of India (RBI) undertook a sharp downward adjustment of the exchange rate of about 18 per cent in two stages on July 1 and July 3, 1991. This set the stage for more fundamental changes in the exchange rate regime as recommended by the High Level Committee on Balance of Payments (GOI, 1991). This adjustment was followed by the introduction of the Liberalized Exchange Rate Management System (LERMS) in March 1992 and the adoption of, for the first time, a dual exchange rate system in India. This dual exchange rate system implied a depreciation of about 11 percent for transactions routed through market. However, the dual exchange rate imposed an implicit tax on export proceeds and remittances, which hindered supplies of foreign exchange in the foreign exchange market. Consequently, downward pressures had been building up and a regime change was overdue. Subsequently, in March 1993, the dual exchange rate system gave way to a unified exchange rate system, which along with removal of exchange restriction on imports through the abolition of foreign exchange budgeting are the initial steps towards current account convertibility. The final step towards current account convertibility was taken in August 1994 by further liberalization of invisible transactions and exchange control regulations upto a specified limit.

Since then, the exchange value of the Indian rupee is determined through demand for and supply of foreign exchange in the market and is not administered. However, the Reserve Bank of India continued to actively intervene trading in the foreign exchange market with an aim of "containing volatility" and thus influencing the currency value. The rupee exhibited a reasonable stability upto mid-1997, when the Indian rupee experienced a mild attack of contagion emanating from East Asian currency crisis. During 1998, exchange rate management of the RBI continued its focus on smoothing excessive volatility in the exchange rate and maintaining orderly market condition. The rupee has marginally appreciated against the US $ after 2002-03.

Despite reforms in the currency system, Calvo and Reinhart (2000) suggest that the de facto currency regime in India has not changed during the period 1979 – 1999. This

evidence also supported by Patnaik (2003) with the same result. The broad finding of this paper is that in the period following the Asian crisis, the rupee appears to be de facto peg to the US dollar. The regime is classified as a de facto peg as volatility of rupee against US dollar was very low owing to the trading by the central bank. Liberalisation of capital account and current account forces Indian economy to implement pegged exchange rate. The Indian exchange rate regime can best be stated as an intermediate between freely floating and managed regimes.

Figure 2: Trends in Rupee-US $ Annual Exchange Rate
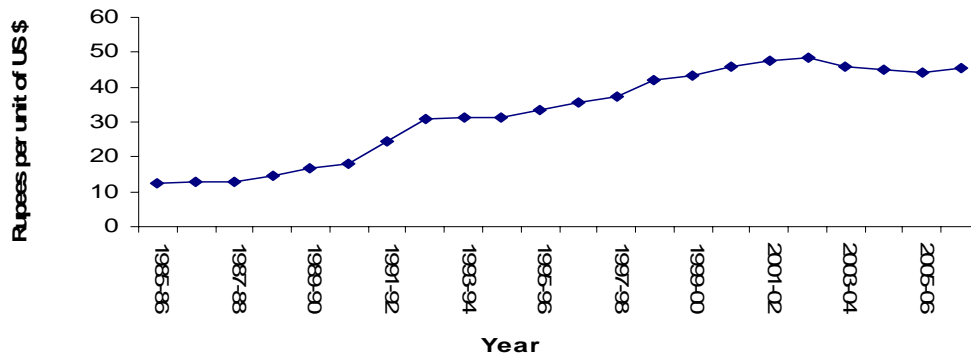
Following depreciation in the rupee currency value after the mid-1980s, as Table 3 shows, both nominal and real effective exchange rates depreciated from mid-1980s to early 1990s.[9] The rate of depreciation was very high during the early 1990s due to the devaluation of rupee. However, the nominal effective exchange rate appreciated during 1993-94 and thereafter again in 1997-98[10]. Between 2000-01 and 2002-03, the NEER appreciated in most years. The large devaluation of Indian rupee during 1991 is also reflected in the behaviour of REER. The depreciation of REER continued till 1992-93. The real rupee however appreciated at 7.9 per cent and 7.2 per cent in 1993-94 and 1994-95 respectively. While NEER depreciated during 1994-95, both NEER and REER depreciated in 1995-96. Similar movements are observed in 1998-99 and 1999-00. Thereafter the REER continued its

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[9] RBI (2005) shows that a rise (fall) in NEER and REER shows appreciation (depreciation) of Indian rupee.
[10] Sinha Roy (2005) also arrives at similar findings.

appreciation up till 2005-06. On an average, NEER and REER depreciated during the entire period, with a higher depreciation rate for NEER than REER.

