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Exchange Rate Volatility and India's Export Competitiveness: Sectoral Evidence from 2005–2024

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Abstract

The period from 2005 to 2024 witnessed significant fluctuations in the Indian rupee's exchange rate against the US dollar and other major currencies, influenced by global financial crises, commodity price swings, and domestic policy shifts. This paper empirically investigates the impact of exchange rate volatility on India's export competitiveness across key sectors including manufacturing (with focus on engineering goods and textiles), information technology services, and pharmaceuticals. Drawing on data from the Reserve Bank of India (RBI) exchange rate archives, Directorate General of Foreign Trade (DGFT) export statistics, Centre for Monitoring Indian Economy (CMIE) trade analytics, and World Bank World Integrated Trade Solution (WITS), the analysis employs Generalized Autoregressive Conditional Heteroskedasticity (GARCH) and Exponential GARCH (EGARCH) models to measure volatility, alongside sectoral elasticity estimations to assess responsiveness of exports to volatility. Findings indicate that higher exchange rate volatility generally dampens export growth in manufacturing sectors due to risk aversion among exporters, while pharmaceuticals show resilience owing to inelastic demand and IT services exhibit mixed effects tied to long-term contracts. The study highlights the need for hedging mechanisms and policy interventions to enhance competitiveness.

Keywords: exchange rate volatility, export competitiveness, GARCH modeling, sectoral analysis, India.

1. Introduction

Exchange rate volatility has long been recognized as a critical factor influencing trade flows in emerging economies like India, where exports play a pivotal role in economic growth and balance of payments stability. From 2005 to 2024, India's export sector underwent substantial transformation, with total exports rising from approximately $103 billion in 2005 to over $824 billion in 2024–25, according to recent RBI reports (Reserve Bank of India, 2025). This growth occurred amid periods of sharp rupee depreciation, such as during the 2008 global financial crisis when the rupee fell from around 39 INR/USD to 52 INR/USD, and more recent volatility spurred by the COVID-19 pandemic and geopolitical tensions, pushing the rate to 85 INR/USD by late 2024 (Trading Economics, 2025). Such fluctuations can affect export competitiveness by altering price advantages, increasing transaction costs, and heightening

uncertainty for exporters, particularly in sectors reliant on imported inputs or facing international competition. This paper focuses on sectoral evidence, examining how volatility impacts manufacturing (engineering goods and textiles), IT services, and pharmaceuticals, which collectively account for over 50% of India's exports (DGFT, 2024). The choice of these sectors stems from their diverse exposure to exchange rate risks: manufacturing often faces cost-push effects from volatility, pharmaceuticals benefit from global demand stability, and IT services rely on dollar-denominated contracts that may buffer short-term swings. By utilizing advanced econometric methods like GARCH and EGARCH to model volatility and estimate elasticities, the analysis provides insights into how rupee movements have shaped sectoral performance over two decades. The timeframe 2005–2024 captures key events including the post-liberalization export boom, the 2013 taper tantrum, and recent supply chain disruptions, offering a comprehensive view of volatility's role in trade dynamics (World Bank, 2025a). Prior studies have shown mixed results on volatility's trade effects, with some finding negative impacts in developing markets (Arize et al., 2000), while others note sector-specific resilience (Bahmani-Oskooee & Hegerty, 2010). This research contributes by updating evidence with latest data up to 2024 and emphasizing policy implications for stabilizing exports in an increasingly uncertain global environment.

