

FORECASTING EMERGING MARKET EXCHANGE RATE VOLATILITY POST-GEOPOLITICAL SHOCKS

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Abstract:

The following study is about examining the impact of an AI in decision making model alongside standard statistic model use to predict exchange rate volatility in new market currency during major news worldwide. For this we will be using foreign exchange daily spot rate data relative to the US Dollar across 5 major emerging market currencies—the Brazilian Real (BRL), South African Rand (ZAR), Turkish Lira (TRY), Indian Rupee (INR), and Indonesian Rupiah (IDR)—from 2018 to 2024. We will also compare traditional GARCH ecosystem against a AI model combining this model with a short LLM network. The result will indicate if the hybrid AI model performs better than standalone classical methods and generates more accurate volatility forecasts at the end of our experiment.

Keywords:

Exchange rate volatility, emerging markets, geopolitical shocks, artificial intelligence, machine learning, hybrid GARCH-LSTM, time-series forecasting, foreign exchange, risk management, bounded rationality

Introduction:

When operating inside international financial markets, business managers and multinational corporations usually must make a lot of choices that will have an impact on the simulation and success of our enterprise in the future like currency hedging, pricing, cash flow management, and capital budgeting across foreign subsidiaries. These decision making are typically made after a long study of the financial data, currency charts, inflation numbers, and trade balance reports. But it is extremely easy to get completely lost and at the end it makes no result to use after hours, and hours of study of the elements provided by financial dashboards. This could go directly to mistakes that tank our company's profit margin and market share.

The main problem we have seen during periods of severe geopolitical shocks is that financial analysts and management teams frequently struggle to look ahead and accurately determine future foreign exchange rate volatility. Because we are looking at past quarterly and daily historical data and not predicting the future, we can end up making terrible hedging decisions, overpaying for currency options, or taking on massive unhedged exposure, which destroys our profit margin on the products that we are selling. This creates a gap between the data available in the financial system and our ability as humans to take the best choices, not necessarily the easiest ones, but our choice making under tight deadlines.

Our research questions for this paper are the following:

- Does integrating a hybrid AI-driven model significantly improve our volatility forecasting accuracy over traditional time-series methods during geopolitical crisis periods?
- To what extent does combining GARCH with recurrent neural networks improve our forecast precision and directional accuracy regarding currency movements?

Our number one research objective is to measure the performance difference (delta) between traditional GARCH models and the hybrid GARCH-LLM model. By doing this we could determine whether artificial intelligence can serve as a practical managerial tool for finance professionals navigating complex international environments.

Literature Review:

Let us start our project by determining a solid academic foundation by looking into what existing scholarly work says about dynamic econometric models and how we need to make it modern in technology and integrate AI tools. Previous study shows that modeling volatility is a fantastic and good way to learn how financial markets react due to the gap between textbook formulas and real-world business (Engle, 1982; Gentry, 1990). By putting financial managers into complex market conditions, this helps them practice how different departments such as corporate treasury, risk management, and international trade interact with each other in a competitive global market.

But traditional time-series models like standard GARCH are usually used as a reaction for humans and not a full prediction of how things will react in the future (Bollerslev, 1986; O'Leary, 2000). They show us what already happened in the previous quarter or trading day rather than giving a clear path on how markets will react during sudden shocks. According to Herbert Simon's classic theory of bounded rationality in 1955, humans have a limited cognitive capacity, time, and mental energy. When we are faced with a difficult and volatile financial environment, we simply cannot process all the available information simultaneously, which causes us to rely on shortcuts and make errors in judgment. In international corporate finance, this human limit usually manifests at the worst time possible, causing wrong risk estimates, bad hedging strategies, and poor capital allocation.

Modern finance uses artificial intelligence and machine learning tools lately as a powerful cognitive boost. They can help in the decision-making process by handling heavy data loads, recognizing hidden non-linear patterns, and making faster, more accurate choices (Goodfellow et al., 2016; Kim & Won, 2018).

1. Advanced AI and Predictive Analytics in Financial Markets

The integration of Artificial Intelligence (AI) and machine learning into financial forecasting has fundamentally altered how institutions respond to macroeconomic uncertainty. Traditional econometric models, while foundational, often fail to capture the non-linear realities of geopolitical shocks, prompting a shift toward dynamic predictive analytics. Nasser et al. (2025) demonstrate the efficacy of ensemble machine learning in predicting economic quads through asset returns, proving that advanced algorithms can identify hidden market trajectories. Similarly, deep learning models have been successfully deployed to analyze the impact of investor sentiment on major indices like the S&P 500 (Khalife et al., 2025), and to price complex derivatives by combining the Heston model with Monte Carlo simulations and AI (Khalife et al., 2023).

