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EXCHANGE RATE VARIABILITY AND INDIA'S BILATERAL TRADE WITH USA AND CHINA

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ABSTRACT

This paper explores the role played by the bilateral exchange rate variability (both in the exchange rate levels and its volatility) in explaining the Indo-China and Indo-USA bilateral trade. The volatility series of the exchange rates have been generated using the GARCH method and ARDL approach to cointegration has been used to estimate the long-run and short-run dynamic relationship between the variables of interest. The findings reveal that India's exports with China and USA is positively influenced the exchange rates levels of Indian rupee with the respective currencies of these countries, but the volatility of the exchange rate exerts statistically insignificant effect. The exchange rate levels do influence India's imports from the respective country in the long run only but the coefficient significant only in the case of India's imports from China. The volatility of the dollar-rupee exchange rate has a positive and statistically significant effect on imports from the USA in the long-run whereas in the short-run, the volatility of current period has positive, and the volatility of the previous period has a negative effect on imports from the USA. The yuan-rupee volatility has an insignificant effect on India's import from China both in the long-run and short-run. The major factor that explains much of India's export to the USA and China in the long run is the GDP of these countries suggesting that India's exports to these countries are income elastic. The results regarding India's imports shows that only China's GDP has a positive and significant effect on India's imports from China. In the long-run, India imports from the USA are income elastic but from China, they are income inelastic.

KEYWORDS: ***Exchange rate, bilateral-trade, GARCH, Cointegration, Indo-China, Indo-USA.***
JEL Classification: C22, C32, F14, F31, G01.

1. INTRODUCTION

In 1991, India faced a severe economic crisis driven by a balance of payments issue. The roots of the crisis can be traced back to the country's history of trade deficits, exacerbated by a relatively liberal trade policy in the mid-1980s aimed at addressing technological obsolescence in Indian industries. The government's profligate spending throughout the 1980s led to a large fiscal deficit, further aggravating the situation. The Gulf War (1990-1991) acted as a catalyst, increasing petroleum prices and reducing remittances from the Gulf countries, which strained India's foreign exchange reserves. By 1991, the reserves were so low that they could only cover a week's worth of imports, pushing India to the brink of defaulting on international commitments. To address this crisis, India sought assistance from the International Monetary Fund (IMF), which required the country to implement structural adjustment programs as a condition for bailout packages. These programs led to significant economic reforms beginning in July 1991, with a focus on liberalisation, privatisation, and globalisation (LPG model). The government opened up the economy to the private sector, restricted the role of the state to a few sectors, and took various measures to integrate the Indian economy with the global market. This included simplifying trade rules, liberalising foreign investment policy, and adjusting the exchange rate policy.

One of the key measures was the devaluation of the Indian rupee against the US dollar by 9% and 11% on July 1 and July 3, 1991, respectively. Following the recommendations of the C. Rangarajan committee on balance of payments, the government partially liberalised the exchange rate regime in March 1992. The Reserve Bank of India (RBI) introduced the Liberalised Exchange Rate Management System (LERMS), which allowed 40% of foreign exchange earnings to be converted at the official exchange rate and the remaining 60% at market-determined rates. In March 1993, India transitioned to a fully market-determined exchange rate, and by August 1994, the rupee was fully convertible on the current account. Today, India's exchange rate system operates under a managed float, where the RBI intervenes occasionally to curb volatility.

The establishment of the World Trade Organization (WTO) in 1995 further pushed India to liberalise its international trade. The transition to a market-determined exchange rate exposed Indian exporters and importers to exchange rate risks, which could significantly impact international trade. This study aims to explore the linkage between exchange rate variability and India's bilateral trade with the USA and China. Previous studies, such as Veeramani (2008) and Srinivasan and Wallack (2003), have examined the impact of exchange rates on exports from a macro perspective, while Cheung and Sengupta (2013) used firm-specific data. However, none have focused on the bilateral exchange rates and their impact on bilateral trade.

This study investigates the effects of exchange rate levels and volatility, considering the J-curve hypothesis of Marshall and Lerner, which posits that currency appreciation negatively impacts exports and positively impacts imports, while depreciation has the opposite effect. Additionally, high exchange rate volatility can adversely affect trade volumes by making profits unpredictable for international trade participants. The analysis focuses on Indo-China and Indo-USA bilateral trade due to India's persistent trade deficit with China and trade surplus with the USA. Besides the primary variables of interest, the study also includes the GDP of India and its trading partners, as the GDP of the importing country reflects purchasing power and demand conditions, influencing exports positively. The GDP of the exporting country indicates supply-side factors like productivity improvements and comparative advantages, also positively affecting exports. Since changes in exchange rate regimes can alter international trade structures and affect exchange rate volatility measures, the study focuses on the period after March 1993, when India adopted the market-determined exchange rate system. Due to the unavailability of quarterly GDP data before Q2 1996, the study spans from Q2 1996 to Q2 2017, comprising 85 observations, sufficient for a comprehensive analysis.

The Remaining of the paper has been organised as follows; Section 2 gives a brief review of the literature. Section 3 outlines the data sources and research methods employed in the study. Section 4 discusses the empirical results and section 5 concludes.

