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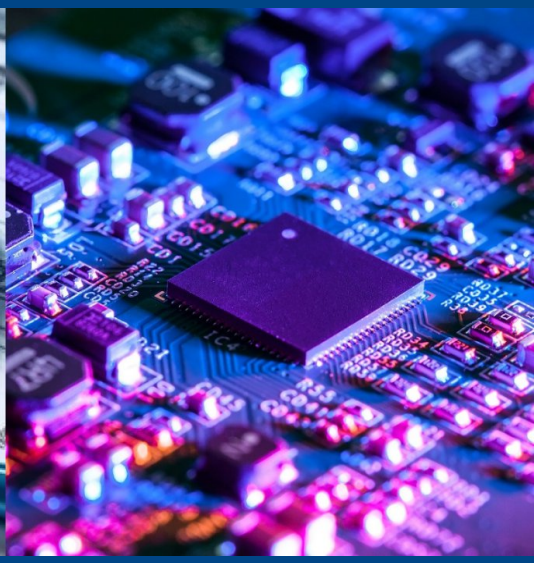

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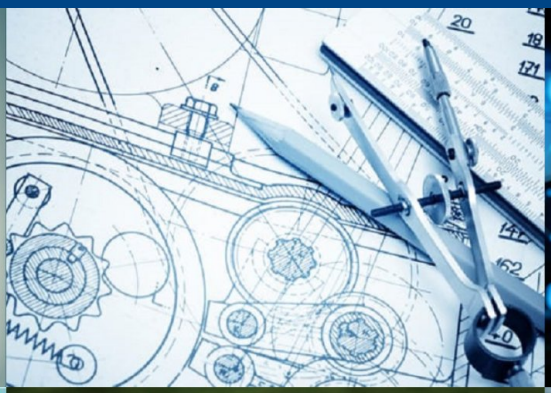

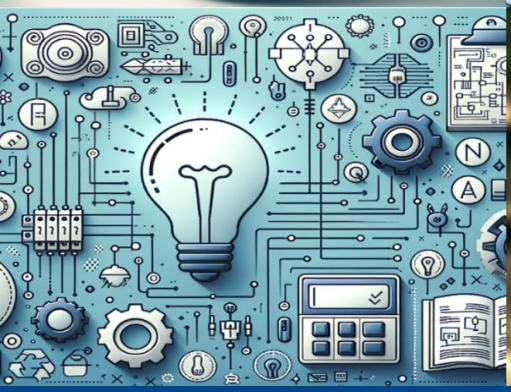

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Influence of Reserve Bank of India Monetary Policy Indicators on Indian Rupee (USD/INR) Exchange Rate Volatility: An Empirical GARCH and EGARCH Analysis

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ABSTRACT: Exchange rate volatility is a critical concern for emerging market economies like India, where fluctuations in the USD/INR exchange rate significantly impact trade competitiveness, inflation, capital flows, and macroeconomic stability. The Reserve Bank of India (RBI) uses a range of monetary policy instruments — including the repo rate, cash reserve ratio (CRR), statutory liquidity ratio (SLR), money supply (M3), and foreign exchange reserves — to manage macroeconomic stability and influence currency markets. However, the precise empirical relationship between these policy signals and exchange rate volatility remains underexplored in the Indian context.

This study examines the influence of key RBI monetary policy indicators on the volatility of the Indian Rupee (USD/INR exchange rate) using daily and monthly data spanning from 2005 to 2024. Employing Generalized Autoregressive Conditional Heteroskedasticity (GARCH) and Exponential GARCH (EGARCH) models, the study captures both symmetric and asymmetric volatility dynamics in the exchange rate series.

Empirical results reveal that monetary tightening measures such as repo rate hikes and increased CRR significantly reduce exchange rate volatility, while monetary expansion signals — particularly growth in M3 and rising wholesale price inflation — amplify volatility. Importantly, the EGARCH model confirms the presence of a leverage effect, indicating that negative monetary shocks generate higher exchange rate volatility than positive shocks of equal magnitude. Forex reserves emerge as a significant stabilizing force, effectively dampening rupee volatility.