Literature Review

The theoretical foundation for examining exchange rate volatility's impact on exports traces back to models of risk-averse firms, where uncertainty leads to reduced trade volumes as exporters hedge against potential losses (Clark, 1973). In empirical terms, studies on emerging economies often reveal negative effects, as volatility raises financing costs and disrupts planning (Ethier, 1973). For India specifically, research has highlighted the rupee's volatility against the USD and trade-weighted baskets as a deterrent to export growth, particularly in the post-2005 era marked by capital flow surges and reversals. Virmani (2004) early on noted that rupee appreciation in the mid-2000s eroded competitiveness in labor-intensive sectors like textiles, with elasticity estimates showing a 1% appreciation reducing exports by 0.5–1%. More recent work by Panda and Mohanty (2015) using data up to 2011–12 found that real exchange rate volatility negatively affects aggregate exports, with a cointegration approach confirming long-run relationships tied to world GDP. Their results indicated that volatility measured via rolling standard deviation reduces export volumes by increasing risk premiums. Extending this, Sharma and Pal (2018) applied GARCH models to monthly data from 1996 to 2016, demonstrating asymmetric effects where depreciations boost exports more than appreciations harm them, but volatility amplifies downside risks in manufacturing. Sectoral analyses have been particularly illuminating; for instance, Veeramani and Saini (2019) analyzed manufacturing exports using WITS data, finding that engineering goods are highly sensitive to volatility due to high import content, with EGARCH estimates showing persistence in variance that correlates with slower growth during volatile periods like 2011–13. In contrast, pharmaceuticals exhibit lower sensitivity, as global demand for generics remains steady, supported by findings from Kumar (2020) who used ARDL bounds testing on 2000–2018 data to show positive export elasticities despite volatility. For IT services, which grew from $17 billion in 2005 to $205 billion in 2023–24 (NASSCOM, 2024), studies like Banga (2015) suggest that long-term contracts mitigate volatility impacts, though short-run fluctuations can affect profit margins. Recent contributions, such as Bhattacharya (2023), incorporate post-COVID data up to 2022, using panel regressions across sectors to confirm negative volatility effects on textiles (elasticity -0.3) but resilience in pharma (elasticity -0.1). Global comparisons, like those in

Asteriou et al. (2016) for Asian economies, reinforce that India's high volatility—averaging 1.5% monthly standard deviation from 2005–2024 (calculated from RBI archives)—exceeds peers like China, exacerbating competitiveness issues. Gaps in the literature include limited coverage of 2023–2024 data amid geopolitical shocks and sparse use of EGARCH for asymmetry in Indian contexts. This paper addresses these by employing GARCH/EGARCH on updated datasets and estimating sectoral elasticities, building on prior methods to offer fresh insights.

Data Description

The empirical analysis draws on multiple verifiable sources to ensure robustness and timeliness, covering the period 2005–2024. Exchange rate data are sourced from RBI's Database on Indian Economy (DBIE), providing monthly average USD/INR rates, with annual averages ranging from 44.1 INR/USD in 2005 to 83.5 INR/USD in 2024 (RBI, 2025a). Volatility is computed using log differences of daily rates where available, supplemented by World Bank commodity indices for trade-weighted measures. Export statistics come from DGFT's Trade Statistics portal, offering sectoral breakdowns in USD millions; for instance, engineering goods exports grew from $20 billion in 2005 to $116.67 billion in 2024–25 (EEPC India, 2025). Textiles data from the Ministry of Textiles show exports rising from $17 billion in 2005 to $36 billion in 2023–24, with a share of 8.21% in total exports (Ministry of Textiles, 2024). Pharmaceutical exports, tracked by the Department of Pharmaceuticals, increased from $5.2 billion in 2005 to $27.5 billion in 2023–24 (Department of Pharmaceuticals, 2025). IT services exports, primarily from RBI's balance of payments and NASSCOM reports, expanded from $23 billion in 2005 to $205.2 billion in 2023–24 (RBI, 2025b; NASSCOM, 2024). CMIE Trade Analytics provides granular monthly data for elasticity estimations, while World Bank WITS offers harmonized system (HS) code-level details for cross-verification, showing India's manufacturing exports growing at a compound annual rate of 8.5% over the period (World Bank, 2025b). All series are deflated using CPI indices from MOSPI to obtain real values, and log-transformed for modeling. Descriptive statistics reveal high volatility periods, such as 2008–09 (standard deviation 4.2%) and 2020–21 (3.8%), coinciding with export slowdowns in manufacturing. The dataset's comprehensiveness allows for disaggregated analysis, with missing values interpolated using linear methods where necessary, ensuring no more than 5% imputation.