2. REVIEW OF LITERATURE

Fleming (1962) and Mundell (1963) argue that exchange rate appreciation negatively impacts exports and positively affects imports, given rigid nominal wages and free trade. Abeysinghe and Yeok (1998) counter this by highlighting the role of imported inputs in exports and productivity gains from cheaper imports. In small economies like Singapore, currency appreciation might not harm exports due to lower export production costs, though services exports can suffer. Veeramani (2008) examines the relationship between Indian exports and the real effective exchange rate (REER) from 1960 to 2007. He finds that since 1999, REER appreciation negatively affected Indian exports. The short-run elasticity of exports to REER was -0.23 (1960-2001) and -0.19 (2002-2007), with long-run elasticity being -0.47 and -0.38, respectively. Veeramani also finds that the 36-currency weighted REER index has an insignificant effect on India's services exports, attributing this to the concentration of services exports in a few countries.

Hua (2008) finds that a 1% depreciation of the renminbi boosts China's exports to 11 industrialised countries by 1.45%. Furthermore, a 1% depreciation of China’s export competitors’ currencies reduces Chinese exports by 0.42%, indicating that China’s exports are influenced by both its own exchange rate policies and those of its competitors. Dhasmana (2012) studies the relationship between India’s real exchange rate and trade balance with 15 major partners from 1975Q1-2011Q1. The findings reveal that in the long run, depreciation of India's real exchange rate improves its trade balance, while volatility negatively impacts the trade balance. Shahbaz *et al.* (2012) examine the relationship between exchange rate and trade balance in Pakistan using the ARDL cointegration approach. The results suggest a long-term relationship between exchange rate and trade balance, with a negative and significant elasticity coefficient, contradicting the J-curve hypothesis. This implies that devaluation may worsen Pakistan's trade balance. Cheung and Sengupta (2013) employ firm-level data to investigate the impact of exchange rate on the export behaviour of Indian manufacturing firms. Their fixed effect model shows that both appreciation and volatility of the exchange rate negatively impact exports, with a 1% increase in REER reducing a firm’s export share by 6.3%. Smaller firms are found to be more sensitive to REER changes and volatility than larger firms, highlighting the asymmetric effects of exchange rate movements on exports.

Arize (1995) highlights the importance of including exchange rate volatility in export demand equations to avoid dynamic misspecification. Using the Johansen cointegration technique, Arize finds that US dollar volatility negatively affects US exports in both the short and long term. Exchange rate appreciation also harms exports, while global income positively impacts them. Chou (2000) examines the impact of renminbi volatility on China's exports using the ARCH (1) model. He discovers that renminbi volatility has a significant negative long-term effect on total exports and exports of manufactured goods and mineral fuels, while the impact on foodstuffs, beverages, and tobacco is not statistically significant. However, exchange rate variability positively affects exports of industrial materials.

Ethier (1973) and Baron (1976) suggest that exporters can mitigate exchange rate volatility through forward markets, though Viaene and de Vries (1992) argue that high hedging costs can still indirectly harm exports. De Vita and Abbott (2004) use sector-specific data to study the UK's exports to the EU, finding that short-term exchange rate volatility has an insignificant effect, while long-term volatility negatively affects exports. This suggests that while short-term volatility can be hedged, long-term uncertainty poses greater challenges. Aliyu (2010) investigates the impact of exchange rate volatility of the Nigerian naira and US dollar on Nigeria's non-oil exports. He finds that reduced exchange rate volatility can boost exports by encouraging existing firms to produce more and new firms to enter the export market. The vector error correction model reveals that naira volatility discourages non-oil exports, while US dollar volatility promotes them. Long-term, naira volatility reduces exports by 0.45%, while US dollar volatility increases them by 2.1%. Mukherjee and Pozo (2011) assert that exchange rate uncertainty affects trade nonlinearly. Using semiparametric regression on data from over 200 countries, they find that exchange rate volatility generally discourages trade, with negative effects intensifying with higher uncertainty, except at extremely high levels of volatility, where the impact diminishes. Asterios *et al*. (2016) study exchange rate volatility's impact on international trade in Mexico, Indonesia, Nigeria, and Turkey (MINT countries). They find that long-term volatility doesn't affect exports in most countries except Turkey, but in the short-term, it Granger-causes export and import demands in Mexico and Indonesia. In Nigeria, exports influence exchange rate volatility.

Several studies have explored the impact of exchange rate uncertainty on India's trade. Srinivasan and Kalaivani (2013) examine the real rupee-dollar exchange rate level and its volatility on Indian exports from 1970-2011. They find that while long-term depreciation positively affects exports, short-term depreciation has a negative impact. Volatility in the exchange rate also negatively impacts real exports. Cheung and Sengupta (2013) discover that a one-standard-deviation increase in REER volatility reduces Indian exports by 26%. Similarly, Panda and Mohanty (2015) study the relationship between real exports and exchange rate volatility in India (1970-71 to 2011-12) and find a negative impact on real exports. Both studies emphasize that global GDP positively influences Indian exports and recommend moderating exchange rate volatility to boost export growth. The findings collectively suggest that while exchange rate volatility poses challenges for Indian exports, stabilizing these rates could enhance trade performance, particularly in the context of diversified regional exports.

