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Asymmetric Exchange Rate Effects on Trade Flows in India

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Abstract: This paper examines the role of exchange rate changes on India's trade. The drivers of exports and imports (income, exchange rate including sectoral differences, and exchange rate variability) are estimated for the short and long run including a structural break. Using annual data from 1994 to 2022, the results of dynamic fixed effects estimation show that both exports and imports are income-elastic in the short and long run, but income elasticity is far stronger for exports. Moreover, exports are responsive to the real effective exchange rate in the short run but not in the long run, and the reverse is true for imports. Furthermore, exchange rates have asymmetric effects for high-volume and primary sectors for exports and imports. The combined impacts show the ineffectiveness of using currency depreciation to address trade imbalances.

Keywords: asymmetric exchange rate effects; dynamic fixed effects; India; rupee variability

JEL Classification: F14; F31; O24

1. Introduction

This paper investigates the role of the exchange rate in India's trade. A depreciation can help exports and hurt imports, thus improving the trade balance and vice versa for an appreciation. This has led countries to pursue policies that depreciate or devalue the currency in an effort to improve trade balances.

Currency interventions by central banks are quite widespread in developing countries. In India, the Reserve Bank of India (RBI) has intervened in the currency market several times over the last few decades. In some cases, the RBI has attempted to depreciate the currency with the goal of improving trade balances, and in other cases, action has been undertaken to slow or reverse the decline in the rupee. However, there is no guarantee that these interventions will successfully translate into the expected change in the currency. Moreover, a currency depreciation may not lead to an improved trade balance.

The relationship between exchange rates and trade has been widely studied in the literature, including in the case of India. Studies have separated exports and imports, examined short-run and long-run effects, and focused on specific sectors. Through these investigations, it is clear that the link between the exchange rate and trade is complex and needs further investigation.

This paper focuses on India which is an important case study on this topic. The value of the rupee has fluctuated greatly following the 1990–91 balance of payments crisis when India moved to a managed float currency regime. Moreover, over the past few decades, the country has suffered large trade deficits leading to a rupee depreciation policy by the RBI. Despite this, or perhaps because of this, the exchange rate has experienced considerable volatility. Also, these changes in the currency have not always had the expected impact on trade balances and this paper aims to understand why that is the case.

The contribution of this paper is that it combines time effects and sectoral differences to provide a more complete picture of how the exchange rate affects India's trade. Focusing on the period after India switched to a managed float regime, this paper incorporates short-run and long-run effects to investigate how income and exchange rates affect exports and imports. The presence of a structural break can complicate the relationship, so this

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paper tests for and incorporates a structural break in the estimation. Furthermore, this study allows for sector-specific and sector-group exchange rate effects. Disaggregated data of exports and imports from various sectors are used in the estimation which also includes a grouping of high-volume sectors studied in the literature. Moreover, this paper extends the investigation of sectoral differences by estimating how exchange rates impact primary vs. manufacturing sector trade flows. Through this, this paper addresses the following questions: Does a change in the exchange rate have a bigger impact on exports or imports? Are the effects different in the long –run and the short –run? Are some sectors more responsive to exchange rate changes?

Using annual data from 1994 to 2022, this paper estimates the drivers of exports and imports in 62 sectors across nine broad sector categories. Long–run and short–run effects of income, exchange rate, and exchange rate volatility are estimated using dynamic fixed effects. The estimation also includes sectoral groupings through interaction dummy variables. Results show that the exchange rate has an impact on exports only in the short run and on imports only in the long run and there are differential effects for high-volume and primary sectors. Overall, the results cast doubt on the effectiveness of using rupee depreciations to improve trade balances.

This paper is organized as follows: Section 2 discusses the relevant literature which is followed by a background on the rupee and India's trade. Section 4 presents the framework and sample used in this study. The results are analyzed in Section 5 and the last section contains a conclusion.

2. The Related Literature

The literature examining the relationship between the exchange rate and trade is considerable. Bahmani-Oskooee (2001) finds that a real exchange rate depreciation improved trade balances for Algeria, Bahrain, Egypt, Jordan, Morocco, Tunisia, and Turkey in the long run and Guechari (2012) showed the same for Algeria for both the total trade and bilateral trade of the country with its major trading partners. Gomes and Paz (2005) and Aziz (2012) show evidence for the J-curve effect in Brazil and Bangladesh, respectively. Genc and Artar (2014) show that in the long run, the exchange rate impacts exports and imports in developing countries. On the other hand, Onakoya et al. (2018) find no J-curve effect for Nigeria.

Some studies have examined exports and imports separately. Younus and Chowdhury (2014) find that in Bangladesh, the real exchange rate affects trade in the short and long run, while Alam (2010) finds no statistically significant impact of Bangladesh's taka on the country's exports. Hassan et al. (2016) find that the real effective exchange rate affects Bangladesh's exports in the long run (not in the short run), while Younus and Chowdhury (2014) find no relationship between trade and the real effective exchange rate in Bangladesh.

