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The Effects of Exchange Rate Volatility on Indian Exports: An ARDL Approach

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Abstract

The purpose of this article is to examine the effect of exchange rate instabilities on the performance of Indian exports, using yearly data from 1999 to 2023. The data was obtained from the World Bank's Indicators (WDI) open dataset. We chose WDI data to assure accuracy and transparency in our research. This time span was selected based on the extensive accessibility of pertinent figures within the chosen timeframe. The empirical results display that exports (EXPs) are cointegrated with the exchange rate (ER), gross capital formation (GCF), inflation (INF) and interest rate (IR). However, it is found that only the ER, INF and IR have long-term effects on India's EXP performance. The error correction model (ECM) results suggest a noteworthy adjustment process towards achieving long-term equilibrium in the association between ER and EXPs. These findings highlight the importance of implementing policies that enhance ER stability and promote a stable and sustainable ER policy.

Keywords: Exchange Rate, Exports, Gross Capital Formation, Inflation, Interest Rate

JEL Classification: C32, F31, F32

Introduction

Major currencies switched from fixed to floating exchange rates following the Bretton Woods (BW) System's collapse in the early 1970s. This change sparked a heated discussion over how currency rate volatility impacts exporters. The detrimental effects of *the exchange rate* (ER) swings on exports (EXPs) have been the subject of numerous researches in the past (Khan et al., 2024; Tarasenko, 2021; Jyoti, 2021; Muinelo-Gallo et al., 2020). While some studies indicate that currency rate fluctuations have no discernible effect on EXPs (Nyeadi, 2014), other research has indicated possible positive effects (Qabhobho, 2023; Sule et al., 2023; Lezar, 2023; Habanabakize et al., 2023; Said et al., 2023; Pun, 2020; Umaru et al., 2018; Hasan et al., 2015). According to Hooper et al. (1978), higher currency rate volatility can have a detrimental impact on enterprises since it increases risk aversion. De Grauwe (1988) claimed, however, that because trade volatility is driven by risk aversion, *the exchange rate* (ER) volatility may positively impact EXPs. Despite substantial study on *the exchange rate*s (ERs), economists continue to focus on their management, particularly in developing countries (Khan et al., 2024). This sustained interest stems from the currency rate's critical position as a link between domestic and international markets for products and assets, as well as a measure of a country's worldwide competitiveness. Furthermore, in the medium to long term, the currency rate serves as a stabilising anchor for maintaining balanced domestic and international macroeconomic conditions. However, determining the equilibrium ER remains challenging. Estimating equilibrium currency rates and evaluating ER disequilibrium are two of the trickiest empirical issues in open-economies (Williamson, 1994). The core obstacle is that it is impossible to observe the equilibrium ER firsthand. When this theoretical equilibrium is not met by the ER, it results in disequilibrium. Since the equilibrium ER cannot be directly observed, this issue remains inherently subjective.

The ERs are a critical determinant of global trade, which has led to increased attention on this issue recently. In

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the post-COVID era, ERs have become particularly prominent due to the Federal Reserve's successive rate hikes aimed at controlling INF. This has resulted in the depreciation of major currencies, including the euro, GBP, yen and yuan. The Indian Rupee (INR) has also experienced significant depreciation in this context. The volatility in the INR has complicated India's international trade dynamics. Historically, India has faced a negative net trade balance, with IMPs consistently exceeding EXPs. Therefore, it is vital for India to recognise and analyse the factors that significantly impact exports (EXP) performance. Hence, this research attempts to investigate the impact of ER differences on India's exports (EXP) performance.

Literature Review

The literature has extensively examined how changes in ERs impact India's exporting practices. A number of hypotheses have been put out to explain how these variations impact EXPs. Increased ER volatility and EXP activity have been found to positively correlate in some studies but to have the opposite effect in others. An overview of the vast amount of literature on this subject is given in this section.

Abdinur et al. (2022) used data from 2005 to 2020 to inspect how changes in the INF and ERs influenced Somalia's economic growth. The analysis discovered a marginally significant positive association between GDP growth and changes in the ER. Economic growth was somewhat positively impacted by INF rates.

Ali et al. (2022) studied the influence of ER volatility on EXP growth using annual time series and panel data during 1980-2020 for selected developed nations. The study employed pooled mean (PM) group and individual cointegration methodologies to analyse short- and long-term impacts. The results reveal that ER instability has a short-term unfavourable effect on EXP growth, especially in Sweden and Italy. According to the study, if real depreciation results in a negative elasticity, it may also broaden the EXP base.