Table 3: Annual Percentage Change in India's NEER and REER

| Year	NEER	REER
1985-86	-2.93	-2.57
1986-87	-12.84	-8.17
1987-88	-5.46	-5.41
1988-89	-6.89	-5.80
1989-90	-4.51	-2.45
1990-91	-6.87	-3.65
1991-92	-21.86	-15.06
1992-93	-17.23	-11.09
1993-94	2.83	7.90
1994-95	-2.95	7.23
1995-96	-8.39	-3.66
1996-97	-1.91	0.30
1997-98	2.67	5.03
1998-99	-9.17	-5.34
1999-00	-2.42	-0.24
2000-01	0.17	5.12
2001-02	0.65	2.86
2002-03	3.64	6.33
2003-04	-2.16	1.90
2004-05	0.20	0.53
2005-06	2.90	2.26
Average	**-4.41**	**-1.14**

Source: RBI, *Handbook of Statistics on Indian Economy*, various years.

2.3. Movements in India's Import Prices

In general, the 1990s decade is described as the era of price stability all over the world. The opening up of Indian economy during the 1990s, along with high order of depreciation, increased uncertainties on account of fluctuations in the global economy and added to pressures on prices to rise. During this period, import prices of most product groups show upward tendencies (see Figure 3). The unit value index for 'Beverages and Tobacco' was the highest among all the non-oil imports. For all other non-oil imports, unit value index

shows an upward trend, through within a narrow band. There are however some fluctuations are there during the nineties, with sharpest fluctuations for 'beverages and tobacco'.

Figure 3: Movements of unit values of Indian imports
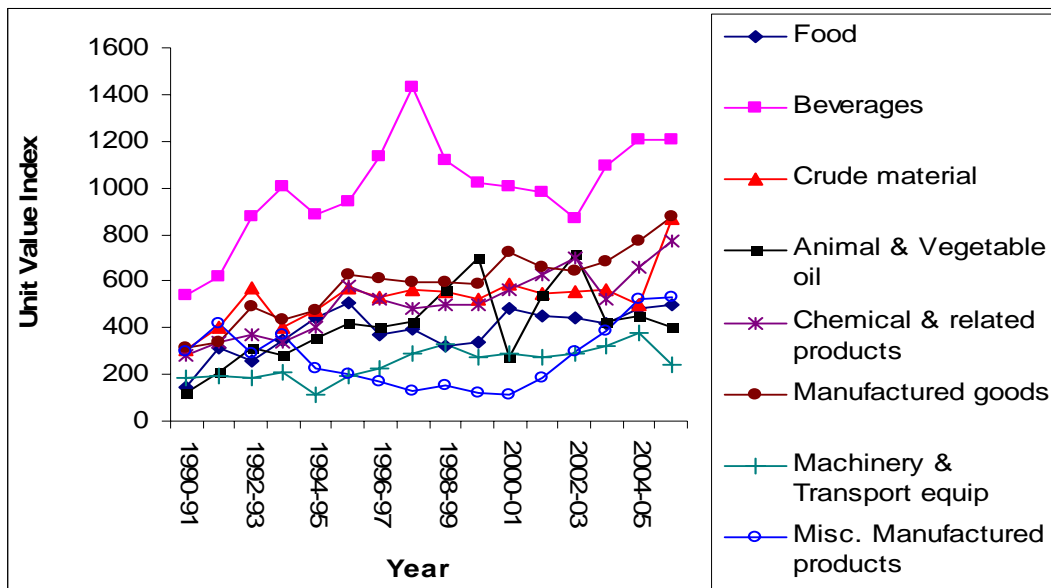
Growth rates for import prices across sectors are shown in Table 4. During the 1990s, average growth rates of import prices for most products are positive. Average growth rate of import prices is highest for animal and vegetable oils at 15.82 per cent followed by that of food and food products at 12.88 per cent after the reforms period. The average growth rates are moderate for crude materials, chemical & chemical products and manufactured goods. The average growth rate is the lowest for machinery at 5.25 per cent. However, there are fluctuations in prices over the years. Prices of major imports fell during 1996-97. The exceptions are beverages and machinery imports. During 2001-02, import prices for major sectors excepting animal and vegetable oils and fats, chemicals, and some miscellaneous manufactures show a downturn. Growth in import prices revived and most products show high positive growth of import prices in 2005-06.