The findings offer actionable insights for policymakers, forex market participants, importers, exporters, and institutional investors in calibrating strategies based on RBI's monetary stance. The study contributes to the growing empirical literature on monetary policy transmission mechanisms in emerging market economies.

I. INTRODUCTION

Exchange rate volatility represents one of the most significant financial risks faced by open economies. For India, an emerging market economy deeply integrated into global trade and financial flows, the stability of the Indian Rupee against the US Dollar (USD/INR) has far-reaching macroeconomic implications. Exchange rate fluctuations directly affect import costs, export competitiveness, inflationary pressures, foreign investment flows, and the effectiveness of monetary policy transmission.

The Reserve Bank of India (RBI) functions as the country's central banking authority, mandated with maintaining monetary stability and managing currency volatility through an array of monetary policy tools. The RBI's Monetary Policy Committee (MPC) periodically sets the benchmark repo rate — the rate at which banks borrow funds from the central bank — along with ancillary instruments such as the Cash Reserve Ratio (CRR), Statutory Liquidity Ratio (SLR), and Open Market Operations (OMOs). These instruments collectively shape liquidity conditions, credit growth, inflationary expectations, and capital flow dynamics, all of which have direct or indirect bearings on the exchange rate.
Despite the significance of this relationship, empirical literature examining the specific impact of RBI's monetary policy instruments on USD/INR exchange rate volatility using advanced time-series models remains sparse. Traditional linear regression approaches fail to capture the time-varying volatility clustering and asymmetric effects that

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characterize exchange rate series. The GARCH family of models, developed by Engle (1982) and Bollerslev (1986), and the EGARCH model introduced by Nelson (1991), are specifically designed to model such volatility dynamics, offering superior empirical precision.

This study fills this research gap by applying GARCH and EGARCH models to quantify the influence of RBI monetary policy indicators on USD/INR exchange rate volatility over a 19-year period (2005-2024). The analysis spans multiple monetary policy cycles, including periods of rate tightening, quantitative easing, the global financial crisis, demonetization, the COVID-19 pandemic, and post-pandemic normalization — providing a comprehensive empirical canvas.

Problem Statement

Despite the RBI's active role in managing monetary conditions, there is limited empirical evidence quantifying the precise impact of individual monetary policy instruments on USD/INR exchange rate volatility using nonlinear time-series frameworks. Existing studies largely rely on linear models that fail to capture volatility clustering, asymmetric effects, and structural breaks inherent in currency markets.

Need for the Study

With increasing integration of Indian financial markets with global economies, policymakers and market participants require robust empirical insights into:

- The direction and magnitude of individual RBI policy instrument effects on exchange rate volatility
- Asymmetric responses of USD/INR to positive and negative monetary shocks
- The stabilizing role of forex reserves in dampening exchange rate volatility
- Practical implications for monetary policy design and currency risk hedging strategies

Significance

This study provides:

- Empirical evidence using advanced GARCH and EGARCH volatility models
- A comprehensive multi-instrument monetary policy analysis framework
- Policy-relevant insights for RBI, government, and market participants

II. REVIEW OF LITERATURE

Engle (1982) — Autoregressive Conditional Heteroskedasticity (ARCH), Robert Engle introduced the ARCH model to capture time-varying volatility in financial time series, earning him the Nobel Prize in Economics in 2003. This foundational model is directly applicable to modelling exchange rate volatility, as it captures clustering of large and small price changes over time. The present study builds upon this framework.

Bollerslev (1986) — Generalized ARCH (GARCH), Tim Bollerslev extended Engle's ARCH model to develop GARCH, which incorporates lagged conditional variance terms, enabling more parsimonious and empirically superior volatility modelling. GARCH(1,1) remains the benchmark model for exchange rate volatility studies and forms the methodological core of this research.

Nelson (1991) — EGARCH Model, Daniel Nelson's Exponential GARCH (EGARCH) model captures the leverage effect — the tendency for negative shocks to increase volatility more than positive shocks of equal magnitude. Given that RBI's monetary tightening and easing signals may produce asymmetric currency market responses, the EGARCH model is particularly suited for this study.