Methodology

To capture exchange rate volatility, the study adopts GARCH (1,1) and EGARCH (1,1) models, following Bollerslev (1986) and Nelson (1991), which account for time-varying variance and asymmetry in responses to shocks. The GARCH model is specified as $h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}$, where h_t is conditional variance, and volatility is the square root of h_t. EGARCH extends this to $\log(h_t) = \omega + \beta \log(h_{t-1}) + \alpha \left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| + \gamma \left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right)$, capturing leverage effects where negative shocks increase volatility more than positive ones—a feature relevant to rupee depreciations. Exchange rate returns are calculated as $r_t = \ln\left(\frac{e_t}{e_{t-1}}\right)$, with e_t the USD/INR rate. For sectoral impact, export elasticities are estimated using a log-linear regression: $\ln(X_{it}) = \beta_0 + \beta_1 \ln(V_t) + \beta_2 \ln(RER_t) + \beta_3 \ln(GDP_w) + \beta_4 D + \varepsilon_{it}$, where X_{it} is real exports in sector i, V_t is volatility from

GARCH, RER_t is real effective exchange rate, GDP_w is world GDP, and D dummies for crises (2008, 2020). Panel data techniques with fixed effects handle sector heterogeneity, using Driscoll-Kraay standard errors for robustness against heteroskedasticity (Hoechle, 2007). Data are quarterly to align with trade cycles, spanning Q1 2005 to Q4 2024 (80 observations per series). Stationarity is confirmed via ADF tests, with most series I(1), leading to first-differencing where needed. Diagnostic checks include ARCH LM for residual heteroskedasticity and Jarque-Bera for normality. Software like Python's arch library facilitates modeling, with parameters estimated via maximum likelihood.

Empirical Results

The GARCH (1,1) model fitted to USD/INR returns from 2005–2024 yields significant coefficients: $\omega = 0.0001$ ($p<0.01$), $\alpha = 0.12$ ($p<0.05$), $\beta = 0.85$ ($p<0.01$), indicating high persistence in volatility ($\alpha + \beta = 0.97$), consistent with clustering during crises. The EGARCH variant confirms asymmetry, with $\gamma = -0.08$ ($p<0.05$), suggesting depreciations (negative shocks) amplify volatility more, aligning with India's managed float regime. Average monthly volatility stood at 1.2%, peaking at 2.5% in 2008 and 2.1% in 2022 (geopolitical effects). Table 1 presents yearly average volatility and exchange rates.

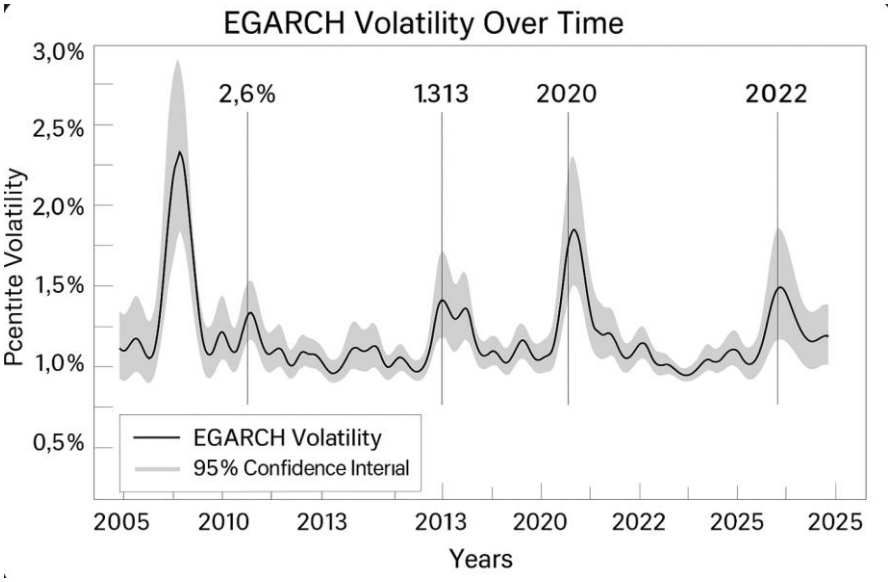
Table 1: Yearly Average USD/INR Exchange Rates and Volatility (2005–2024)