Other studies extend this analysis to incorporate sectoral differences. For Turkish agricultural trade, Fidan (2006) finds that the relationship between the real effective exchange rate is stronger in the long run than the short run. Lanau (2017) finds that for Latin American countries, depreciation helps high-export sectors more than low-export sectors. Meanwhile, Bernardina (2004) finds that in the long run, real exchange rate appreciation hurts non-oil exports in Russia while Mehare and Edriss (2013) find that exchange rate variability hurts Ethiopia's coffee exports in the short run only.

There have also been India-specific studies. Panda and Mohanty (2015) find that exchange rate volatility hurts Indian exports, as does Tripathi (2021), although the impact is not statistically significant. Cheung and Sengupta (2013) show that rupee changes have a bigger impact on firms with small export shares and Tripathi (2021) finds that the exchange rate has a bigger impact on manufacturing goods.

This paper builds on these studies and the previous literature by combining these various drivers of exports and imports and analyzing them through the lens of time and sectoral differences. This study includes 62 sectors and includes both high-volume and primary sector groupings. Also, in recognition that a structural break could affect the relationship between trade and its drivers, this paper tests for, identifies, and incorporates a structural break in the estimation.

3. Background

Prior to 1991, India was a closed economy with a fixed exchange rate. After the 1990–91 balance of payments crisis, India undertook a significant restructuring of the economy. Following a transition period, India moved to a managed float system in 1993. This paper focuses on the period after that shift from 1994 to 2022, the last year for which there is complete data.

The RBI has attempted to change the value of the rupee through direct and indirect means. For example, direct intervention through the sale of foreign currency to increase the demand for rupees is designed to appreciate the rupee while indirect intervention through a cut in short-term interest rates reduces foreign demand for rupees and thus lowers its value (depreciation).

These interventions can be costly. Attempts to appreciate the currency, for example, can put pressure on foreign reserves (direct intervention) and can hurt investment and growth (indirect intervention through an increase in interest rates). Moreover, there is a concern that intervention increases dependency, where markets may be spooked if the RBI did not intervene (Anand 2018).

Moreover, these interventions may not have the expected impact. Figures 1 and 2 show periods of direct and indirect intervention between 2018 and 2019.

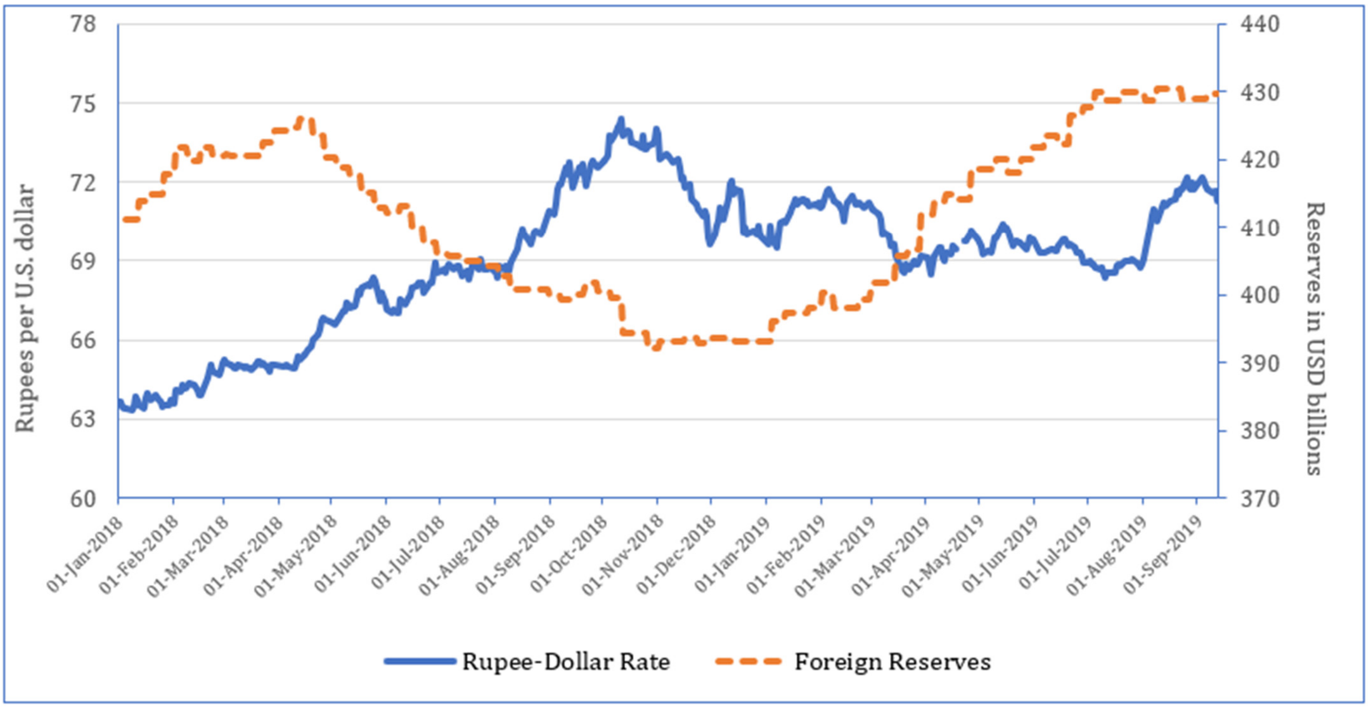

Figure 1. Direct intervention in rupee market by the Reserve Bank of India. Notes: exchange rate is measured on the left–hand–side axis and foreign reserves on the right–hand–side axis. A decrease in foreign currency is used to purchase/increase demand for the rupee and thus increase its value (an appreciation) and vice versa. A decrease (increase) in rupee–to–dollar rate indicates an appreciation (depreciation) of the rupee. Data from CMIS, Database for Indian Economy (n.d.), Reserve Bank of India (Bank for International Settlements n.d.). Author's graph.