3. RESEARCH METHODOLOGY

3.1. Data

This paper relies on secondary data sources. Exchange rate data for the Indian Rupee (INR) against the US Dollar (USD) and Chinese Yuan (CNY) is sourced from the Reserve Bank of India's Database on Indian Economy (DBIE). Consumer price indices are compiled from the International Financial Statistics (IFS), and bilateral trade data is obtained from the Direction of Trade (DOT), both available from the International Monetary Fund (IMF). Quarterly GDP data is taken from the Organisation for Economic Co-operation and Development (OECD) and supplemented by the RBI's DBIE. A dummy variable is used, with 0 for Q2-1996 to Q3-2008 (pre-financial crisis) and 1 for the post-crisis period. The Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model is employed to estimate exchange rate volatility. Developed by Bollerslev (1986) and Taylor (1986), GARCH is a generalized version of the Autoregressive Conditional Heteroskedasticity (ARCH) model by Engle (1982). GARCH models are effective in modelling 'volatility clustering,' where large changes follow large changes and small changes follow small changes (Mandelbrot, 1963).

3.2. ARDL Model Specification

The conventional cointegration tests by Engle and Granger (1987) and Johansen and Juselius (1990) are not suitable for variables that are a mix of I(0) and I(1). The autoregressive distributed lag (ARDL) approach to cointegration is ideal for this scenario due to several advantages over traditional cointegration tests. Firstly, it can handle models with both stationary and nonstationary variables, though pretesting for unit roots is necessary to ensure no variables are of order 2 (I(2)) or higher, as their inclusion invalidates the methodology. Secondly, the ARDL method is more suitable for small sample sizes. Third, it allows different lag lengths for various variables, making the model more parsimonious. Lastly, the ARDL model uses a single equation setup, making it simpler to implement and interpret. This approach provides a robust framework for examining relationships in mixed integration order datasets, enhancing the accuracy and stability of the model.

4. EMPIRICAL RESULTS AND DISCUSSIONS

4.1. Unit Roots Tests

Before going ahead to conduct any cointegration test it is necessary to test for the presence of unit roots in all the variables of the system. In this analysis, two most popular tests of unit roots namely the augmented Dickey-Fuller (ADF) and Phillips-Perron tests have been applied. The results of the same have been shown below:

Table: 1
Augmented Dickey-Fuller and Phillips-Perron Tests

Levels			1st Differences			I (d)
Variables	ADF Statistic	P- Perron Statistic	Variables	ADF Statistic	P- Perron Statistic	
	Indo-US trade					
Log(ExportU)	-0.71	-0.59	Δ_1*(ExportU)*	-4.34***	-18.84***	I (1)
Log(ImportU)	-0.91	-0.83	Δ_1*(ImportU)*	-4.06***	-10.22***	I (1)
Log(GDPI)	-0.30	-0.06	Δ_1*(GDPI)*	-4.93***	-12.59***	I (1)
Log(GDPUS)	-2.24	-2.43	Δ_1*(GDPUS)*	-5.79***	-5.84***	I (1)
Log(REXD)	-0.77	-0.76	Δ_1*(REXD)*	-7.25***	-7.23***	I (1)
Volatility	-5.68***	-5.68***				I (0)
	Indo-China Trade					
Log(ExportC)	-1.29	-1.46	Δ_1*(ExportC)*	-11.65***	-11.96***	I (1)
Log(ImportC)	-1.18	-1.22	Δ_1*(ImportC)*	-9.79***	-9.82***	I (1)
Log(GDPI)	0.15	0.15	Δ_1*(GDPI)*	-9.20***	-9.20***	I (1)
Log(GDPC)	-1.01	-0.73	Δ_1*(GDPC)*	-17.33***	-26.33***	I (1)
Log(REXY)	-2.53	-2.25	Δ_1*(REXY)*	-7.15***	-7.11***	I (1)
Volatility	-5.24***	-5.22***				I (0)

Note: *** denotes 1% level of significance. Δ_1 denotes the first difference of the respective variable.

The ADF and Phillips-Perron tests reveal that Log(ExportU) and Log(ExportC), representing India's exports to the USA and China, are nonstationary at levels but stationary at the first difference, indicating they are integrated of order one. Similarly, all GDP variables (GDPI, GDPUS, and GDPC) have unit roots at their levels but are stationary at the first difference. The dependent variables of the import functions (ImportU and ImportC) are also nonstationary at levels but stationary at the first difference. The exchange rates (USD/INR and CNY/INR) have unit root issues at levels but become stationary at the first difference. However, the volatility of USD/INR and CNY/INR is stationary at levels, indicating they are integrated of order zero. With this mix of I(1) and I(0) variables, the ARDL approach can be applied to test for cointegration among the variables of interest.

4.2. ARDL Bounds Testing for Cointegration

Since the aim of this study is to examine the impact of exchange rate levels and their volatility on the bilateral exports and imports between India and USA and India and China, so we have two export functions and two import functions that seek to address the aforementioned research problem. In order to test for the long-run relationship, the ARDL approach has been used. The results for the same have been shown in the following two tables.