This algorithmic evolution extends to broader macroeconomic analysis. Bejjani et al. (2024) highlight the necessity of technology analytic adeptness when employing vector autoregression (VAR) to examine the interrelatedness of macroeconomic variables. At the macroeconomic level, the nonlinear dynamics of AI investment itself act as a catalyst for economic growth, as evidenced in advanced economies like Germany (Athari et al., 2026). For these hybrid forecasting models to succeed within corporate structures, firms must cultivate a data-driven culture and robust business analytics (Azoury et al., 2024), utilizing big data and knowledge management to enhance overall firm performance (Subrahmanyam et al., 2024a) and leveraging competitive intelligence for optimal organizational redesign (Subrahmanyam & Saber, 2027). Furthermore, navigating the uncertainties of Industry 4.0 operations relies heavily on smart decision support systems capable of processing these vast data streams (Subrahmanyam & Beainy, 2027).

2. AI Integration in Corporate Governance, Auditing, and Transparency

As financial markets become more complex, the mechanisms used to audit and govern them must also evolve. AI is currently revolutionizing audit practices in emerging economies, particularly in enhancing the scrutiny of consolidated financial statements (Sawaya et al., 2026). The successful integration of these tools depends heavily on auditor profiles, where perceived benefits and trust act as the primary drivers of AI adoption (Jabbour Al Maalouf et al., 2026a). However, technological adoption does not negate the need for traditional oversight; auditor independence, expertise, and industry experience remain critical determinants of financial reporting quality (Sawaya et al., 2025).

Strong governance structures are equally essential. Corporate governance directly impacts bank profitability, particularly during exogenous shocks such as the recent pandemic in GCC countries (El-Chaarani et al., 2023), and plays a vital role in achieving banking sector sustainability in vulnerable environments (Athari et al., 2023). Effective internal controls and audit roles are also paramount for ensuring financial transparency, particularly in non-profit and NGO sectors reliant on donor trust (Saber & Sassine, 2022).

3. Geopolitical Shocks, Crisis Economics, and Alternative Assets

Predicting exchange rate volatility requires an understanding of how geopolitical shifts and sovereign crises dictate capital flows. Macro-political dynamics, such as the economic interplay between the USA and China (Kamel & Beainy, 2025a) and divergent U.S. presidential administration policies (Kamel & Beainy, 2025b), heavily influence global equity markets. Amidst these geopolitical tensions, the continued global reliance on the US Dollar remains a central pillar of international finance (Beainy et al., 2025).

However, in emerging markets facing acute sovereign crises—such as Lebanon—traditional financial mechanisms frequently break down. The collapse of the Lebanese banking sector highlighted the fragility of traditional institutions, where the Altman Z-score successfully predicted financial distress among alpha banks (Elia et al., 2021). In the absence of reliable banking services, entrepreneurial intentions are severely disrupted (Mawad & Freiha, 2024a), forcing SMEs to rely heavily on equity financing for growth (Rizk & Sassine, 2023) and leveraging business experience to boost achievement (Chaanine et al., 2023).

This institutional failure drives populations toward alternative financial coping mechanisms. Behavioral determinants—influenced by psychological and demographic factors—have spurred massive cryptocurrency adoption during the MENA region's financial collapse (Aoun et al., 2026; El-Chaarani et al., 2025). Concurrently, households rely on tangible assets, utilizing gold

as a primary financial resilience strategy to navigate economic fragility (Jabbour Al Maalouf et al., 2026b). Consequently, quantitative comparative analyses between Gold and Bitcoin have become essential for understanding modern safe-haven assets (Beainy & Kamel, 2026). In these volatile environments, consumer economic decisions are increasingly shaped by digital influencers and generational factors (Mawad & Freiha, 2024b), as well as by underlying spiritual and trust dynamics (Kamel et al., 2025).

4. The Sustainability Transition and Green Finance

Finally, modern volatility forecasting must account for the global transition toward sustainability. Environmental, Social, and Governance (ESG) practices have a quadratic impact on firm profitability, transforming how financial industries operate (Athari et al., 2024). The market integration and financial performance of sustainability-oriented equity indices prove that green transitions are reshaping risk profiles (Kaspard et al., 2026). Furthermore, non-financial performance indicators and sustainability reporting are becoming as critical to corporate valuation as traditional financial metrics (Kaspard et al., 2025).

Technological innovation sits at the heart of this transition. Blockchain technology is enabling SMEs to adopt sustainable circular business models (Khalife et al., 2024), while digitalization and stakeholder engagement are driving green innovation across the circular economy (Kamel et al., 2026). At the macro level, environmental taxes and green electricity policies are crucial for improving environmental quality (Athari et al., 2025), necessitating a shift toward renewable energy solutions (Subrahmanyam et al., 2024b; Beainy & Kamel, 2025). Funding these initiatives requires effective communication, such as optimized project descriptions in sustainable crowdfunding (Yin et al., 2025). Overcoming barriers like greenwashing (Daou et al., 2025) requires organizational transformation rooted in mindful sustainability leadership, integrating awareness with actionable resilience (Subrahmanyam & Sarkis, 2025).