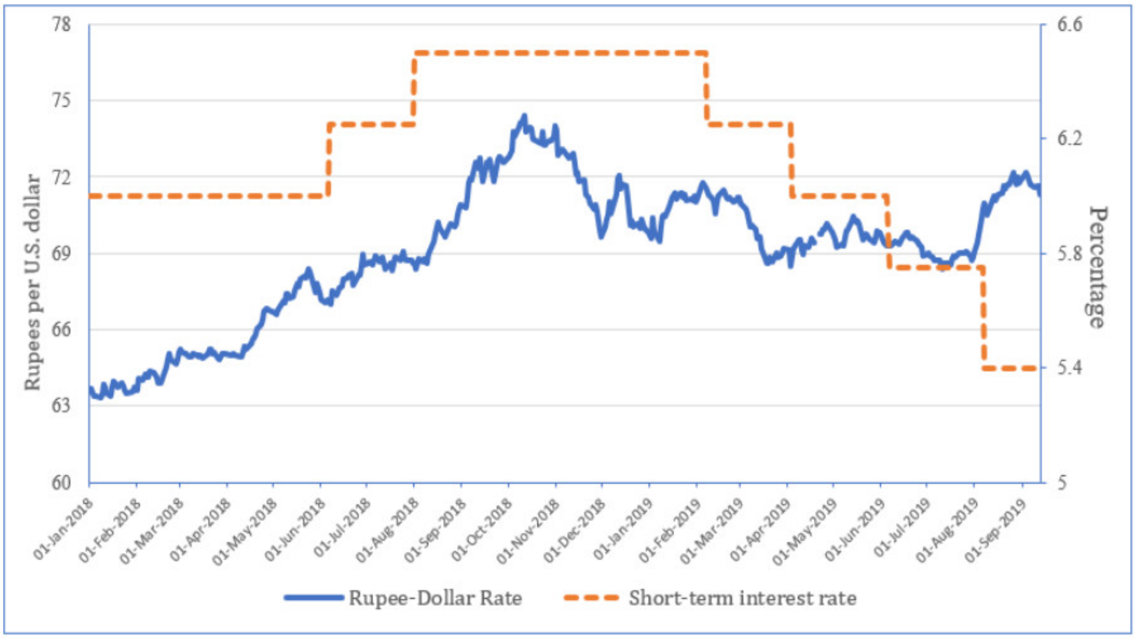

Figure 2. Indirect intervention in rupee market by the Reserve Bank of India. Notes: Notes: exchange rate is measured on the left-hand-side axis and foreign reserves on the right-hand-side axis. A decrease in short-term interest rate reduces demand for the rupee and thus lowers its value (depreciation) and vice versa. A decrease (increase) in rupee–to–dollar rate indicates an appreciation (depreciation) of the rupee. Data from CMIS, Database for Indian Economy (n.d.), Reserve Bank of India (Bank for International Settlements n.d.). Author's graph.

As can be seen from the figures, there have been periods of effective intervention such as during July–August 2019 when both direct and indirect intervention led to a depreciation of the currency. However, between January 2018 and October 2018, both direct and indirect efforts failed in their efforts to appreciate the rupee.

A further consideration is the effectiveness of these interventions, meaning do exchange rate changes affect the trade balance as expected. Figure 3 shows that the changes in the real effective exchange rate do not correlate neatly with the expected impact on the trade balance. For example, while the rupee depreciated considerably between 2010 and 2013, this marked the period when the trade deficit rose to its highest at 6.5% and 6.7% of GDP in 2011 and 2012. Also, when the rupee appreciated significantly between 2013 and 2016, the trade balance improved. Yet, as Veeramani (2008) notes for earlier episodes, this does not indicate that the appreciation did not hurt exports. It is possible that without the appreciation, there may have been an even greater improvement in the trade balance.

Why did rupee depreciations not improve trade deficits? The reason is that the relationship between the exchange rate changes and trade flows is much more nuanced, as discussed earlier. The impact may differ for exports and imports over time and across sectors. The methodology to examine the complex link between trade and exchange rates is discussed in the next section.