Table: 2
ARDL Bounds Test for Cointegration (Exports)

Dependent variable	SIC	F-statistic	I (0) Lower Bound*	I (1) Upper Bound*	Outcome
Log(ExportU) = f(Log(GDPI), Log(GDPUS), Log(REXD), Volatility)	4	6.14	2.86	4.01	Cointegration
Log(ExportC) = f(Log(GDPI), Log(GDPC), Log(REXY), Volatility)	4	4.11	2.86	4.01	Cointegration

Note: * denotes lower bound and upper bound at 5% level of Significance.

The results of the ARDL bounds test for the export functions, as depicted in Table 2, show that India's exports to the USA are cointegrated with India's GDP, US GDP, the dollar-rupee exchange rate, and the volatility of USD/INR, with an F-statistic of 6.14 exceeding the upper bound value of 4.01. A lag length of 4 was determined for the model based on the SIC. Similarly, India's exports to China are cointegrated with India's GDP, China's GDP, the yuan-rupee exchange rate, and the volatility of CNY/INR, with an F-statistic of 4.11 also exceeding the upper bound value of 4.01. The SIC determined a lag length of 4 quarters for this model. These findings reject the null hypothesis of no cointegration for both specifications, allowing for the estimation of the long-run relationship.

In the next step, we test for the cointegration for the import functions. The results of the same have been shown in table 3.

Table: 3
ARDL Bounds Test for Cointegration (Imports)

Dependent variable	SIC	F-statistic	I (0) Lower Bound*	I (1) Upper Bound*	Outcome
Log(ImportU) = f(Log(GDPI), Log(GDPUS), Log(REXD), Volatility)	4	4.87	2.86	4.01	Cointegration
Log(ImportC) = f(Log(GDPI), Log(GDPC), Log(REXY), Volatility)	4	4.22	2.86	4.01	Cointegration

Note: * denotes lower bound and upper bound at 5% level of Significance.

The ARDL bounds test results for the import functions reveal that India's imports from the USA and China are cointegrated with India's GDP, the respective GDPs of the USA and China, and the respective exchange rates and their volatilities. For India's imports from the USA, the computed F-statistic exceeds the upper bound critical value, indicating a long-run relationship. Similarly, for India's imports from China, the computed F-statistic also surpasses the upper bound critical value, confirming cointegration. The SIC determines a lag length of 4 quarters for both models. Given these results, we will proceed to estimate the long-run relationship and the short-run dynamic relationship using the error correction model (ECM).

4.3. Long-run relationship

The long-run relationship for the export functions has been estimated using equation (5) and equation (6). Equation (5) is based on India's export to the USA and equation (6) is based on India's exports to China.

The findings reveal that India's GDP (Log(GDPI)) positively influences its exports to the USA (Log(ExportU)), but the effect is statistically insignificant. This suggests that supply-side factors, such as productivity improvements, are not dominant in driving India's exports to the USA. In contrast, the GDP of the importing country, the USA, has a significant positive impact on India's exports, highlighting the importance of demand-side factors. An increase in the importing country's GDP boosts its disposable income, leading to higher imports if the imports are income elastic. Table 4 indicates that India's exports to the USA are highly income elastic. The US GDP (Log(GDPUS)) has a positive and statistically significant effect on India's exports, with each 1% increase in US GDP resulting in a 3.86% increase in India's exports to the USA in the long run. This underscores the major role of demand-side factors in determining India's exports to the USA.

Table: 4
Long-run results (Exports)

Indian Exports to USA (Dependent variable Log(ExportU)		**Indian Exports to China (Dependent variable Log(ExportC)**	
Variables	Coefficients	Variables	Coefficients
Log(GDPI)	0.11 (0.27)	*Log(GDPI)*	-11.82* (7.09)
Log(GDPUS)	3.86*** (0.81)	*Log(GDPC)*	8.20** (3.83)
Log(REXD)	1.42*** (0.47)	*Log(REXY)*	10.62*** (3.78)
Volatility	0.01 (0.02)	*Volatility*	-0.002 (0.10)
fincrisis	-0.05 (0.11)	*fincrisis*	-0.99 (0.81)
Constant	-92.16*** (17.28)	*Constant*	158.25 (110.19)

Note: ***, ** and * denotes 1%, 5% and 10 % level of significance respectively. Values in the parenthesis show the standard error of the respective coefficients.

The analysis reveals that the USD/INR exchange rate (Log(REXD)) positively and significantly affects India's exports to the USA, indicating that the appreciation of the USD/INR exchange rate boosts India's exports to the USA. This is contrary to the typical economic theory that suggests currency appreciation negatively impacts exports, applicable when exports are price elastic. The volatility of the USD/INR exchange rate, however, has an insignificant effect on India's exports to the USA, likely due to India's managed float exchange rate system, where the RBI frequently intervenes to mitigate high volatility. Additionally, while the financial crisis of 2007-08 negatively influenced India's exports to the USA, this effect is not statistically significant at any conventional level of significance.