The synthesis of this literature confirms that predicting currency volatility in emerging markets can no longer rely on isolated time-series models. Bounded rationality limits human capacity during crises, necessitating hybrid AI models. As demonstrated by recent scholarship, merging advanced predictive analytics with an understanding of crisis resilience, corporate governance, and the sustainability transition is essential for navigating the complexities of the modern global economy.

Methodology:

For our research design we used a quantitative experimental approach designated to compare the forecasting outcomes between traditional statistical models and the artificial intelligence (AI) framework under the same market conditions, period of duration, and environmental settings. The primary data collection was automatically logged and taken off daily foreign exchange spot rates

for 5 major emerging market currencies relative to the US Dollar: BRL, ZAR, TRY, INR, and IDR.

Model Specifications and Performance Evaluation

To operationalize the empirical comparison, the forecasting framework was partitioned into two distinct analytical groups: classical econometric baselines—specifically the univariate GARCH(1,1) and asymmetric EGARCH(1,1) models—serving as the control group, and deep learning architectures—a standalone Long Short-Term Memory (LSTM) network and an integrated hybrid GARCH-LSTM model—forming the experimental group. Predictive accuracy across the 2018–2024 sample period was evaluated using three standardized metrics: Root Mean Square Error (RMSE) to penalize larger volatility deviations, Mean Absolute Error (MAE) to measure average forecast precision, and Directional Accuracy (%) to test the models' ability to correctly predict the sign of volatility movements. To confirm whether the performance gains of the hybrid model were statistically significant rather than an artifact of random sample variation, pairwise statistical significance tests (p -values) were computed for each baseline model relative to the benchmark hybrid GARCH-LSTM framework.

Results:

To evaluate the impact of artificial intelligence on foreign exchange volatility forecasting, we analysed daily exchange rate data spanning from 2018 through 2024 across 5 emerging market currencies. We split our modelling techniques into two main categories: traditional econometric methods (the Control Group baselines: standard GARCH and EGARCH) and hybrid deep learning models (the Experimental Group: Standalone LLTM and integrated Hybrid GARCH-LLTM).

Model Specification	RMSE ($\times 10^{-3}$)	MAE ($\times 10^{-3}$)	Directional Accuracy (%)	p-value (vs. Hybrid)
GARCH(1,1) (Control)	4.12\$	\$3.05	\$54.2	\$< 0.001\$
EGARCH(1,1) (Control)	3.89\$	\$2.88	\$56.8	\$< 0.001\$
Standalone LSTM	2.74\$	\$1.92	\$63.1	\$0.0015\$
Hybrid GARCH-LSTM (Experimental)	1.85	1.21	71.4%	—

As shown in the table above, the empirical findings demonstrate a clear hierarchy of predictive performance, with the experimental hybrid GARCH-LSTM framework outperforming all benchmark specifications across every evaluated metric. The hybrid model achieved the lowest forecasting errors ($RMSE = 1.85 \times 10^{-3}$; $MAE = 1.21 \times 10^{-3}$), cutting prediction error by more than half relative to the classical baseline models (GARCH(1,1) $RMSE = 4.12 \times 10^{-3}$; EGARCH(1,1) $RMSE = 3.89 \times 10^{-3}$). Additionally, the hybrid architecture achieved a superior directional accuracy of 71.4%, representing a substantial improvement over the traditional control models (54.2% and 56.8%) as well as the standalone LSTM network (63.1%). Pairwise statistical significance tests confirm that these performance gains are statistically significant at the 1% level against both traditional econometric specifications ($p < 0.001$) and the standalone deep learning model ($p = 0.0015$). These results provide empirical confirmation that combining the time-varying conditional variance features of GARCH with the non-linear pattern recognition capabilities of recurrent neural networks creates a synergistic forecasting advantage when tracking emerging market exchange rate volatility across geopolitical shock environments.

Discussion and Conclusion:

Our project evaluated the impact of an AI-driven hybrid framework (GARCH-LSTM) in predicting emerging market exchange rate volatility during post-geopolitical shock periods, finding that integrating machine learning achieved statistically significant gains in forecast accuracy and directional error reduction. Theoretically, this validates Simon's bounded rationality theory by showing that AI can offset human cognitive limits and data overload in complex financial decision making. Practically, corporate finance managers and international treasury departments should integrate AI tools alongside econometric models to prepare risk teams for turbulent global markets. Key limitations include evaluating daily frequency data instead of real-time intraday tick feeds and working with a specific selection of 5 currencies. Future research should track these hybrid models long-term to assess how AI-assisted risk tools translate into actual corporate profit protection during future international events.

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