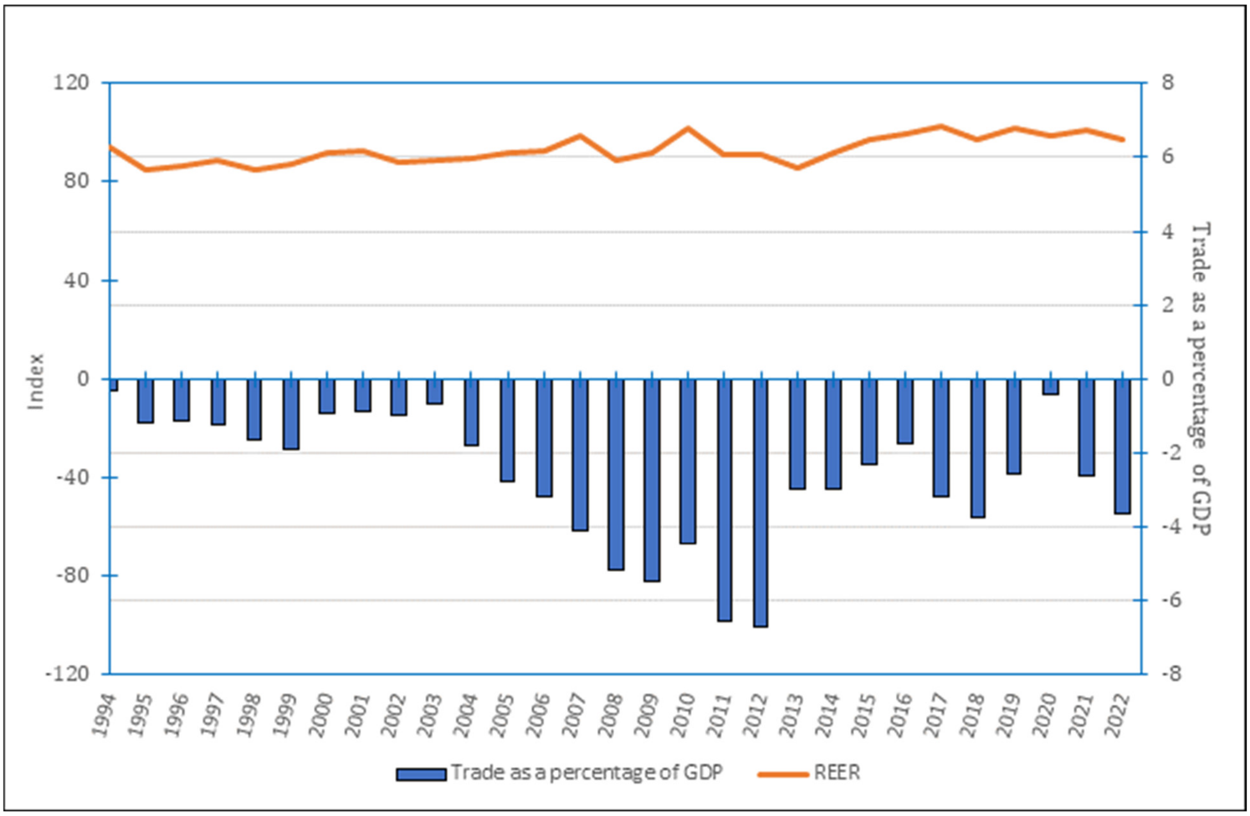

Figure 3. India's real effective exchange rate and trade balance. Notes: The real effective exchange rate is measured on the left–hand–side axis and the trade balance on the right–hand–side axis. Data for real effective exchange rate from Bank for International Settlements, Real Broad Effective Exchange Rate for India [RBINBIS], retrieved from FRED, Federal Reserve Bank of St. Louis https://fred.stlouisfed.org/series/RBINBIS, 19 October 2023. Trade data from United Nations Statistics Division (n.d.), UN COMTRADE. International Merchandise Trade Statistics. Available online at http://comtrade.un.org/ (accessed on 5 February 2024). Author's graph.

4. Methods

4.1. Empirical Model

Following the literature, exports (*ex*) and imports (*im*) are separately estimated with the real effective exchange rate (*reer*) and exchange rate variability (*volatility*) being included in both cases. The export equation also includes the world real GDP (*rgdppcw*) and the import equation includes domestic real GDP (*rgdppcind*). In addition, the differential impact of the exchange rate based on sectoral differences (high vs. low volume and primary vs. manufacturing) are also included. The impact for both these sector groups are captured through interactive terms between the exchange rate and dummy variable for the sector group (*exvol* × *reer* or *imvol* × *reer* and *prim* × *reer*). Thus, the equations to be estimated for exports and imports are as follows:

$$ex = f(rgdppcw,\ reer,\ volatility,\ exvol \times reer,\ prim \times reer) \quad (1)$$

$$im = f(rgdppcind,\ reer,\ volatility,\ imvol \times reer,\ prim \times reer) \quad (2)$$

The variables in the model are macroeconomic series with a time component which have to be tested for non-stationarity prior to estimation. If the variables are stationary, then Equations (1) and (2) can be estimated using OLS. If there are non-stationary variables, the next step is to test for cointegration. Evidence of cointegration requires use of an error correction model which includes short- and long-run effects. The appropriate test and method are based on whether there is a mix of I(0) and I(1) variables or if all variables are non-stationary.