Table 4: Growth of Import Prices across Sectors for India

Year	Food and Food Products	Beverages & Tobacco	Crude Material	Animals & Veg. oil	Chemical	Manufactured Good	Machinery	Misc. Manufacture
1991-92	119.86	15.67	31.49	76.03	21.79	8.36	3.19	42.86
1992-93	-15.81	41.61	40.99	47.89	8.21	45.10	-6.70	-30.48
1993-94	31.42	14.12	-29.60	-9.84	-8.67	-11.66	17.68	26.03
1994-95	30.03	-11.68	18.91	23.94	20.47	9.26	-46.95	-39.13
1995-96	13.23	6.10	19.25	18.18	42.61	32.63	69.03	-10.27
1996-97	-26.53	20.45	-6.67	-3.61	-9.84	-2.24	18.32	-15.42
1997-98	5.39	26.70	5.26	5.99	-7.28	-2.78	29.65	-25.29
1998-99	-18.41	-21.77	-1.43	32.24	2.89	0.17	13.65	19.69
1999-00	5.96	-8.56	-5.43	24.38	0.60	-1.34	-17.12	-18.42
2000-01	42.90	-1.76	12.64	-60.52	11.78	23.64	4.71	-10.48
2001-02	-6.21	-2.98	-6.80	94.20	12.14	-9.22	-5.88	64.86
2002-03	-2.65	-11.36	0.55	33.40	11.94	-2.42	5.88	61.75
2003-04	-4.31	26.44	1.81	-40.42	-25.89	5.90	10.76	31.42
2004-05	13.74	10.05	-11.41	5.63	26.87	13.64	18.50	33.42
2005-06	4.58	0.17	75.05	-10.22	16.34	12.90	-35.98	2.12
Average	**12.88**	**6.88**	**9.64**	**15.82**	**8.26**	**8.13**	**5.25**	**8.84**

Note: Values are from RBI, *Handbook of Statistics on Indian Economy*, various years.

Having shown the movements in exchange rate and import price behavior during reforms, it is pertinent to show whether the two variables have moved synchronously. The movements in NEER reveal depreciation of Indian rupee at the beginning of 1990s. As a result of this depreciation, import prices show an upward movement. Figure 4, shows that in most years the two series have moved in opposite directions. This evidence indicates that when the rupee currency depreciated, there is an increase in the price of imports. On the other hand, an appreciation in exchange rate and a decline in import price are simultaneous. This observation would tend to show synchronous movements in NEER and import prices, which call for a detailed econometric analysis.