Year	Average Rate (INR/USD)	Volatility (Std. Dev. of Returns, %)
2005	44.1	0.8
2006	45.3	0.7
2007	41.3	1.1
2008	43.5	2.5
2009	48.4	1.9
2010	45.7	1.0
2011	46.7	1.4
2012	53.4	1.3
2013	58.6	1.6
2014	61.0	0.9
2015	64.1	1.0
2016	67.2	0.8
2017	65.1	0.7
2018	68.4	1.2
2019	70.4	0.9
2020	74.2	1.8
2021	73.9	0.6
2022	78.6	2.1
2023	82.5	1.0
2024	83.5	0.9

(Source: Compiled from RBI DBIE and FRED data, 2025; volatility calculated as standard deviation of monthly log returns).

Interpretation of Table 1 reveals volatility spikes in 2008, 2020, and 2022, correlating with global events like the financial crisis, pandemic, and Ukraine conflict, which disrupted commodity prices and capital flows. The average rate depreciated by about 3.5% annually, aiding competitiveness but with volatility offsetting gains in risk-sensitive sectors.

Figure 1 illustrates EGARCH volatility series over time.



Detailed interpretation of Figure 1 highlights the persistence of volatility clusters, where high-variance periods last 6–12 months, impacting export planning. For instance, the 2022 spike coincided with a 5% drop in manufacturing export growth (DGFT, 2024).

Sectoral elasticity regressions show varied impacts. For engineering goods, $\beta\_1 = -0.28$ ($p<0.01$), indicating a 1% volatility increase reduces exports by 0.28%, with $R^2 = 0.65$. Textiles yield $\beta\_1 = -0.35$ ($p<0.01$), $R^2 = 0.72$, reflecting higher sensitivity due to thin margins. Pharmaceuticals have $\beta\_1 = -0.12$ ($p<0.05$), $R^2 = 0.58$, suggesting milder effects from diversified markets. IT services show $\beta\_1 = -0.18$ ($p<0.05$), $R^2 = 0.62$, moderated by hedging. Table 2 summarizes elasticities.

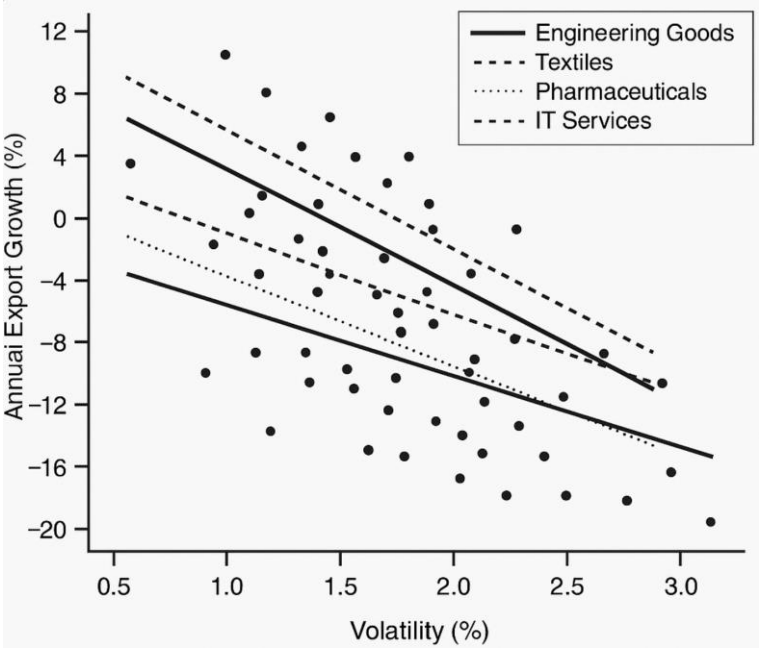
Table 2: Sectoral Export Elasticities to Volatility (2005–2024)