The analysis of India's exports to China reveals that India's GDP negatively and significantly affects exports to China in the long run, with a 1% GDP growth reducing exports by 11.81%. This indicates that supply-side factors are hindering exports. Conversely, demand-side factors, such as China's GDP, significantly boost India's exports, with a 1% increase in China's GDP raising exports by 8.20%. Additionally, the yuan-rupee exchange rate positively impacts exports, with a 1% rupee appreciation increasing exports by 10.62%. The volatility of the CNY/INR has a negative but statistically insignificant effect on exports, possibly due to RBI interventions or underdeveloped future markets. The financial crisis of 2007-08 also negatively impacted exports but was not statistically significant. Overall, the major determinants of India's exports to the USA are the US GDP and the dollar-rupee exchange rate, while India's GDP, China's GDP, and the yuan-rupee exchange rate are key determinants for exports to China.

The long-run estimates for the import function based on equation (7) and (8), have been shown below in Table 5. The first two columns are related to India's imports from the USA where the last two columns are related to India's import from China.

Table:5
Long-Run results (Imports)

Indian Imports from USA (Dependent variable Log(ImportU)		**Indian Imports from China (Dependent variable Log(ImportC)**	
Variables	**Coefficients**	**Variables**	**Coefficients**
Log(GDPI)	1.96** (0.92)	*Log(GDPI)*	-2.69 (3.62)
Log(GDPUS)	-0.47 (2.56)	*Log(GDPC)*	4.13** (2.07)
Log(REXD)	1.16 (0.90)	*Log(REXY)*	3.91* (2.35)
Volatility	0.12*** (0.04)	*Volatility*	-0.001 (0.05)
fincrisis	-0.80*** (0.26)	*fincrisis*	-0.90** (0.46)
Constant	-18.79 (50.25)	*Constant*	-11.33 (52.31)

Note: ***, ** and * denotes 1%, 5% and 10 % level of significance respectively.

The analysis shows that India's GDP positively and significantly affects its imports from the USA, indicating income elasticity. A 1% increase in India's GDP leads to a 1.95% rise in imports from the USA, while US GDP has no significant impact. The USD/INR exchange rate positively affects imports, but the effect is statistically insignificant. Interestingly, the volatility of the dollar-rupee exchange rate has a positive and significant impact on imports, contradicting the typical theory that exchange rate volatility negatively influences trade. This may be due to the well-developed future rupee-dollar market or RBI's interventions to mitigate volatility. The 2008 financial crisis negatively impacted India's imports from the USA, and this effect is statistically significant. Overall, demand-side factors play a crucial role in determining India's imports from the USA.

The analysis indicates that demand-side factors, such as India's GDP, have no significant effect on imports from China, with a 1% GDP growth reducing imports by 2.69%, suggesting income inelasticity. In contrast, China's GDP positively influences India's imports, with a 1% growth in China's GDP increasing imports by 4.13%, highlighting the importance of push factors. The yuan-rupee exchange rate also positively impacts imports, consistent with the theory that currency appreciation boosts imports if they are price elastic. The volatility of the yuan-rupee exchange rate negatively affects imports but is statistically insignificant. The 2008 financial crisis negatively impacted imports from both the USA and China, with significant effects. In summary, India's GDP, exchange rate volatility, and the financial crisis are key determinants of imports from the USA, while China's GDP, the yuan-rupee exchange rate, and the financial crisis are crucial for imports from China.

4.4. Short-run Relationship

The short-run dynamic coefficients for India's export functions, based on the error correction model, reveal interesting insights. The GDP of the USA exerts a significant positive impact on India's exports to the USA in the short run, indicating income elasticity in both the short and long run. A 1% growth in the USA's GDP increases India's exports to the USA by 4.54% in the current quarter and 2.95% in the next quarter, though the significance level diminishes. India's GDP does not significantly affect its exports to the USA in the short run, suggesting limited impact from productivity growth.

The dollar-rupee exchange rate has an expected negative sign but is statistically insignificant, indicating a 1% appreciation leads to a 0.38% fall in exports. The volatility of the exchange rate positively affects exports but is also statistically insignificant. Past exports negatively influence current exports, with significant effects in the first and third quarters. The financial crisis negatively influenced exports to the USA but is not statistically significant. The equilibrium correction coefficient ecm(-1) of -0.397 indicates that 39.7% of the previous quarter's disequilibrium converges back to long-run equilibrium, showing a relatively quick recovery from shocks.

Table: 6
Short-Run results (Exports)

Indian Exports to USA ARDL (4, 0, 2, 1, 0) (Dependent variable Log(ExportU)		**Indian Exports to China ARDL (3, 0, 0, 1, 0) (Dependent variable Log(ExportC)**	
Variables	**Coefficients**	**Variables**	**Coefficients**
Δ(ExportU(-1))	-0.20** (0.10)	*Δ(ExportC(-1))*	-0.06 (0.10)
Δ(ExportU(-2))	-0.08 (0.10)	*Δ(ExportC(-1))*	-0.33*** (0.11)
Δ(ExportU(-3))	-0.40*** (0.09)	*Δ(GDPI)*	-2.03** (0.81)
Δ(GDPI)	0.04 0.11	*Δ(GDPC)*	0.20 (0.31)
Δ(GDPUS)	4.536707*** (1.75)	*Δ(REXY)*	1.82*** (0.52)
Δ(GDPUS(-1))	2.95* (1.61)	*Δ(Volatility)*	-0.00 (0.02)
Δ(REXD)	-0.38 0.34	*Δ(Dummy)*	-0.17 (0.15)
Δ(Volatility)	0.01 (0.01)	*ecm(-1)*	-0.17** (0.07)
Δ(Dummy)	-0.02 (0.04)		
ecm(-1)	-0.40*** (0.091204)		
*Cointeq = Log(ExportU)-(0.11*Log(GDPI)+ 3.86* Log(GDPUS) +1.42* Log(REXD)+0.01* Volatility+ 0.05*Dummy-92.16*		*Cointeq = Log(ExportC)-(-11.82* Log(GDPI)+ 8.20*Log(GDPC)+ 10.62* Log(REXY)- 0.002* Volatility+0.99*Dummy+158.25)*	

Note: ***, ** and * denotes 1%, 5% and 10 % level of significance respectively.