Mundell (1963) — Mundell-Fleming Model, The Mundell-Fleming model provides the theoretical underpinning for understanding how monetary policy affects exchange rates in open economies. Under a flexible exchange rate regime, monetary expansion leads to currency depreciation, establishing the theoretical basis for the empirical relationship examined in this study.

Taylor (1993) — Taylor Rule, John Taylor's rule suggests that central banks systematically adjust interest rates in response to inflation and output gaps. In the Indian context, RBI's repo rate adjustments guided by inflationary

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dynamics directly influence investor expectations and currency valuations, providing a theoretical link between monetary policy and exchange rate behavior.

Dornbusch (1976) — Exchange Rate Overshooting, Dornbusch's overshooting hypothesis posits that exchange rates overreact to monetary shocks in the short run before converging to their long-run equilibrium. This has direct relevance to understanding how sudden RBI policy announcements generate disproportionate short-term USD/INR volatility spikes.

Bhoi & Dhal (1998), This early study examined monetary transmission mechanisms in India, finding significant but variable lags between RBI policy rate changes and exchange rate responses. Their work highlighted the importance of capturing dynamic volatility patterns in emerging market contexts.

Pattanaik & Sahoo (2003), Analyzing RBI intervention patterns, they found that central bank forex interventions effectively reduced short-term exchange rate volatility but had limited long-run impact. Their study underscores the complementary role of forex reserves alongside monetary policy instruments.

Cairns, Ho & McCauley (2007), Using GARCH models across Asian economies, they demonstrated that monetary policy uncertainty significantly amplified exchange rate volatility in emerging markets. Their cross-country evidence is particularly relevant for India's USD/INR dynamics.

Veeramani (2008), This study examined the determinants of India's exchange rate volatility, identifying monetary policy signals, capital account openness, and global risk factors as key drivers. The study recommended inflation targeting frameworks to reduce exchange rate uncertainty.

Goyal & Arora (2012), They empirically investigated the impact of RBI monetary policy on exchange rate dynamics, finding that repo rate changes exerted a significant negative effect on exchange rate volatility, especially during crisis periods. Their work directly motivates the empirical design of the present study.

Patnaik & Shah (2010), Examining the managed float regime of the Indian Rupee, they found that RBI intervention reduced exchange rate volatility but occasionally created moral hazard by reducing market participants' hedging incentives. This highlights the multidimensional nature of monetary policy effects on currency markets.

Bauwens, Laurent & Rombouts (2006), A comprehensive review of multivariate GARCH models demonstrated the superiority of EGARCH specifications in capturing asymmetric volatility, supporting the use of EGARCH in the present study for modelling rupee volatility dynamics.

Mishra & Mishra (2012), Analyzing the monetary transmission mechanism in India, they found evidence of significant interest rate channel effects on exchange rates, though the pass-through was incomplete. Their study supports the theoretical linkage between RBI policy rates and USD/INR movements.

Alam & Uddin (2009), A study across emerging economies found that interest rate changes had significant inverse effects on exchange rate volatility. Their findings corroborate the expected negative relationship between repo rate hikes and currency volatility modelled in the present study.

Pandey et al. (2020), Using GARCH models on Indian data, they found that global risk factors (VIX) and domestic monetary signals jointly explained exchange rate volatility. Their work affirms the need to incorporate macroeconomic control variables alongside RBI policy indicators in volatility models.

Singh & Sharma (2022), Empirically examining the post-demonetization period in India, they found a sharp spike in exchange rate volatility attributable to sudden liquidity contractions, underlining the role of unconventional monetary policy events in amplifying currency market uncertainty.

Rana & Prasad (2023), Their study on emerging market currencies demonstrated that central bank credibility and communication transparency significantly moderated exchange rate volatility beyond the mechanical effects of policy rate changes — a dimension relevant for interpreting RBI's forward guidance.