The error correction model for exports can be rewritten as follows:

$$\begin{aligned}\Delta \ln ex_{it} = \alpha_0 + \beta_1 \Delta \ln ex_{it-1} + \beta_2 \Delta \ln rgdppcw_{t-1} + \beta_3 \Delta \ln reer_{t-1} + \beta_4 \Delta volatility_{t-1} + \\ \beta_5 \Delta\, (exvol \times \ln reer)_{t-1} + \beta_6 \Delta\, (prim \times \ln reer)_{t-1} + \mu_1 \ln ex_{it-1} + \mu_2 \ln rgdppcw_{t-1} + \\ \mu_3 \ln reer_{t-1} + \mu_4 volatility_{t-1} + \mu_5\, (exvol \times \ln reer)_{t-1} + \mu_6 (prim \times \ln reer)_{t-1} + \lambda\, EC_{t-1} + u_{it}\end{aligned} \tag{3}$$

where *ex* = exports in current dollars, *rgdppcw* = world real GDP per capita in 2010 dollars, *reer* = end-of-period real broad effective exchange rate index (2020 = 100), *volatility* is calculated using the monthly standard deviation for each year (following Cheung and Sengupta 2013). The dummy variables for sector groups are *exvol* which equals 1 when exports in a specific sector exceed the average of the broad category of that particular sector and 0 otherwise and *prim* which equals 1 if a primary sector and 0 for manufacturing. These group dummy variables are multiplied by the exchange rate to generate the interactive term that enables estimation of sector-group exchange rate impacts. *EC* is the error correction term and *ln* = natural log. Short-run impacts are captured by β_i and long-run impacts by μ_i and error correction by λ.

As GDP per capita of India's trade partner countries (*rgdppcw*) rises, their ability to purchase goods increases, and thus Indian exports are expected to rise. An increase in the real effective exchange rate (*reer*) or appreciation is expected to hurt exports as does variability of the exchange rate (*volatility*). The literature shows contradictory results for the differential exchange rate effect on high-volume exports. Cheung and Sengupta (2013) find that exchange rate appreciation effects are exacerbated for smaller export share sectors, and thus a smaller impact is expected for larger sectors. On the other hand, Lanau (2017) finds that exchange rate depreciation benefits high-volume exports more than low volume exports. Thus, the sign for the differential effect for high-volume sectors (*exvol*) is ambiguous. Based on Tripathi's (2021) findings, the exchange rate is expected to have a smaller impact on primary goods (*prim*).

Similarly, the error correction model for imports is given as:

$$\begin{aligned}\Delta \ln im_{it} = \alpha_0 + \beta_1 \Delta \ln im_{it-1} + \beta_2 \Delta \ln rgdppcind_{t-1} + \beta_3 \Delta \ln reer_{t-1} + \beta_4 \Delta volatility_{t-1} + \\ \beta_5 \Delta\, (imvol \times \ln reer)_{t-1} + \beta_6 \Delta\, (prim \times \ln reer)_{t-1} + \mu_1 \ln im_{it-1} + \mu_2 \ln rgdppcind_{t-1} + \\ \mu_3 \ln reer_{t-1} + \mu_4\, volatility_{t-1} + \mu_5\, (imvol \times \ln reer)_{t-1} + \mu_6 (prim \times \ln reer)_{t-1} + \lambda\, EC_{t-1} + u_{it}\end{aligned} \tag{4}$$

where *im* = imports in current dollars, *rgdppcind* = India's real GDP per capita in 2010 dollars, *imvol* = 1 when imports in a specific sector exceed the average of the broad category of that particular sector and 0 otherwise, and other variables are as defined earlier.

The impact India's GDP per capita (*rgdppcind*) on imports is expected to be positive because higher income increases demand for goods, including imports. As noted earlier, an exchange rate (*reer*) appreciation is expected to raise imports and variability of exchange rate (*volatility*) will reduce imports. Similarly to exports, the differential exchange rate impact on high-volume import sectors (*imvol*) is assumed to be ambiguous and lower for primary goods (*prim*).

4.2. Data and Statistical Analysis

This is a pooled data estimation where the period of this study is from 1994 to 2022 using trade data from 62 sectors. Data for exports and imports from the 62 sectors (2-digit SITC) in nine broad categories are from UN Comtrade database (the complete list can be found in Table 1).

To capture exchange rate and price effects, this paper uses the real broad effective exchange rate which is calculated as price adjusted weighted bilateral exchange rates sourced from the Bank of International Settlements and retrieved from the Federal Reserve Economic Database. Real GDP capita for the world and for India in 2010 dollars is from the World Bank (n.d.) database and retrieved from the Federal Reserve Economic Database. For *exvol* and *imvol*, averages of exports and imports for each of the nine broad categories are calculated for each year and if the trade flow exceeds its average for that category in that period it equals 1 which indicates a high-volume export or import sector and 0 otherwise. For *prim*, if the exports and imports are in a sector in categories 0–4 (primary sectors) they are set equal to 1 and 0 if they are in categories 5–8 (see Table 1 for categories).

Table 1. Sample sectors.