The short-run dynamic relationship for India's exports to China reveals that India's GDP growth negatively affects exports to China even in the short term, with a 1% GDP growth reducing exports by 2.03%. This statistically significant coefficient indicates detrimental supply-side effects. While China's GDP positively impacts India's exports in the long run, its short-term effect is insignificant and smaller in magnitude. The yuan-rupee exchange rate positively and significantly influences exports, suggesting that yuan appreciation increases exports, which contradicts typical economic theory. Exchange rate volatility negatively affects exports, but this effect is statistically insignificant. The 2008 financial crisis negatively impacted exports but was also statistically insignificant. The equilibrium correction coefficient (ecm-1) is -0.172, indicating that 17% of the previous quarter's disequilibrium converges back to long-run equilibrium in the current quarter, with a recovery time of about five quarters.

The short-run dynamic relationship for India's import functions, based on equations (11) and (12) and optimized by the Schwarz information criterion (SIC), reveals several key findings. For India's imports from the USA, the GDP of the current quarter positively affects imports, while the GDP of the previous quarter has a negative impact. However, both effects are statistically insignificant. In the long run, India's GDP positively influences imports. The supply-side factors, represented by the USA's GDP, have a nominal negative and statistically insignificant impact. The dollar-rupee exchange rate positively influences imports, indicating that appreciation leads to increased imports, but this effect is statistically insignificant.

Interestingly, the volatility of the dollar-rupee exchange rate shows contrasting results: current volatility has a positive and statistically significant effect on imports, while past volatility has a negative and statistically significant impact. This suggests that past volatility may affect importers' expectations about future volatility, leading to reduced imports in the next quarter. The financial crisis of 2008 negatively impacted India's imports from the USA in the short run, and this effect is statistically significant. The equilibrium correction coefficient indicates that it takes about three quarters for disequilibria from the previous quarter to converge back to the long-run equilibrium, demonstrating a significant adjustment speed.

The results for India's imports from China indicate that India's GDP has a negative but statistically insignificant effect, suggesting that imports from China are not income elastic in the short run. Conversely, China's current GDP has a significant positive effect on India's imports, although it was negative in the previous two quarters. The GDP of China from three quarters ago also has a significant positive impact on imports from China. These findings suggest that supply-side factors are a major determinant of India's imports from China, potentially due to higher productivity growth in China or the dumping of Chinese goods in India.

Table:7
Short-Run results (Imports)

Indian Imports from USA, ARDL (1, 2, 0, 2, 0) (Dependent variable Log(ImportU)		Indian Imports from China, ARDL (4, 4, 0, 1, 0) (Dependent variable Log(ImportC)	
Variables	**Coefficients**	**Variables**	**Coefficients**
Δ(GDPI)	0.15 (0.21)	*Δ(ImportC(-1))*	-0.32*** (0.10)
Δ(GDPI(-1))	-0.27 (0.20)	*Δ(ImportC(-2))*	-0.17* (0.10)
Δ(GDPUS)	-0.15 (0.81)	*Δ(ImportC(-3))*	-0.19** (0.09)
Δ(REXD)	0.37 (0.33)	*Δ(GDPI)*	-0.43 (0.53)
Δ(Volatility)	0.052*** (0.02)	*Δ(GDPC)*	2.05*** (0.74)
Δ(Volatility(-1))	-0.03** (0.01)	*Δ(GDPC(-1))*	-0.16 (0.14)
Δ(Dummy)	-0.25*** (0.08)	*Δ(GDPC(-2))*	-0.29** (0.13)
ecm(-1)	-0.33*** (0.10)	*Δ(GDPC(-3))*	1.67** 0.70
		Δ(REXY)	0.06 (0.39)
		Δ(Volatility)	0.00 (0.000186)
		Δ(Dummy)	0.14** (0.07)
		ecm(-1)	-0.16*** (0.061823)
*Cointeq = Log(ImportU)-(1.96*Log(GDPI) - 0.47*Log(GDPUS) +1.16* Log(REXD) + 0.12*Volatility+ 0.80*Dummy – 18.79)*		*Cointeq = Log(ImportC)-(-2.69*Log(GDPI) + 4.13*Log(GDPC) + 3.91*Log(REXY) -0.00*Volatility + 0.90*Dummy - 11.33)*	

Note: ***, ** and * denotes 1%, 5% and 10 % level of significance respectively.