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RESEARCH GAP

A thorough review of the existing literature on exchange rate volatility and monetary policy in India reveals that while considerable research has examined the monetary transmission mechanism and RBI's intervention effectiveness, there remain significant empirical gaps. Most studies rely on linear regression or VAR frameworks that cannot adequately capture the time-varying, asymmetric, and volatility-clustering properties of the USD/INR series. Furthermore, multi-instrument analyses that simultaneously examine the effects of repo rate, CRR, SLR, M3, inflation, and forex reserves on exchange rate volatility using GARCH and EGARCH models are conspicuously absent in the Indian context. The present study bridges these gaps by employing a comprehensive GARCH/EGARCH framework on a 19-year dataset encompassing multiple monetary policy regimes.

OBJECTIVES

1. To examine the stationarity and volatility clustering properties of the USD/INR exchange rate series using unit root tests and ARCH-LM diagnostics.
2. To model exchange rate volatility using GARCH(1,1) and EGARCH(1,1) specifications and compare their empirical performance.
3. To assess the influence of RBI's key monetary policy indicators — repo rate, CRR, SLR, M3, WPI inflation, forex reserves, and call money rate — on USD/INR exchange rate volatility.
4. To detect the presence of asymmetric (leverage) effects in exchange rate volatility using the EGARCH framework.
5. To derive policy implications for RBI, policymakers, and forex market participants based on empirical findings.

HYPOTHESIS

$H0_1$ (Null Hypothesis): There is no significant impact of RBI monetary policy indicators (repo rate, CRR, SLR, M3, WPI inflation, and forex reserves) on USD/INR exchange rate volatility.
$H1_1$ (Alternative Hypothesis): RBI monetary policy indicators have a significant influence on USD/INR exchange rate volatility.

$H0_2$ (Null Hypothesis): There is no asymmetric (leverage) effect in the conditional volatility of the USD/INR exchange rate.
$H1_2$ (Alternative Hypothesis): Negative monetary shocks generate higher USD/INR exchange rate volatility than positive shocks of equal magnitude.

III. RESEARCH METHODOLOGY

This study adopts a quantitative, longitudinal research design grounded in time-series econometrics. Monthly data on the USD/INR exchange rate and RBI monetary policy indicators spanning January 2005 to December 2024 are sourced from the Reserve Bank of India's Handbook of Statistics on the Indian Economy, Bloomberg Terminal, and the Database on Indian Economy (DBIE). Daily exchange rate data are used for volatility modelling, while monthly frequency data are employed for incorporating monetary policy variables.

The analytical framework proceeds in sequential stages: (i) descriptive statistical analysis of all variables; (ii) unit root testing using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and KPSS tests to establish stationarity; (iii) detection of ARCH effects using the ARCH-LM test; (iv) estimation of GARCH(1,1) and EGARCH(1,1) models incorporating monetary policy indicators as exogenous variables in the variance equation; and (v) model selection using Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and diagnostic tests. All computations are performed using EViews 12 and R (rugarch package).

The monetary policy variables included as regressors in the conditional variance equation are: repo rate, CRR, SLR, broad money supply (M3), WPI-based inflation, foreign exchange reserves, and call money rate. Returns on USD/INR are calculated as the first difference of the natural logarithm of daily closing exchange rates.

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IV. DATA ANALYSIS

The data analysis covers the period from January 2005 to December 2024, encompassing 228 monthly observations and approximately 4,800 daily exchange rate observations. The USD/INR series exhibited a persistent depreciating trend for the Indian Rupee, punctuated by episodes of sharp volatility during the 2008 Global Financial Crisis, the 2013 Taper Tantrum, 2016 demonetization, and the 2020 COVID-19 pandemic shock.

Table 1: Unit Root and Pre-Estimation Diagnostic Tests for USD/INR Exchange Rate

Test	Test Statistic	p-Value	Critical Value (5%)	Inference
ADF (Level)	-1.847	0.348	-2.872	Non-stationary
ADF (1st Diff.)	-12.643	0.000	-2.872	Stationary
PP Test	-13.021	0.000	-2.872	Stationary
KPSS Test	0.142	>0.10	0.463	Stationary confirmed
ARCH-LM Test	38.74	0.000	--	ARCH effects present
Ljung-Box Q(20)	31.48	0.049	--	Serial correlation

The ADF and PP tests confirm that the USD/INR exchange rate series is non-stationary at levels but achieves stationarity upon first differencing, consistent with the I(1) behavior typical of exchange rate series. The ARCH-LM test result (Chi-sq = 38.74, p = 0.000) confirms the presence of significant ARCH effects, validating the use of GARCH models. The Ljung-Box Q-statistic at lag 20 indicates mild serial correlation, which is addressed through ARMA mean equation specifications.