Code	Description (Primary)
0	**Food and live animals**
00	Live animals other than animals of division 03
01	Meat and meat preparations
02	Dairy products and birds' eggs
03	Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof
04	Cereals and cereal preparations
05	Vegetables and fruit
06	Sugars, sugar preparations, and honey
07	Coffee, tea, cocoa, spices, and manufacturers thereof
08	Feeding stuff for animals (not including unmilled cereals)
09	Miscellaneous edible products and preparations
1	**Beverages and tobacco**
11	Beverages
12	Tobacco and tobacco manufacturers
2	**Crude materials**
21	Hides, skins and furskins, raw
22	Oil seeds and oleaginous fruits
23	Crude rubber (including synthetic and reclaimed)
24	Cork and wood
25	Pulp and waste paper
26	Textile fibers (other than wool tops and other combed wool) and their wastes (not manufactured into yarn or fabric)
27	Crude fertilizers, other than those of division 56, and crude minerals (excluding coal, petroleum, and precious stones)
28	Metalliferous ores and metal scrap
29	Crude animal and vegetable materials, n.e.s.
3	**Minerals and fuels**
32	Coal, coke, and briquettes
33	Petroleum, petroleum products, and related materials
34	Gas, natural and manufactured
4	**Animal and vegetable oils**
41	Animal oils and fats
42	Fixed vegetable fats and oils, crude, refined, or fractionated
43	Animal or veg fats and oils, proc; waxes of animal or veg origin; inedible mix or prep of animal or veg fats or oils, n.e.s.

Table 1. *Cont.*

Code	Description (manufacturing)
5	**Chemicals**
51	Organic chemicals
52	Inorganic chemicals
53	Dying, tanning, and coloring materials
54	Medicinal and pharmaceutical products
55	Essential oils and resinoids and perfume materials; toilet, polishing, and cleansing prep
56	Fertilizers (other than those of group 272)
57	Plastics in primary forms
58	Plastics in non-primary forms
59	Chemical materials and products, n.e.s.
6	**Manufactured**
61	Leather, leather manufactures, n.e.s., and dressed furskins
62	Rubber manufactures, n.e.s.
63	Cork and wood manufactures (excluding furniture)
64	Paper, paperboard, and articles of paper pulp, of paper, or of paperboard
65	Textile yarn, fabrics, made-up articles, n.e.s., and related products
66	Non-metallic mineral manufactures, n.e.s.
67	Iron and steel
68	Non-ferrous metals
69	Manufactures of metals, n.e.s.
7	**Machinery and transport equipment**
71	Power-generating machinery and equipment
72	Machinery specialized for particular industries
73	Metalworking machinery
74	General industrial machinery and equipment, n.e.s., and machine parts, n.e.s.
75	Office machines and automatic data-processing machines
76	Telecommunications and sound-recording and reproducing apparatus and equipment
77	Electric mach, app and appl, n.e.s., and electric parts
78	Road vehicles (including air-cushion vehicles)
79	Other transport equipment
8	**Miscellaneous manufactured articles**
81	Prefabricated buildings; sanitary, plumbing, heating, and lighting fixtures and fittings, n.e.s.
82	Furniture, and parts thereof; bedding, mattresses, mattress supports, cushions, etc.
83	Travel goods, handbags, and similar containers
84	Articles of apparel and clothing accessories
85	Footwear
87	Professional, scientific, and controlling instruments and apparatus, n.e.s.
88	Photographic apparatus, equipment, and supplies and optical goods, n.e.s.; watches and clocks
89	Miscellaneous manufactured articles, n.e.s.

Note: Data from United Nations Statistics Division (n.d.), UN COMTRADE. International Merchandise Trade Statistics. Available online at http://comtrade.un.org/ (accessed on 5 February 2024).

As noted earlier, the series are first tested for stationarity. The augmented Dickey–Fuller test is used for variables without a panel component, real GDP, and real effective exchange rate and the Im Pesaran Shin panel unit root test for those with a panel component, exports, and imports. If there is a mix of I(0) and I(1) variables, ARDL bounds testing and estimation can be used. If all variables are I(1), the equations are tested for cointegration using the Kao test. If there is evidence of cointegration, then the correct estimation incorporating long-run and short-run effects must be determined. Two options are a pooled mean group (PMG) estimation or a dynamic fixed effects (DFE) model. These techniques include an error correction term which calculates the adjustment to equilibrium and are estimated using *xtpmg* Stata code from Blackburne and Frank (2007). The appropriate method (PMG and DFE) is determined using the Hausman test. Test and estimation results are discussed in the following section.

5. Results

Prior to estimation, the variables were tested for multicollinearity. As expected, the real effective exchange rate was correlated with the GDP variables. Neither variable can be excluded because of its importance in explaining exports and imports, and thus the estimation was conducted with no changes.

Test results are reported in Table 2. The augmented Dickey–Fuller and the Im Pesaran Shin test results show that all series are non-stationary. Given that all variables are I(1), cointegration tests were conducted using the Kao test and showed evidence of cointegration. The Hausman test showed that dynamic fixed effects is preferred over pooled mean group estimation

Table 2. Preliminary test results.