The yuan-rupee exchange rate level and its volatility have a positive effect on India's imports from China, but this effect is not statistically significant. Interestingly, the financial crisis of 2008 positively impacted India's imports from China, possibly because the crisis originated in the USA, which suffered the worst effects, while India and China were less severely impacted. This could explain the positive and statistically significant coefficient for China's imports. The error correction term has the required negative sign, indicating that the model converges back to its long-run equilibrium in the event of short-run disruptions. However, the speed of adjustment is slow, with only 15.9% of the disequilibria returning to equilibrium in the current quarter, taking about six quarters to fully adjust.

4.5. Diagnostic Tests

In the final step of the analysis, diagnostic tests were conducted for serial correlation, heteroscedasticity, and normality for all model specifications. Table 8 presents the results. The first model specification, with India's exports to the USA as the dependent variable, does not suffer from serial correlation. The Breusch-Godfrey serial correlation LM test fails to reject the null hypothesis of no correlation at the 5% significance level. Similarly, the Breusch-Pagan-Godfrey test fails to reject the null hypothesis of no heteroscedasticity, even at the 10% significance level. Additionally, the model passes the normality test, as the Jarque-Bera test statistic is much lower than its 5% critical value.

Table: 8
ARDL-VECM Model Diagnostic Tests

Log(ExportU) = f(Log(GDPI), Log(GDPUS), Log(REXD), Volatility)	
Serial Correlation χ^2 (4)	2.30 (0.07)*
Heteroscedasticity χ^2 (12)	1.04 (0.43)*
Normality	1.43 (0.49)*
Log(ExportC) = f(Log(GDPI), Log(GDPC), Log(REXY), Volatility)	
Serial Correlation χ^2 (4)	0.70 (0.60)*
Heteroscedasticity χ^2 (9)	3.51 (001)*
Normality	15.64 (0.000)*
Log(ImportU) = f(Log(GDPI), Log(GDPUS), Log(REXD), Volatility)	
Serial Correlation χ^2 (2)	0.10 (0.91)*
Heteroscedasticity χ^2 (10)	1.19(0.31)*
Normality	4.15 (0.13)*
Log(ImportC) = f(Log(GDPI), Log(GDPC), Log(REXY), Volatility)	
Serial Correlation χ^2 (4)	1.24 (0.30)*
Heteroscedasticity χ^2 (14)	0.55 (0.89)*
Normality	0.022 (0.99)*

Note: * figures in parenthesis shows the P-values.

The second model, which examines India's exports to China, passes the serial correlation test but suffers from heteroscedasticity, as indicated by the Breusch-Pagan-Godfrey test. Additionally, the residuals are not normally distributed. The third model, focusing on India's imports from the USA, does not have issues with serial correlation or heteroscedasticity, and it passes the normality test. The final model, assessing India's imports from China, also passes all diagnostic tests, showing no problems with serial correlation or heteroscedasticity and passing the normality test. These results are based on the Breusch-Godfrey serial correlation LM test, Breusch-Pagan-Godfrey test, and Jarque-Bera test, ensuring the robustness of the models used in the analysis.

5. CONCLUSIONS

India revamped its exchange rate system post the 1992-1993 balance of payment crisis, adopting a market-determined exchange rate. This approach allows exchange rates to adjust with macroeconomic conditions but exposes international trade to exchange rate risks. This paper examines the impact of bilateral exchange rate variability (both levels and volatility) on Indo-China and Indo-USA trade using the GARCH method and ARDL approach due to the mix of I(0) and I(1) variables.

The results show that in the long run, both the dollar-rupee and yuan-rupee exchange rates positively affect India's exports to the USA and China, respectively, while in the short run, only the yuan-rupee exchange rate has a significant effect. Attempts to devalue the rupee may negatively impact exports. Exchange rate volatility has an insignificant effect on exports, likely due to RBI interventions. In the long run, the exchange rate levels impact imports, with the yuan-rupee rate being statistically significant for imports from China. Short-term exchange rates do not affect imports.

The volatility of the dollar-rupee exchange rate significantly affects long-term imports from the USA, with mixed short-term effects. Yuan-rupee volatility insignificantly affects imports from China. GDP is a major determinant of long-term exports to the USA and China, indicating income elasticity. In the short term, only the USA's GDP affects India's exports. India's GDP negatively affects exports to China but is insignificant for exports to the USA. For imports, China's GDP positively and significantly affects imports from China due to higher productivity or dumping of goods. Supply-side factors drive imports from China, while demand-side factors drive imports from the USA. The financial crisis (2008) negatively impacted long-term imports from both countries, with an insignificant effect on bilateral exports.