Esquivias et al. (2020) observed the impact of ER volatility on EXP commodities by means of monthly data between 2006 and 2018. They applied a GARCH model for volatility estimation; the study employed both linear and non-linear ARDL models. The findings reveal that ER volatility significantly influences EXPs of ores, chemicals, rubber and pulp paper both in the short and long term. EXPs to China are primarily influenced for plastics, with overall negative effects attributed to ER depreciation. The study shows that ER instability has a generally undesirable impact on Indonesian EXPs across different commodities and trading partners.

Joshi et al. (2023) investigated how Nepal's EXPs and ERs are co-integrated. Evidence of both short-term dynamic relationships and long-term co-integration between ERs and EXP performance was discovered by the study. The intricate effects of currency rate swings on Nepal's EXPs throughout various time periods were also emphasised.

Khan and Ahmed (2024) used World Development Indicators annual data from 1981 to 2022 to assess how ER fluctuations influenced Bangladesh's EXP performance. The study discovered that ER variations had a negative influence on EXPs, with a longer-term effect being more substantial than a short-term one, using the ARDL (AutoRegressive Distributed Lag) approach. Furthermore, real interest rates and GCF have a detrimental effect on EXPs.

Koroma et al. (2023) used data from 1980 to 2018 to evaluate how ER changes influenced Sierra Leone's economic growth. The study discovered a substantial optimistic relation between the growth of the economic and the depreciation of the Leones. The results of the analysis, which used the OLS regression, show that depreciation in Sierra Leone is linked to positive economic growth and that ER fluctuations can have a variety of effects. Using annual data from 1974 to 2011, Pun (2023) investigated the connection between Nepal's currency rates and EXPs while controlling for real interest rates, investment and INF. The study exposed a strong optimistic connection between EXP levels and ERs, representing that Nepal's EXP performance is positively impacted by favourable ER changes.

Sharma (2020) explored the impact of ER risk on India's EXP performance at the commodity level, using monthly panel data from December 2012 to November 2017 for about 100 products. The researcher applied both real nominal ER measures and using an autoregressive conditional heteroscedasticity-based model. The study found that ER volatility negatively influences EXPs in

both the short and long term. The negative impact is more pronounced in the long term, particularly for nominal ER volatility, while short-term effects are less severe and can be partially offset using financial instruments.

Sule et al. (2023) used multiple regression analysis to examine the factors influencing EXP promotion and the impact of ERs on EXP performance in Nigeria. They found that while there was a positive but statistically unimportant association between ERs and EXP, FDI significantly increased EXP, indicating that increased FDI supports EXP growth, while INF had an adverse and negligible effect on EXP performance. Tejesh (2024) used ARDL cointegration and ECM to examine the effects of ER and INF on stock market returns in India. The study found no important long-term association between stock market returns and either INF or ER, but significant short-term relationships were observed.

Urgessa (2024) studied the effects of real effective ER (REER) fluctuation on Ethiopian EXP revenues using quarterly data from 2007 to 2021. The study used a GARCH model to assess REER volatility and investigate its influence on individual commodities and partner countries. The data show that an increase in the REER significantly reduces total EXP earnings as well as earnings from specific commodities such as vegetables, meat and oilseeds. REER volatility was found to have a negative influence on total EXP earnings, as well as earnings from coffee, vegetables and meat.

Data and Methodology

Data

Indian yearly sequential data from 1999 to 2023 were used in this study. The WDI open data served as the source of the information. To guarantee accuracy and openness in our study, we chose WDI data. This time frame was chosen due to the thorough accessibility of pertinent data during the chosen time frame. With "EXPs" as the response variable, the dataset comprises the independent variables "ER", "IR", "INF" and "GCF", which serves as a stand-in for investment. The time series data are converted into natural logarithms before analysis. The software programs R and EViews are used for statistical analysis, data cleansing and data organisation. We use basic exponential smoothing on the actual exchange rate data to increase the model's accuracy. The nominal ER of the INR is the ratio of domestic to foreign (US) price levels to determine the ER.