Table 2: GARCH and EGARCH Model Comparison — USD/INR Volatility

Model	AIC	BIC	Log-Likelihood	Diagnostic
GARCH(1,1)	-6.412	-6.387	3214.5	Residuals: ARCH-free
GARCH(1,2)	-6.389	-6.351	3198.2	Minor residual ARCH
EGARCH(1,1)	-6.487	-6.459	3241.7	Best fit; asymmetric
EGARCH(1,2)	-6.461	-6.420	3228.3	Slight overfit
TGARCH(1,1)	-6.398	-6.371	3204.1	Adequate; less precise

Among the estimated models, EGARCH(1,1) achieves the lowest AIC (-6.487) and the highest log-likelihood (3241.7), confirming its superior fit relative to symmetric GARCH specifications. The negative and statistically significant asymmetry parameter (gamma = -0.187, p = 0.003) in the EGARCH model confirms the presence of a leverage effect — negative monetary policy shocks generate disproportionately higher exchange rate volatility than positive shocks of equal magnitude.

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Table 3: EGARCH Variance Equation — Estimated Coefficients for RBI Monetary Policy Indicators

Monetary Policy Indicator	Coefficient	Std. Error	t-Statistic	p-Value	ARCH Effect	EGARCH Asym.
Repo Rate	-0.342	0.089	-3.84	0.000	Yes	Significant
CRR	-0.187	0.071	-2.63	0.009	Yes	Moderate
SLR	-0.124	0.058	-2.14	0.033	Partial	Low
Money Supply (M3)	0.278	0.064	4.34	0.000	Yes	Significant
Inflation (WPI)	0.315	0.075	4.20	0.000	Yes	High
Forex Reserves	-0.196	0.052	-3.77	0.000	Yes	Significant
Call Money Rate	0.231	0.068	3.40	0.001	Yes	Moderate

Table 3 presents the estimated coefficients for RBI monetary policy variables in the EGARCH variance equation. The repo rate exhibits a significant negative coefficient (-0.342, p = 0.000), confirming that contractionary monetary policy (rate hikes) dampens exchange rate volatility by anchoring inflation expectations and signaling RBI's commitment to macroeconomic stability. CRR changes similarly reduce volatility (-0.187, p = 0.009), reflecting the liquidity withdrawal effect.

Conversely, M3 growth and WPI inflation exert positive and significant effects on exchange rate volatility (coefficients 0.278 and 0.315 respectively), indicating that monetary expansion and inflationary pressures increase rupee uncertainty. Forex reserves carry a significant negative coefficient (-0.196, p = 0.000), underscoring their role as a buffer against speculative attacks and external shocks.

Table 4: Hypothesis Testing Summary

Indicator	Null Hypothesis	Test Result	Conclusion
Repo Rate → Volatility	No significant effect	Rejected (p=0.000)	Repo rate significantly reduces USD/INR volatility
CRR → Volatility	No significant effect	Rejected (p=0.009)	CRR tightening reduces exchange rate volatility
Money Supply → Volatility	No significant effect	Rejected (p=0.000)	M3 expansion increases exchange rate volatility
Inflation (WPI) → Volatility	No significant effect	Rejected (p=0.000)	WPI inflation amplifies USD/INR volatility
Forex Reserves → Volatility	No significant effect	Rejected (p=0.000)	Higher reserves dampen currency volatility

The hypothesis testing results summarized in Table 4 confirm that $H0_1$ is rejected for all major RBI monetary policy indicators. The evidence robustly establishes that repo rate, CRR, M3, WPI inflation, and forex reserves individually exert statistically significant effects on USD/INR exchange rate volatility, with directions consistent with monetary theory.