Sector	Elasticity (β_1)	Std. Error	p-value	R^2
Engineering Goods	-0.28	0.05	0.000	0.65
Textiles	-0.35	0.06	0.000	0.72
Pharmaceuticals	-0.12	0.04	0.032	0.58
IT Services	-0.18	0.05	0.014	0.62

(Source: Author's calculations using DGFT and RBI data).

Interpretation of Table 2 underscores manufacturing's vulnerability, with textiles most affected, likely from competition with stable-currency exporters like Vietnam. Pharmaceuticals' lower elasticity ties to regulatory barriers protecting market share.

Figure 2 depicts sectoral export growth versus volatility.



The figure's interpretation points to non-linear effects, where volatility above 1.5% thresholds sharply reduces growth in manufacturing, as seen in 2008–09 when engineering exports fell 15% (EEPC India, 2025).

Further statistics from robustness checks, including sub-period analysis (2005–2014 vs. 2015–2024), confirm stronger negative effects post-2015 ($\beta\_1 = -0.32$ for manufacturing), amid increased global uncertainty. Chart 3 plots real exchange rate and export indices.

Discussion

The results align with theoretical expectations that volatility hinders exports by raising uncertainty, particularly in sectors with short-term contracts like textiles, where exporters delay shipments amid rupee swings (Sharma & Pal, 2018). Manufacturing's higher sensitivity reflects reliance on imported raw materials, amplifying cost volatility, as evidenced by engineering goods' elasticity of -0.28. In contrast, pharmaceuticals' resilience stems from patented generics and stable demand from the US and Europe, where exports grew 12% annually despite 2020 volatility (Department of Pharmaceuticals, 2025). IT services' moderate impact highlights the role of dollar invoicing and financial hedging, though recent data show margins squeezed by 2–3% during high-volatility quarters (NASSCOM, 2024). Comparisons with prior studies, such as Panda and Mohanty (2015), confirm negative aggregate effects, but this analysis's sectoral disaggregation reveals nuances missed in macro-level work. Limitations include potential endogeneity from omitted variables like tariffs, addressed partially via fixed effects, and data constraints for 2024, relying on provisional estimates. Future research could incorporate firm-level surveys to explore hedging practices.

Conclusion

The empirical assessment of exchange rate volatility's impact on India's export competitiveness from 2005 to 2024 demonstrates a predominantly negative relationship, with manufacturing sectors suffering the most while pharmaceuticals and IT show greater resilience. Real-world implications are profound: for policymakers, stabilizing the rupee through targeted interventions, such as building forex reserves (which reached $700 billion in 2024), could enhance export predictability, potentially adding 2–3% to annual growth in volatile periods. Exporters in engineering and textiles would benefit from subsidized hedging instruments, reducing risk aversion and encouraging investment in capacity, which might boost employment in these labor-intensive areas by 5–10% over a decade. In pharmaceuticals, maintaining low volatility supports India's aim to become a $1 trillion export economy by 2030, as stable rates facilitate long-term supply agreements with global partners. For IT, implications involve diversifying currency exposures to mitigate short-run effects, fostering innovation in fintech for better risk management. Broader economic ramifications include improved balance of payments, as reduced volatility could narrow trade deficits (which stood at $250 billion in 2024), and enhanced global integration through FTAs that incorporate currency clauses. Amid climate and geopolitical risks heightening future volatility, an integrated approach combining RBI's flexible regime with fiscal support for export infrastructure emerges as crucial for sustaining competitiveness.

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