Test	*p*-Value or [t-statistic]
Stationarity test	
lnexports	0.99
lnimports	0.99
lngdppcind	[0.57]
lngdppcw	[−0.46]
lnreer	[−1.66]
reervolatility	[−1.55]
Cointegration test	
Exports	0.00 *
Imports	0.00 *
Hausman test	
Exports	0.89
Imports	0.99

Notes: Table reports stationarity test, cointegration test, and Hausman test results. For stationarity tests, either *p*-values or t-statistics (in square brackets) are reported. For series with a panel component, stationarity is tested using the Im Pesaran Shin test assuming maximum lags = 2 and *p*-values are reported. * indicates rejection of the null hypothesis at 5% level of significance. Rejection of the null indicates that variables are stationary for at least some panels. For variables with no panel component, the augmented Dickey–Fuller test is used assuming maximum lags = 2 and test statistics are reported. Rejection of the null (if the test statistic in absolute value is greater than the critical test statistic of −2.6540 at 1% level of significance) indicates that variables are stationary. Results show that all series are nonstationary. For the Kao cointegration test, *p*-values are reported. * indicates rejection of the null hypothesis and rejection of the null shows that there is cointegration. Results show cointegration for both exports and imports. For the Hausman test, *p*-values are reported. * indicates rejection of the null hypothesis, and rejection of null for the Hausman test indicates that PMG is preferred over DFE. Results show that DFE is preferred for both exports and imports.

The presence of a structural break can affect the relationship between variables. Thus, tests were conducted for structural breaks using *xtbreak* Stata code from Ditzen et al. (2021). Test results showed evidence of a break point of 1999 for exports and 2000 for imports. Thus, the two equations were revised to include a dummy variable for the period after the break points labeled *SBx* and *SBm* for exports and imports, respectively. For exports, *SBx* = 1 for periods 2000 onward and 0 otherwise and *SBm* = 1 for periods 2001 onward and 0 otherwise. The estimation results are reported in Table 3.

Table 3. Dynamic fixed effects results (DV = *lnexports or lnimports*).

	Exports	Imports
Variables	**Coeff [*p*-Value]**	**Coeff [*p*-Value]**
EC	−0.26 * [0.00]	−0.21 * [0.00]
	SR	
SBx	0.30 [0.00]	
SBm		0.21 [0.00]
Δ*lngdppcw*	6.38 * [0.00]	
Δ*lngdppcind*		2.78 * [0.00]
Δ*lnreer*	−0.81 * [0.04]	0.02 [0.47]
Δ*(exvol*lnreer)*	0.09 * [0.00]	
Δ*(imvol*lnreer)*		0.12 * [0.00]
Δ*(prim*lnreer)*	−0.38 + [0.17]	−0.35 + [0.17]
Δ*reervolatility*	−0.01 * [0.02]	0.003 * [0.04]
Constant	−10.46	−3.93
	LR	
lngdppcw	4.74 * [0.00]	
lngdppcind		1.30 * [0.00]
lnreer	1.05 [0.25]	4.10 * [0.02]
*(exvol*lnreer)*	0.13 * [0.00]	
*(imvol*lnreer)*		0.21 * [0.00]
*(prim*lnreer)*	−0.32 [0.41]	−1.70 *** [0.14]
reervolatility	−0.03 * [0.03]	−0.02 ** [0.09]
n = 1798 (29 years from 1994 to 2022 and 62 sectors in nine categories described in Table 1)		

Notes: Structural break points are identified using *xtbreak* code by Ditzen et al. (2021). Based on the results, dummy variables were included in the two equations. Equations were estimated using *xtpmg* Stata code by Blackburne and Frank (2007). The table reports coefficients and *p*–values for the error correction terms and short– and long– run coefficients for export and import estimations. *, **, and *** indicate variables are statistically significant at 5%, 10%, and 15% level of significance., respectively. + indicates that while the variable is not statistically significant at typical levels of significance, it is important.

For exports, we find that the error correction term is −0.26 and statistically significant, which indicates that 26% of the disequilibrium is corrected in the following period and the speed of adjustment to equilibrium is about 4 years. The error correction term for imports is −0.21 meaning that 21% of the disequilibrium is corrected in the following period and a slower (than exports) speed of adjustment to equilibrium that is about five years.

The structural break points for both exports and imports are positive and statistically significant. Results show that exports were approximately 0.30 percentage points higher from 2000 compared with those from earlier periods and imports were 0.21 percentage points higher from 2001 compared to those from earlier years. Both these shifts can be traced back to the economic reforms of the 1990s that opened the country to trade. Higher imports are a result of the reduction in tariffs that were part of these reforms and these trade restrictions continued to decline in the 2000s. The push to boost exports in these reforms also were successful with an increase in the 1990s and an even bigger jump in the 2000s. Chinoy and Jain (2019) highlight that a shift in the types of exports (from the more traditional textiles to auto parts) is a reason for the significant rise in exports during that period.

Both exports and imports are income-elastic, but there are differences in magnitude. Real GDP per capita of the world has a positive and statistically significant impact on Indian exports in the short and long run. For the long run, a 1% increase in the world's real GDP per capita is associated with about a 4.74% increase in exports. In the short run, the impact is higher at 6.38%. The real GDP per capita of India has a positive and statistically significant impact on Indian imports in the short and long run. A 1% increase in India's real GDP per capita is associated with a 1.30% increase in imports in the long run and a 2.78% increase in the short run. For both exports and imports, income elasticity is greater in the short run compared with in the long run and exports are considerably more income-elastic than imports. According to these results, an equal increase in India's GDP per capita and world GDP per capita would lead to improvement in India's trade balances.

The volatility of the exchange rate hurts exports in the long and short run, although the impact is small (−0.01 in the short run and −0.03 in the long run). Imports are also reduced by exchange rate volatility in the long run (−0.02); however, in the short run, there is an unexpected small positive (0.003) and statistically significant impact on imports. A likely explanation is that imports are inelastic in the short run and cannot be reduced even in the face of some uncertainty.