Figure 4: Growth of import price and NEER
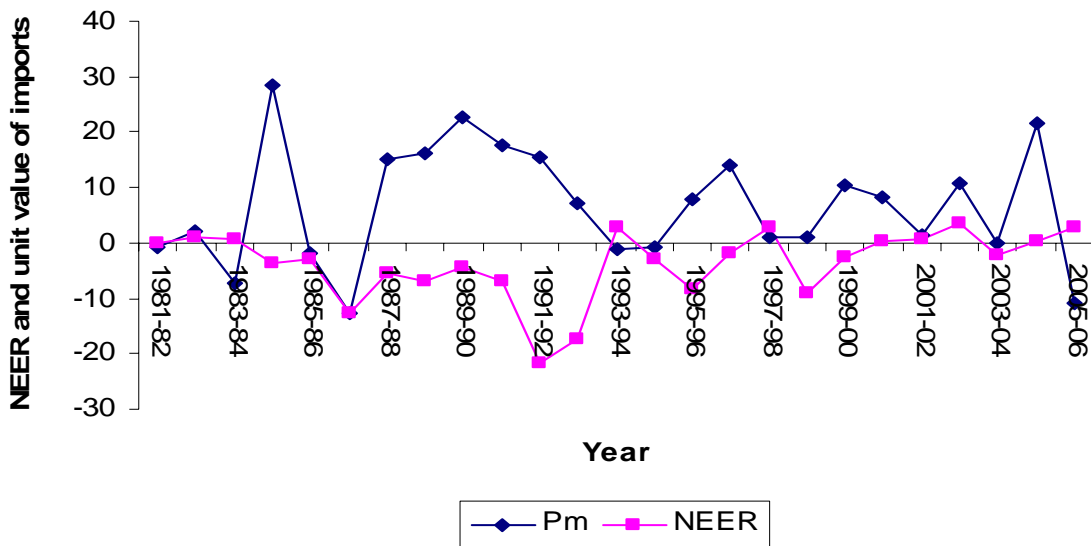
3.   Empirical Estimation

This section provides an econometric estimate of exchange rate pass-through to import prices in India. This estimation assumes importance in the context of the observation made in the earlier section that India's import prices moved in conjunction with exchange rate. To recapitulate, import prices in domestic currency moved upward during years of depreciation, and in years of appreciation import prices fell. It can thus be hypothesized that changes in exchange rate are passed pass-through into import prices, but the extent to which the import prices have responded need to be estimated.

To estimate the exchange rate pass-through to prices in general and to trade prices in particular, economists use various models and methodologies. In general earlier studies apply single side regression equation to estimate exchange rate pass-through to trade prices for various economies. There are very little findings for the Indian economy. For instance, Mallick and Marques (2006) applies panel techniques to find out the exchange rate pass-through to import prices in local currency terms. The study uses only the Re/US $ exchange rate as an explanatory variable for this purpose. The equation used is as below:

$$d \ln P_{it}^m = \alpha_i + \beta_i d \ln e_t + \varepsilon_{it} \tag{1}$$

where $d \ln P_{it}^m$ is the change in log of import prices in domestic currency, and $d \ln e_t$ is the variation in the log of rupee/US$ exchange rate. The coefficient β represents the extent of exchange rate pass-through to import prices. Earlier models are themselves robust; their approach is different from that in the present study. As a result, some of these models are not fully specified for estimation. Moreover, data limitations in the Indian case restrict the use of any time series method for estimation purpose. Hence, in this case, there is a need for an alternate model of estimation.

3.1. The Model

In this study the econometric model is based on a simultaneous equation imperfect substitutes model as in Goldstein and Khan (1985). In the model, the quantity of import demand depends on the price of imports in domestic currency and price of domestic substitute commodities. The domestic demand for imports can also be an important factor influencing import demand. Another influencing factor is the trade openness of the economy. Therefore the import demand function can be specified as:

$$M^d = f(EP_m^*, P_s, GDP, TOI) \tag{2}$$

where M^d is the quantity demanded for imports, E is the exchange rate of foreign currency in terms of domestic currency, P_m^* is the price of imports in foreign currency, P_s is the price of

domestic substitute commodities in terms of domestic currency, GDP is the real gross domestic product of the economy, and TOI is the trade openness index of the economy.

Equation (2) can also be written in log linear form, as suggested by Khan and Ross (1977) and Salas (1982), in the following way:

$$\ln M^d = \alpha_0 + \alpha_1 \ln E + \alpha_2 \ln P_m^* + \alpha_3 \ln P_s + \alpha_4 \ln GDP + \alpha_5 \ln TOI + \varepsilon_1 \qquad (3)$$

with $\alpha_1, \alpha_2 < 0$ and $\alpha_3, \alpha_4, \alpha_5 > 0$.