Methodology

Investigating the effect of ER variations on India's EXP performance is the aim of this study. ERs, GCF, INF, IR and EXPs are among the variables taken into account for this research in order to accomplish this. The justification for choosing these explanatory factors lies in the study's analysis of how ER variations affect India's EXPs. The ER reflects currency movements, which have a direct impact on EXP competitiveness. GCF includes investments in infrastructure and technology that increase production capacity and boost EXPs. INF influences production costs and prices, reducing India's worldwide competitiveness. IR influences borrowing costs and investment decisions, which disturbs EXP capacity. Together, these variables give a full knowledge of how macroeconomic factors interact to influence India's EXP performance, with EXPs acting as the dependent variable to quantify these interactions. Instead of depending on a simple method like simple time series regression analysis, it is essential to employ the right statistical tools to appropriately examine these correlations. Finding appropriate statistical tools and procedures is the initial step in this process. Thus, choosing sophisticated econometric models that take into consideration the properties of the data and performing a unit root test on the time series variables to verify stationarity constitute the first stage. The ADF and PP tests were used in this study to evaluate the stationarity of each series.

One popular statistical procedure for defining if a time series has a unit root is the ADF test. The Dickey-Fuller (DF) test, which was first presented by Wayne Fuller and David Dickey in 1979, is expanded upon by this one. The below equation is applied to calculate the ADF test statistic:

$$\Delta\gamma_t = (\gamma_t - \gamma_{t-1}) - \lambda \times \Delta\gamma_{t-1} \quad (1)$$

In this case, γ_t and γ_{t-1} are the sequential series values at times t and t-1, $\Delta\gamma_{t-1}$ is the difference at time one t-1, λ is the coefficient linked to the time series' lagged level and Δ is a first difference operator. The ADF test makes the frequently unrealistic assumption that the

regression model's errors are homoskedastic and serially uncorrelated. Consequently, by taking autocorrelation and skedasticity in the error terms into consideration, the PP test expands upon the DF test. The following formula is used to estimate the PP test statistic:

$$PP\ stat = \frac{\hat{\gamma}}{SE(\hat{\gamma})} \quad (2)$$

Where $SE(\hat{\gamma})$ is the std. error of $\hat{\gamma}$ and $\hat{\gamma}$ and is the coefficient. If there is a stationary linear blend of the variables, they are said to be cointegrated. The long-run connection among the variables can be determined if their unit roots are of the same order. The ARDL method is better suited, nevertheless, if the variables show distinct orders of integration. Because the variables in this study exhibit different orders of integration, as illustrated in Table 1 and Fig. 2, the ARDL methodology is employed.

Pesaran et al. (1990, 1999, 2001) created the adaptable ARDL bounds testing strategy, which permits the factors in the model to be combined at either order *0* or *1*, represented as I_0 or I_1. The ARDL model is then estimated by choosing the ideal lag length (p) based on factors like the AIC or the SBC. The ARDL model is designed and assessed in accordance with the suitable lag length.

The short-run association under the ARDL model is stated as:

$$\Delta\lambda_t = \phi_0 + \sum_{i=1}^{p_t} \phi_i \, \Delta\lambda_{t-i} + \sum_{i=0}^{q_t} \mu_i \, \Delta\nu_{t-i} + \varepsilon_t$$

The long-run relationship under the ARDL model is stated as:

$$\lambda_t = \phi + \sum_{i=1}^{p} \gamma_i \, \Delta\lambda_{t-i} + \sum_{i=0}^{q} \delta_i \, \nu_{t-i} + \varepsilon_t$$

The aforementioned equations have λ_t and v_t as the response and predictors at time t, Δ as the difference signifying the short-run connection, p_t and q_t as the lag for the response and predictors, ϕ_0 as the short-run (SR) equation's intercept term, ϕ as the long-run intercept term, ϕ_i, μ_i, γ_i *and* δ_i as estimates related to the past values of λ and v variables and ε_t as the residual at time t.

Empirical Results and Discussion

Test for Unit Root

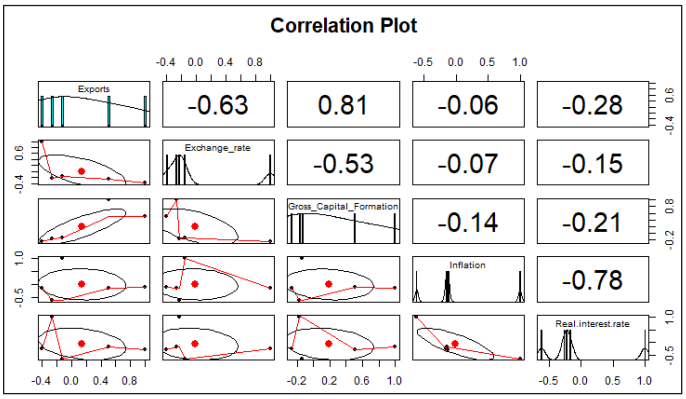

Fig. 1: Correlation Matrix

The study aims to explore the effects of ER variations on India's EXP performance. Being sure that the data series are stationary is a crucial and first step in creating a time series model. First, we used correlation analysis to measure the associations among the variables, as shown in Fig. 1. With the exception of the connection between GCF and ERs, the majority of the variables have a weak to moderate negative association.