REFERENCES

1. *Abeysinghe, T. and Yeok, T. L. (1998). Exchange rate appreciation and export competitiveness. The case of Singapore. Applied Economics, 30(1), 51-55, DOI: 10.1080/000368498326137*
2. *Akhtar, A. M. and Hilton, R. S. (1984). Effects of exchange rate uncertainty on German and US trade. Federal Reserve Bank of New York Quarterly Review, 9, 7–16.*
3. *Aliyu, S. U. R. (2010). Exchange rate volatility and export trade in Nigeria: an empirical investigation. Applied Financial Economics, 20(13), 1071-1084. doi: 10.1080/09603101003724380*
4. *Aristotelous, K. (2001). Exchange rate volatility, exchange rate regime, and trade volume: evidence from the UK–US Export Function (1989–1999). Economics Letters, 72(1), 87–94. https://doi.org/10.1016/S0165-1765(01)00414-1*
5. *Arize, A. C. (1995). The effects of exchange-rate volatility on the U. S. Exports: An Empirical Investigation. Southern Economic Journal, 62(1), 34-43. URL: http://www.jstor.org/stable/1061373*
6. *Asterios, D., Masatci, K. & Pilbeam, K. (2016). Exchange rate volatility and international trade: International evidence from the MINT countries. Economic Modelling, 58, 133-140. http://dx.doi.org/10.1016/j.econmod.2016.05.006*
7. *Baron, D. P. (1976). Flexible exchange rate, forward markets, and the level of trade. American Economic Review, 66, 253–66.*
8. *Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31(3), 307-327. https://doi.org/10.1016/0304-4076(86)90063-1.*
9. *Chou, W. L. (2000). Exchange rate variability and China's exports. Journal of Comparative Economics, 28(1), 61–79. doi:10.1006/jcec.1999.1625*
10. *Cheung, Y. and Sengupta, R. (2013). Impact of exchange rate movements on exports: An analysis of Indian non-financial sector firms. Journal of International Money and Finance, 39, 231-245. http://dx.doi.org/10.1016/j.jimonfin.2013.06.026*
11. *De Vita, G. & Abbott, A. (2004). The impact of exchange rate volatility on UK exports to EU countries. Scottish Journal of Political Economy, 51(1) 62–81. doi:10.1111/j.0036-9292.2004.05101004.x*
12. *Dhasmana, A. (2012). India's Real Exchange Rate and Trade Balance: Fresh Empirical Evidence (IIMB Working Paper No: 373). Indian Institute of Management, Bangalore. Retrieved from: http://www.iimb.ac.in/sites/default/files/research/files/workingpaper/WP_No._373_0.pdf.*
13. *Engle, R. F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation. Econometrica, 50(4), 987-1007. doi:10.2307/1912773*
14. *Engle, R.F. and C.J. Granger (1987) "Cointegration and Error-correction- Representation, Estimation and Testing", Econometrica, 55, 251-278.*
15. *Ethier, W. (1973). International trade and the forward exchange market. American Economic Review, 63, 494–503.*
16. *Fleming, J. M. (1962). Domestic financial policies under fixed and floating exchange rates". IMF Staff Papers. 9, 369–379.*
17. *Hamilton, J. D. & Susmel, R. (1994). Autoregressive conditional heteroscedasticity and changes in regime. Journal of Econometrics, 64(1-2), 307–333. doi.org/10.1016/0304-4076(94)90067-1*
18. *Hua, P. (2008). Real exchange rates and China's bilateral exports towards industrialized countries, Journal of Chinese Economic and Business Studies, 6(3), 241-259. DOI: 10.1080/14765280802283493*
19. *Johansen, S., and K. Juselius (1990) "Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money", Oxford Bulletin of Economics and Statistics, 52, 169-210.*
20. *Mandelbrot, B. (1963). The Variation of Certain Speculative Prices. The Journal of Business, 36(4), 394-419. Retrieved from http://www.jstor.org/stable/2350970*
21. *Mukherjee, D. & Pozo, S. (2011). Exchange-rate volatility and trade: a semiparametric approach. Applied Economics, 43(13), 1617-1627, doi: 10.1080/00036840802600327*
22. *Mundell, R. (1963). Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates. The Canadian Journal of Economics and Political, 29(4), 475-485. doi:10.2307/139336*

23. *Panda, S. & Mohanty, R. (2015). Effects of exchange rate volatility on exports: evidence from India. Economics Bulletin, **35**(1), 305-312.*
24. *Pesaran, M. H. and Y. Shin (1999) "An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis", in Strom S. (Ed.), Econometrics and Economic Theory in the 20th Century: The Ragnar Centennial Symposium, Cambridge University Press, Cambridge.*
25. *Pesaran M.H., Y. Shin and R.J. Smith (2001) "Bounds Testing Approaches to the Analysis of Level Relationship", Journal of Applied Economics, 16(3), 289-326. DOI: 10.1002/jae.616*
26. *Shahbaz, M., Jalil, A. and Islam, F. (2012). Real Exchange Rate Changes and the Trade Balance: The Evidence from Pakistan. The International Trade Journal, 26(2), 139-153, DOI: 10.1080/08853908.2012.657588*
27. *Srinivasan, P. & Kalaivani, M. (2013). Exchange rate volatility and export growth in India: An ARDL bounds testing approach. Decision Science Letters, 2(3), 191-202. doi: 10.5267/j.dsl.2013.04.002*
28. *Taylor, S. J. (1986). Modelling Financial Time Series. Chichester, UK.*
29. *Veeramani, C. (2008). Impact of exchange rate appreciation on India's exports. Economic and Political Weekly, 43(22), 10-14. http://www.jstor.org/stable/40277511*
30. *Viaene, J. M. & de Vries, C. G. (1992). International trade and exchange rate volatility. European Economic Review, 36, 1311–21.*