On the other hand, even if Indian imports account for a very small share of the world trade, the supply side of the imports cannot be assumed away based on infinite elastic assumption. Assuming law of one price not to hold, supply of imports depends on the price of imported commodities in exporters' currency as well as exporters' domestic price. The import supply equation can be specified as:

$$M^s = g\left(P_m^*, P^*\right) \qquad (4)$$

where P^* is exporters' domestic price, P_m^* is the price of the importable in source country currency. It is thus obvious that producers' currency pricing is assumed here. This is not necessary due to stability in producers' currency, but it may be optimal to do so. Moreover, India is not a major importer of most of these products. In log linear form the equation can be written as:

$$\ln M^s = \beta_0 + \beta_1 \ln P_m^* + \beta_2 \ln P^* + \varepsilon_2 \qquad (5)$$

with $\beta_1 > 0$ and $\beta_2 < 0$.

In equilibrium, demand for and supply of imports are equal. From the equilibrium condition:

$$M^d = M^s = M \text{ (say)} \qquad (6)$$

the following equation can be derived.

$$\ln P_m^* = \delta_0 + \delta_1 \ln E + \delta_2 \ln P^* + \delta_3 \ln P_s + \delta_4 \ln GDP + \delta_5 \ln TOI + v \qquad (7)$$

where $\delta_0 = \left(\dfrac{\beta_0 - \alpha_0}{\alpha_2 - \beta_1}\right)$, $\delta_1 = -\left(\dfrac{\alpha_1}{\alpha_2 - \beta_1}\right)$, $\delta_2 = \left(\dfrac{\beta_2}{\alpha_2 - \beta_1}\right)$, $\delta_3 = -\left(\dfrac{\alpha_3}{\alpha_2 - \beta_1}\right)$,

$\delta_4 = -\left(\dfrac{\alpha_4}{\alpha_2 - \beta_1}\right)$, $\delta_5 = -\left(\dfrac{\alpha_5}{\alpha_2 - \beta_1}\right)$ and $\nu = (\varepsilon_2 - \varepsilon_1)$.

The coefficient δ_1 provides us the degree of pass-through to import prices expressed in foreign currency. The sign of this coefficient is expected to be negative. This can also be referred to as the elasticity of import prices in terms of foreign currency with respect to exchange rate.

Now for estimation purpose equation (7) can be rewritten for i^{th} sector in t^{th} time period as follows:

$$\ln P^*_{m\,it} = \delta_0 + \delta_1 \ln E_t + \delta_2 \ln P_{it}^* + \delta_3 \ln P_{sit} + \delta_4 \ln GDP_{it} + \delta_5 \ln TOI_{it} + \nu_{it} \tag{8}$$

with $\delta_1 < 0$, $\delta_2 < 0$, $\delta_3 > 0$, $\delta_4 > 0$, and $\delta_5 > 0$. The parameter of interest is δ_1.

Now if P_m is expressed as the price of imports in terms of domestic currency then the relationship between exchange rate, import prices in foreign currency and domestic currency can be written as:

$$P^*_m = \left[\dfrac{P_m}{E}\right] \tag{9}$$

where P^*_m = import prices in terms of foreign currency

P_m = import prices in terms of domestic currency

E = Exchange rate in terms of domestic currency

Taking logarithm on both sides of the equation (9), we get

$$\ln P^*_m = \ln P_m - \ln E \tag{10}$$

Now differentiating both sides with respect to E, we get

$$\frac{1}{P_m}\left(\frac{dP^*_m}{dE}\right) = \frac{1}{P_m}\left(\frac{dP_m}{dE}\right) - \frac{1}{E}$$

Multiplying both sides by E,

$$\left(\frac{dP_m^*}{P_m^*}\right)\left(\frac{E}{dE}\right) = \left(\frac{dP_m}{P_m}\right)\left(\frac{E}{dE}\right) - 1 \tag{11}$$

$$\left(\frac{dP_m}{P_m}\right)\left(\frac{E}{dE}\right) = \left(\frac{dP_m^*}{P_m^*}\right)\left(\frac{E}{dE}\right) + 1 \tag{12}$$

The elasticity of the domestic currency import prices with respect to the exchange rate is thus equal to that of foreign currency prices plus one. The degree of pass-through to import prices in domestic currency can be measured as $(\delta_1 + 1)$.