We used the ADF and PP tests for modelling, checking for stationarity by combining both constant and linear trends. The AIC was used to calculate the lag length for these tests. Table 1 provides the unit root test summary.

Table 1: Unit Root Test

Variable	*ADF*		*PP*	
	t-stat	*Sig.*	*t-stat*	*Sig.*
Part A: At Level (I_0) –				
EXPs	-4.688	0.005***	-4.683	0.005***
ER	-1.104	0.907	-1.043	0.918
GCF	-4.392	0.010**	-4.392	0.010**
INF	-3.401	0.080*	-1.618	0.755
IR	-2.492	0.329	-2.463	0.341
Part B: At First Difference (I_1) –				
ER	-4.590	0.007***	-4.623	0.007***
INF	-5.289	0.002***	-4.553	0.008***
IR	-5.814	0.001***	-5.814	0.001***

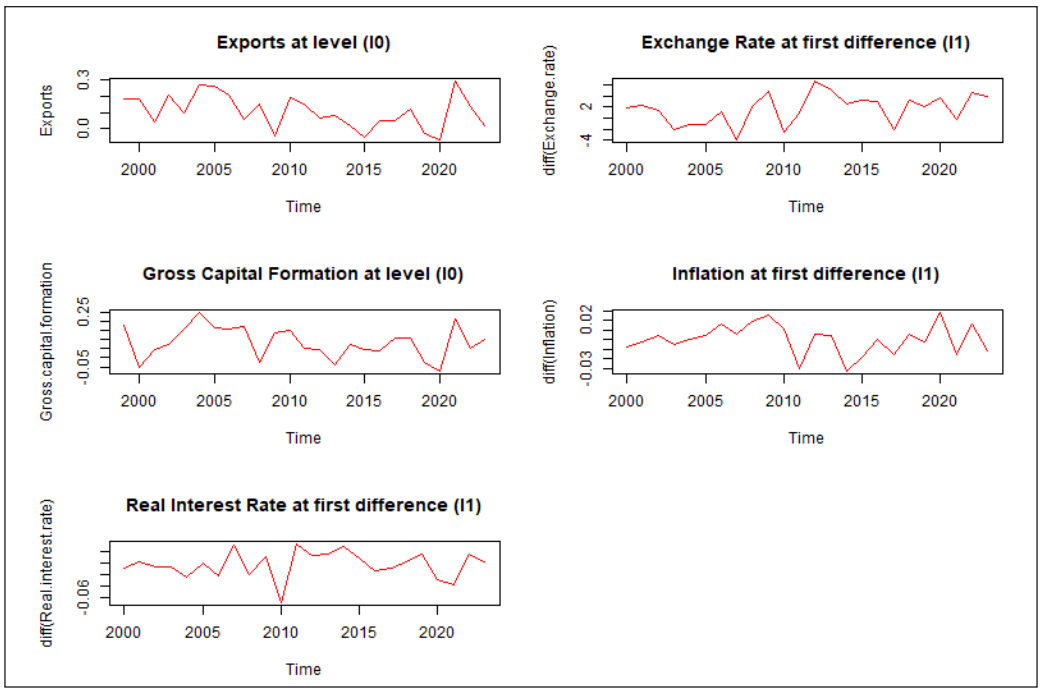

Fig. 2: Time Series After Stationarity Adjustment

The results from the above-mentioned table indicate that the ER, INF and IR are stationary at the first differencing (I_1), whilst the EXP and GCF are stationary at the level (I_0). For analysing the associations between these variables at their respective levels, the ARDL model is a better option because the data series contains both (I_0) and (I_1) variables.

Bound Testing Results

The AIC was employed to identify the optimal lag length, as shown in Fig. 3. The AIC is a widely recognised econometric criterion for determining which model best balances goodness-of-fit and complexity. The specified lag minimises the AIC value, ensuring that the model detects the temporal subtleties of the data without overfitting.