For exports, the impact of the exchange rate is only statistically significant in the short run, and thus only those results are discussed. For a 1% real effective exchange rate depreciation, exports rise by 0.81% in the short run. The differential coefficient for high-volume sectors is statistically significant and positive (0.09), while for primary sectors, the differential coefficient is negative (−0.38) and important although not statistically significant. These results indicate that a 1% decrease in *reer* leads to a 0.72% increase in high-volume sector exports in the short run. The reduced impact is similar to Cheung and Sengupta's (2013) findings. Depending on the year, this affects between 19 and 26 sectors or 31–41% of the sample. A 1% *reer* depreciation raises primary sector exports by 1.19% in the short run, affecting 27 sectors or 44% of the sample. Thus, the positive impact of an exchange rate depreciation is reduced in high-volume sectors but increased in primary sectors.

For imports, exchange rate changes are only statistically significant in the long run. A 1% real effective exchange rate depreciation lowers imports by 4.1%. The differential coefficient for high-volume sectors is statistically significant and positive (0.21), while for primary sectors it is negative (−1.70) and statistically significant. A 1% decrease in *reer* leads to a bigger decline in high-volume imports at 4.22% (similar to Lanau 2017). This impacts 16 and 24 sectors or 26–39% of the sample. Also, a 1% decrease in *reer* is associated with a 2.4% decline in primary sector imports in the long run. For imports, sectoral differences work to raise the effect of an exchange rate depreciation for high-volume sectors and reduce it for primary sectors.

Overall, the results show the importance of three inter-related effects in explaining how income and exchange rates impact trade: the necessity of separating of exports and imports, the role of time, and the importance of sectoral differences. The statistically significant structural break period shows that both trade flows have been on an increasing trajectory since the early 2000s, although, as Chinoy and Jain (2019) note, growth rates for both have declined in recent years due to de-globalization and India's demonetization. Time also enters the analysis through short- and long-run estimation which reveal important differences. The impact of income (world and domestic) is stronger in the short run compared with in the long run for both exports and imports. In both periods, exports have a stronger income elasticity.

In the short run, exports (all exports as well as high-volume and primary sectors) increase due to a depreciation, while results for imports are not statistically significant.

In the long run, exports are not affected by the exchange rate, while imports for all cases are highly responsive to the exchange rate (although the impact on primary sectors is substantially lower). Thus, these results show that an exchange rate depreciation can improve the trade balance in both the short and long run by raising exports and lowering imports in the two periods, respectively. This conclusion is dependent on the structure (sector types) of trade flows and on the changes in India's and world income.

The following section offers concluding remarks.

6. Conclusions

Exports and imports are estimated by incorporating structural breaks and including long- and short-run effects. The latter is important because it shows that income and exchange rate effects vary for exports and imports. Sectoral differences add another layer of nuance to exchange rate effects on trade flows.

The results show that while both exports and imports in India have been on an upward trajectory since the early 2000s, income and exchange rates play an important role in trade. Given that exports are more income-elastic than imports, this indicates that equal rates of GDP growth in India and in the world could lead to an improvement in trade balances in both the short and long run (assuming no other effects). Over the sample period, an average growth rate in India of 4.68% was more than three times that of the world's real GDP growth of 1.35% (World Bank database), suggesting that for reasonable GDP growth rates, the trade balance will worsen.

Exchange rates affect trade in two ways: through changes and variability. As expected, exchange rate variability hurts both exports (in the short and long run) and imports (in the long run only), but the effect is small. There is an unexpected positive (although minimal) impact on imports in the short run which is likely related to the inability of imports to adjust to fluctuations in the short run.

There are asymmetric exchange rate effects on trade flows. While exports and imports are expected to respond to exchange rate changes differently (depreciation increases exports and reduces imports), the results show that these effects are only seen in the short run for exports and only in the long run for imports. In the short run, a depreciation will help exports for all sectors and even more for primary sectors, but the improvement will be smaller for high-volume sectors. In the long run, following a depreciation, imports will fall substantially for all sectors and even more for high-volume sectors, but much less for primary sectors. Thus, if exports are primarily dominated by high-volume sectors, a depreciation would lead to a smaller improvement in the trade balance in the short run, and if they are dominated by primary goods, the improvement would be greater. In the long run, if imports are mostly dominated by high-volume sectors, depreciation would lead to a substantial improvement in the trade balance and would be considerably smaller than if primary-sector goods dominated imports.

During the various interventions by the RBI in the foreign exchange rate market, promoting exports and addressing trade imbalances have been an important consideration. While the results provide an argument for using rupee depreciation to improve trade balances, the asymmetry in the responses of exports and imports across time and sectors shows the limits to that strategy. It is also important to emphasize the importance of income effects, notably domestic income effects, on imports. The strong effect of India's GDP per capita on imports in both the short and long run coupled with high growth rates in India will continue to worsen trade balances irrespective of rupee depreciations. Given that currency interventions are costly and can lead to volatility which hurts exports, depreciation is not an effective policy in addressing trade imbalances.

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