3.2.   The Data

For the purpose of estimation, the data requirements are immense. There is a need for appropriate data, especially with regards to data on import and other prices.[11] The import prices used in the estimation is the rupee price based unit value index of imports for the products under study. Data for that is taken from the *'Handbook of Statistics on Indian Economy'* published by Reserve Bank of India. The base year of the data on unit value index is 1993-94=100. In the final equation we have the explanatory variable as unit value for the products in terms of foreign currency. For that purpose the unit value index is converted to foreign currency unit value by multiplying with the ratio of exchange rate for the year concerned and exchange rate for the base period. The domestic price (P*) of the source countries is proxied by the producer price index across product groups in the US. To be very restrictive here we use the producer price index for US economy. On account of paucity in data on price for substitute commodities, wholesale price index, the consumer price index, or the GDP deflator is used. Here the wholesale price index is used as a proxy variable for the price of import substitute commodities in the domestic economy.

Pollard and Coghlin (2006) show that exchange rate pass-through to import prices for US manufacturing industries vary depending on the types of exchange rate indexes. Hence, the data

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[11] Ito and Sato (2006) also find that the degree of pass-through to the exchange rate shock varies across the different price indices. Bacchetta and van Wincoop (2002) shows pass-through to import prices is more than that to consumer prices. The use of imported intermediate to produce final goods by the domestic firm to sell to consumers is pointed out as one of the reasons for such type of pass-through.

on nominal effective exchange rate becomes important for the study. The exchange rate data used in the study is nominal effective exchange rate (NEER) based on 36-country bilateral weights. The base year for NEER is 1993-94=100. As NEER is used for estimation, and its increase implies appreciation, its increase will have a negative influence on the import prices in home currency terms. Therefore the expected sign of the term $(\delta_1 + 1)$ becomes negative.

Gross Domestic Product (GDP) of the economy is generally used to specify demand for imports. As the study is at a disaggregated level, we use value of output for these products instead of GDP. The data on value of output for these products are collected form the Annual Survey of Industry (ASI) database of the Central Statistical Organisation, Government of India. ASI database provides data according to the National Industrial Classification (NIC). On account of a revision in classification based on NIC 1998, the data for the pre- and post-1998 are matched for use in the econometric exercise. Further, with regards to trade openness, import orientation ratio (IOR) is used in place of trade openness index. IOR is calculated as the ratio of import value to value of output for respective disaggregated products.

3.3.   Estimation Results

Panel data estimation of the equation (8) is carried out to estimate the degree of exchange rate pass-through to import prices across sectors by applying sector-specific dummy. For estimating exchange rate pass-through into import prices at the sectoral level or otherwise, sectors selected are namely food products, beverages, animal & vegetable oil, chemicals, and machinery and transport equipment. The choice of sectors, as has been stated earlier, is restricted by data availability and comparable dataset. It is thus needless to mention that the results arrived at are contingent on the availability of appropriate data.

As data for all arguments for all the years are not available it becomes an unbalanced panel. The model has suited the data well and the results thus obtained by estimating equation (8) are robust. Results for aggregate imports, both fixed effects and random effects, are shown in Table 5 a and b, while disaggregated results are presented in Table 6 only for the coefficient of exchange rate pass-through to import price. Hausman test is done to check the relevance of fixed effect estimator and random effects estimator.