According to Fig. 3, the AIC identifies the ARDL (1, 1, 0, 0, 0) model as the optimal choice. The chosen lag length emphasises how past macroeconomic variables influence current outcomes. They also indicate a slower market adjustment process toward equilibrium, as shown by the error correction model, demonstrating that markets take time to fully absorb changes in macroeconomic variables. The premise that error terms are serially independent is the foundation of the bound testing methodology put forth by Pesaran et al. (2001). The LM test was used to confirm this assumption and evaluate the H_0 that there is no sequential connection. The findings show that there is not enough sign to rule out the H_0 at a significance level of 1 percent. As a result, the model can be used to inspect the variables' long-term associations. We employed the critical limit values given by Narayan (2005) because of the short sample size. Table 2 displays the estimated outcomes of the bound testing.

Table 2: ARDL Bound Test Estimates for Cointegration

Test Stat	*Value*	*Sig.*	*Lower Value of the Bound*	*Upper Value of the Bound*
F-stat	16.082	10%	2.45	3.52
k	4	5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.06

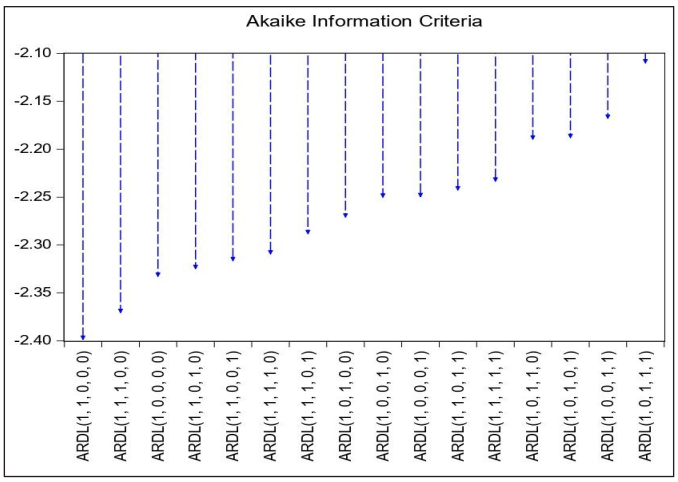

Fig. 3: Akaike Information Criteria for ARDL Model Selection

At the 1% level of significance, Table 2 demonstrates that the F-stat is greater than the upper value bound of the critical values. This demonstrates that our model includes long-term relations between EXPs, GCF, INF, IR and currency rates. After that, the chosen ARDL model is reformed as a single ECM that separates short-term dynamics from long-term dynamics.

Short- and Long-Run Relationships

Table 3: ARDL (1, 1, 0, 0, 0) Models Estimated Long-Run Coefficients

Variable	*Coeff.*	*S.E.*	*t-Stat*	*Sig.*
Intercept	1.035	0.192	5.394	0.000***
ER	-0.008	0.002	-4.484	0.000***
GCF	0.083	0.214	0.390	0.702
INF	-4.600	1.047	-4.394	0.000***
IR	-4.465	0.910	-4.908	0.000***

Three of the four variables have a considerable and negative impact on EXP performance, according to the results of our model. In particular, India's EXP performance is negatively impacted by changes in INF, the IR and ER. Every other factor, with the exception of GCF, impacts India's EXP performance over the long term.

Table 4: Estimated Results of ECM

Variable	*Coeff.*	*S.E.*	*t-Stat.*	*Sig.*
d(ER)	0.005	0.005	1.083	0.294
ECM (- 1)	-1.187	0.119	-9.966	0.000***
R^2	0.843	Mean (D.V)		-0.007
Adj. R^2	0.828	S.D. (D.V)		0.141
S.E.	0.058	AIC		-2.730
Log likelihood	35.760	SC		-2.583
F-stat	56.346	HQC		-2.691
Sig.	0.000***	DW stat		2.334

The estimated coefficient for the first difference of the ER demonstrates a positive but statistically negligible short-term effect on EXPs. An estimated error correction coefficient of -1.187, the model exhibits error correction. This points to a substantial process of adjustment in the direction of long-term equilibrium. The model also has a high explanatory power of 84%, indicating that it fits well.

Diagnostic Test

Table 5: Residual Diagnostic Test

1. Breusch-Godfrey (BG) test for Serial Correlation:	
F-stat	1.520
Sig.	0.235
2. Breusch-Pagan-Godfrey (BPG) test for Heteroskedasticity:	
F-stat	0.876
Sig.	0.533
3. Jarque-Bera (JB) test for Normality:	
JB-statistic	2.018
Sig.	0.365

Source: Author's Calculation.