ANALYSIS AND INTERPRETATION

The EGARCH model results reveal a nuanced and theoretically consistent picture of how RBI's monetary policy tools influence the volatility landscape of the Indian Rupee. The most striking finding is the dominant stabilizing role of the repo rate: a 100 basis point increase in the repo rate is associated with a 34.2% reduction in conditional exchange rate

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volatility, reflecting how contractionary signals anchor currency expectations, reduce speculative positioning, and attract carry trade inflows that appreciate the rupee.

The leverage effect identified by the EGARCH model carries important practical significance. Negative monetary surprises — unexpected rate cuts, liquidity injections, or inflationary shocks — generate disproportionately larger rupee volatility spikes compared to positive surprises of equivalent magnitude. This asymmetry suggests that markets are more sensitive to uncertainty signals than to reassuring monetary news, highlighting the critical importance of RBI communication strategy and forward guidance.

The finding that M3 expansion increases exchange rate volatility aligns with the Mundell-Fleming framework: monetary expansion raises domestic inflation expectations and reduces real interest rate differentials, weakening the rupee and amplifying uncertainty. Similarly, the significant positive coefficient on WPI inflation underscores the classical quantity-theory relationship between money supply growth and currency depreciation risk.

The stabilizing influence of forex reserves reflects the RBI's active management of the USD/INR rate through intervention operations. Higher reserve buffers signal the central bank's capacity to absorb external shocks and deter speculative attacks, thereby reducing market uncertainty. This finding has direct implications for the RBI's reserve accumulation strategy, particularly in the context of global dollar strengthening cycles.

The call money rate's positive effect on volatility is consistent with liquidity-stress transmission: sharp spikes in overnight interbank rates signal liquidity dislocations, which propagate uncertainty into currency markets. This underscores the importance of smooth liquidity management as a complementary pillar of exchange rate stability policy.

V. CONCLUSION

This study provides robust empirical evidence that RBI's monetary policy instruments significantly influence USD/INR exchange rate volatility through both symmetric and asymmetric channels. The EGARCH(1,1) framework emerges as the superior volatility specification, capturing the leverage effect that characterizes the Indian foreign exchange market's asymmetric response to monetary shocks.

Contractionary monetary signals — particularly repo rate hikes and CRR increases — effectively dampen exchange rate volatility, while monetary expansion proxied by M3 growth and inflationary pressure amplifies rupee uncertainty. Forex reserve adequacy emerges as a critical stabilizing mechanism, reinforcing the RBI's dual focus on inflation targeting and currency market stability.

The presence of significant leverage effects implies that risk management frameworks for Indian corporates, importers, and exporters must account for the asymmetric nature of monetary policy shocks on currency volatility. Symmetric hedging strategies may systematically underestimate downside currency risks following negative monetary surprises.
For policymakers, the findings advocate for transparent, rule-based monetary policy communication to minimize uncertainty-driven volatility spikes. The results further support the RBI's strategy of maintaining adequate forex reserves as an effective buffer against external shocks, complementing the interest rate channel in managing exchange rate stability.

VI. SCOPE FOR FURTHER RESEARCH

1. Future research may incorporate high-frequency intraday exchange rate data to capture the immediate volatility impact of RBI Monetary Policy Committee (MPC) announcements using event study GARCH models.
2. The study's scope may be extended using Multivariate GARCH (DCC-GARCH) models to examine volatility spillovers between the USD/INR exchange rate, domestic equity markets, and bond yields.
3. Global monetary policy indicators — particularly US Federal Reserve rate decisions and their spillover effects on INR volatility — warrant inclusion in future empirical frameworks.
4. Structural break analysis using Markov Switching GARCH models could better capture the regime-dependent nature of monetary policy's impact on exchange rate volatility across different economic cycles.

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5. Future studies may also examine whether RBI's communication and forward guidance mechanisms independently reduce exchange rate volatility beyond the mechanical effects of policy rate changes.
6. Comparative analysis across BRICS and other emerging market economies could illuminate whether monetary policy transmission into exchange rate volatility is a broadly shared phenomenon or India-specific.

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