Results on all sectors show that the coefficients of exchange rate in both the models are significant indicating significant pass-through (see Tables 5 a and b). The fixed effect shows that exchange rate pass-through to import prices is about 65 per cent and random effect shows the same at about 31 per cent. This finding matches with the findings of incomplete exchange rate pass-through to import prices in earlier studies. Further, the Hausman test results, as shown in Table 5 c, reject the null hypothesis meaning fixed effect estimation providing consistent result.

Table 5 a: Estimation of Degree of ERPT to Aggregate Import Prices: *Fixed Effect*

	Coefficient	Std. Error	t	P>t	[95% Conf. Interval]	
E	-1.654931	0.4265085	-3.88	0.000	-2.494236	-0.815626
P*	-0.197542	0.2990276	-0.66	0.509	-0.785983	0.390899
P_s	0.598179	0.1447741	4.13	0.000	0.313286	0.883074
GDP	0.056904	0.0476042	1.20	0.233	-0.036774	0.150582
TOI	0.018213	0.0342318	-0.53	0.595	-0.085575	0.049150
Constant	9.709485	2.8121090	3.45	0.001	4.175676	15.243290

Table 5 b: Estimation of Degree of ERPT to Aggregate Import Prices: *Random Effect*

	Coefficient	Std. Error	z	P>z	[95% Conf. Interval]	
E	-1.315027	0.3927092	-3.35	0.001	-2.084723	-0.545331
P*	-0.154646	0.2809479	-0.55	0.582	-0.705294	0.396001
P_s	0.592910	0.1340689	4.42	0.000	0.330139	0.855680
GDP	0.109345	0.0365705	2.99	0.003	0.037668	0.181022
TOI	0.012720	0.0287473	0.44	0.658	-0.043624	0.069064
Constant	7.265090	2.5603260	2.84	0.005	2.246945	12.283240

Table5 c: Hausman Test: ERPT to Aggregate Import Prices

	Coefficients			
	(b) Fixed	(B) Random	(b - B) Difference	sqrt (diag(V_b - V_B) SE
E	-1.654931	-1.315027	-3.3399043	0.1664000
P*	-0.197542	-0.154646	0.0428957	0.1024001
P_s	0.598180	0.592910	0.0527030	0.0546357
GDP	0.569044	0.109350	-0.0524408	0.0304755
TOI	-0.018213	0.012720	-0.0309327	0.0185852

b = consistent under Ho and Ha; obtained from fixed effect estimation
B = inconsistent under Ha, efficient under Ho; obtained from random effect estimation

Test: Ho: difference in coefficients not systematic

$$chi^2(5) = (b\text{-}B)'[(V\_b\text{-}V\_B)^\wedge(\text{-}1)](b\text{-}B)$$
$$= 4.36$$
$$Prob>chi^2 = 0.4983$$

Sector specific results show some variations. Like aggregate imports, applying Hausman test fixed effect estimation results for imports across disaggregated product groups are found to provide consistent results. Accordingly, only fixed effect estimation results for disaggregated imports are provided in Table 6. The consistency of fixed effects estimates over random effects estimates is indicative of the relative importance of sector specific factors in the determination of exchange rate pass-through coefficient of import prices. For all the sectors, the sign of the coefficient is as expected and the pass-through is incomplete. However, there are variations in the level of significance of the pass-through coefficients across sectors.

Table 6: Estimates of ERPT at the Sectoral Level: *Fixed Effect Estimates*

Sectors	Constant	E	P*	P_s	GDP	TOI
Food Products	9.709 (0.00)	-1.274 (0.34)	-0.158 (0.61)	0.782 (0.00)	0.152 (0.00)	0.247 (0.47)
Beverages	-0.220 (0.85)	-0.381 (0.78)	-0.173 (0.57)	0.815 (0.00)	0.155 (0.00)	0.019 (0.59)
Animal & Vegetable Oil	0.263 (0.84)	-1.444 (0.31)	-0.268 (0.40)	0.843 (0.00)	0.151 (0.00)	0.011 (0.75)
Chemicals	4.177 (1.01)	-1.411 (0.03)	-0.610 (0.06)	0.630 (0.00)	0.158 (0.00)	0.131 (0.00)
Machinery	0.581 (0.68)	-0.666 (0.27)	-0.143 (0.64)	0.792 (0.00)	0.145 (0.00)	0.012 (0.73)

Note: All variables are in logarithm. Figures in parentheses are the level of significance.