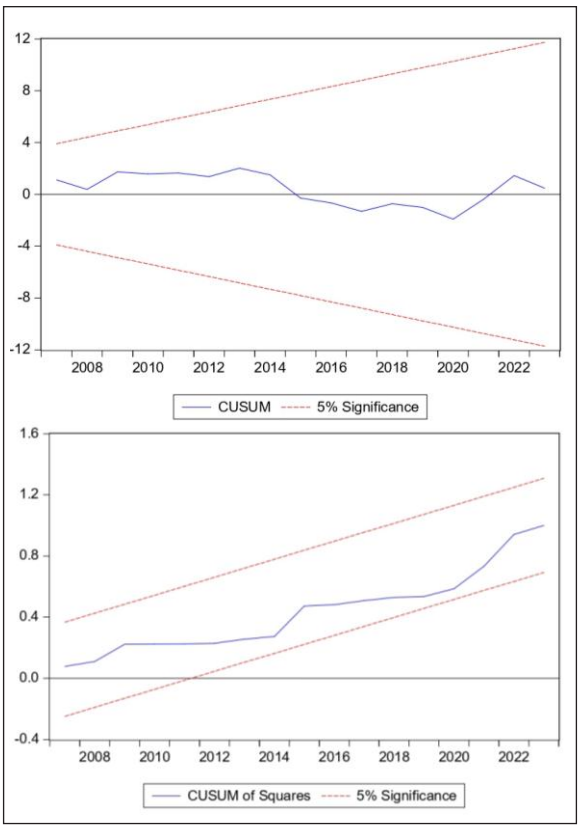

Fig. 4: CUSUM and CUSUMSQ Plots for Stability

As presented in Table 5, we ran different diagnostic tests on the predicted model. The BG was utilised to evaluate autocorrelation and showed no discernible correlation in the residuals. We used the BPG test for heteroscedasticity, and the H_0 of homoscedasticity was not rejected. The residuals in the model have a normal distribution, according to a normality test. We used both the CUSUM and CUSUMSQ tests to assess the constancy of the model. These tests are applied to measure the constancy of both short- and long-term dynamics and coefficients (Brown et al., 1975). The cumulative sum of the squared recursive residuals is used in the CUSUMSQ test, whereas the cumulative sum of the recursive residuals is used in the CUSUM test. At the 5% significance level in Fig. 4, the stability lines stay inside the critical boundaries. This attests to the model's long-term stability.

Conclusion, Limitations and Future Research

We attempted to observe the effect of the ER on India's EXP performance in this article. The WDI, a publicly available set of annual data series, was used in the analysis. The dataset includes a combination of factors that are stationary at I_0 and are stationary at I_1, according to the results of the unit root tests. To investigate both short- and long-term associations between the response and predictors, the ARDL model is utilised. Specified its comparatively limited usage in earlier research on this subject in India, the ARDL limits testing approach's applicability in this work is noteworthy. The results showed that the IR, INF, GCF and ER are all cointegrated with EXPs. Additionally, the analysis demonstrates that while GCF does not show a long-term impact on India's EXP performance, the ER, INF and IR do. The ER's short-term effects on EXPs appear to be negligible, according to the coefficients for the initial differences. The ECM shows that the relationship between the ER and EXPs is undergoing a substantial adjustment process towards long-term equilibrium. The model's long-term stability was also acknowledged by the study, which found no appreciable variations.

This study makes a substantial contribution to the body of knowledge already available on how ER variations impact EXP success, particularly when considering India. Our study's conclusions have significant ramifications for investors, regulators and legislators. Comprehending the detrimental impacts of ER fluctuations on EXPs can aid in the development of policies intended to stabilise the ER and foster EXP expansion. In order to improve EXP performance, policies that promote investment and efficiently control IRs are also necessary, as seen by the notable detrimental effects of INF and IRs on EXPs. However, the study's primary focus was on a small number of macroeconomic factors. Additional macroeconomic and non-macroeconomic factors could be included in future studies to examine further topics like interconnection, instability and contagion effects, especially during periods of economic crisis. The use of annual data in this study has limitations, such as the inability to capture short-term variations and the insignificant sample size, which may undermine the reliability of the results. These shortcomings may result in an insufficient knowledge of more immediate dynamics and changes in EXP success. Future studies could also solve this by using quarterly or monthly data to capture short-term patterns, as well as larger datasets to improve the reliability and depth of analysis.

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