For food products, it is small and insignificant. In case of food product, import prices are determined by other factors including domestic prices. For beverages imports as well, despite the

expected sign, the coefficient is small and insignificant. For animal and vegetable oil sector, the coefficient of the variable exchange rate is insignificant; though exchange rate pass-through to import prices in domestic currency is estimated to be around 45 per cent. In case of machinery import price, Table 6 shows insignificant coefficient for exchange rate, even though the degree of pass-through is estimated to be high. The only exception to this pattern is with regards to import prices chemicals and related products. In the fixed effect model, the coefficient of exchange is found to significant and the degree of pass-through is incomplete estimated to be at 41 per cent. The observed variations in the degree of pass-through across sectors can be largely due to sector specific factors including market concentration and competition, the degree of (non) homogeneity of products, etc..

On the whole, the above results show that fixed effect model is better over random effect model in this exercise. It can be observed that significant exchange rate pass-through to import prices occurs when all the sectors are taken into account. The estimated coefficient indicates incomplete pass-through. However, the coefficient is found to be insignificant in case of most import sub-sectors with the only exception of chemicals. In case of chemicals as well, the degree of exchange rate pass-through to import prices is incomplete. It is important to note that in all the cases, trade orientation index is found to be insignificant. This shows that improved trade orientation after 1991 did not in any way determine import prices across sectors. As pass-through is found to be either insignificant or incomplete across sectors, market power of the exporting country might be of importance in this analysis. This may be an important gap in this analysis.

4.   Conclusions

This paper has investigated into the degree of exchange rate pass-through to prices of imports across sectors in India during reforms. For the purpose of analysis, certain non-oil imports including chemicals, machinery, transport equipments, metal manufactures and food processing into India are considered, which account for about 70 per cent of the country's total imports. It is observed that, during post-reforms, import prices have moved synchronously with exchange rate indicating the possibility of exchange rate pass-through to import prices.

In the econometric analysis, an econometric model based on simultaneous equation imperfect substitutes model is made use of, which is distinctly different from econometric

models being used for estimation purposes in the literature. Panel data regression techniques are used as the econometric method on a dataset carefully compiled from different sources. The data appendix will provide an indication of the care with which comparable data was compiled for the purpose. The regression exercise was, thus, carried out using a fully specified econometric model, best possible econometric method and a time-comparable dataset. The model has suited the data well and the results are thus robust.

The econometric results show incomplete pass-through to import prices on account of movements in exchange rate in India. The results are based on the fixed effect model as Hausman test finds it to provide consistent estimates over random effect model. It can be observed that significant exchange rate pass-through to import prices occurs when all the sectors are taken into account. However, the coefficient is found to be insignificant in case of most import sub-sectors with the only exception of chemicals. In case of chemicals as well, the degree of exchange rate pass-through to import prices is incomplete. As pass-through coefficient is incomplete across sectors, factors such as market concentration of the exporting country and product characteristics might be of importance in this analysis. This analysis also shows that factors like domestic prices play a significant role in determining import prices in certain sectors.

It is important to note that in all the cases, trade orientation index is found to be insignificant. This shows that improved trade orientation after 1991 did not in any way determine import prices across sectors. This result in a way contrasts the findings of an earlier study by Mallick and Marques (2006), which show that exogenous factor like reforms, have played a significant role in exchange rate pass-through. This may be an important gap in this analysis. These results have important implications for policy.

The above results show that even though some import sectors have responded to exchange rate movements, this is in no way extensive as is expected during reforms. The impact of exchange rate on import prices is limited. This conforms to the fact that of phenomenal increase in imports during reforms despite depreciation in exchange rate over the years. On the other hand, import prices across sectors, are more dependent on factors other than exchange rate.

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