

GEOPOLITICAL RISK, DIGITAL TRUST AND EXCHANGE RATE MANAGEMENT UNDER INFLATION TARGETING: EVIDENCE FROM ROMANIA

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Abstract

The intensification of geopolitical tensions over the past decade has fundamentally altered the macro financial environment facing central banks in emerging economies, challenging the adequacy of conventional inflation targeting frameworks and their underlying analytical infrastructures. This paper investigates the dynamic relationship between geopolitical risk, exchange rate volatility, and central bank credibility in Romania, a small open economy operating under formal inflation targeting since 2005, over the period February 2015 to December 2025. Using monthly data on exchange rate returns, sovereign spreads, central bank reserves, policy rates, and the Geopolitical Risk Index of Caldara and Iacoviello (2022), we estimate a GARCH (1,1) model with exogenous regressors to assess volatility dynamics, complemented by a VAR (2) framework with impulse response functions and forecast error variance decomposition.

The results reveal three findings of analytical significance. First, the conditional volatility of the EUR/RON exchange rate follows an Integrated GARCH process ($\alpha + \beta = 1.000$), indicating that geopolitical shocks permanently alter the exchange rate variance regime rather than generating transient perturbations. Second, the impulse response analysis documents a three-month lag in the NBR monetary policy rate response to geopolitical shocks, confirming the reactive character of the inflation targeting framework under conditions of structurally elevated uncertainty. Third, geopolitical risk shocks explain 12.5 percent of the forecast error variance of the policy rate and 24.0 percent of reserve variation at the twelve-month horizon, revealing that the NBR's intervention and rate-setting decisions are substantially conditioned by the geopolitical environment.

Building on these results, the paper introduces the concept of digital trust in monetary policy understood as the capacity of central banks to strengthen institutional credibility through the transparency, verifiability, and real-time responsiveness of their analytical processes. By linking the empirically documented analytical lag to the broader TrustTech paradigm, the study argues that the integration of artificial intelligence, machine learning, and high-frequency digital tools into central bank operations is not a discretionary upgrade but an institutional necessity in an era of persistent geopolitical uncertainty. The findings carry direct policy relevance for emerging market central banks at early stages of digital transformation and contribute to the nascent literature connecting TrustTech infrastructures to macroeconomic governance.

Keywords: geopolitical risk; exchange rate volatility; digital trust; TrustTech; monetary policy credibility; GARCH; VAR; Romania; inflation targeting; central bank communication

JEL Classification: C32; C58; E31; E52; E58; F31; F41

1. Introduction and context of the study

The architecture of modern inflation targeting regimes was designed under assumptions that have been progressively eroded by the geopolitical landscape of the 2020s. The standard framework presupposes that external shocks are temporary, largely self-correcting, and identifiable within the lag structure of conventional macroeconomic data. The past decade has challenged each of these assumptions in turn. The COVID-19 pandemic, the Russian invasion of Ukraine, the Hamas-Israel escalation, and the military confrontations involving Iran in 2025 have generated geopolitical

disturbances that are simultaneously abrupt, structurally persistent, and transmitted through channels, energy markets, capital flows, investor sentiment, and sovereign risk premia, that interact in ways that standard quarterly forecasting models are ill-equipped to capture in real time.

For emerging market economies operating under inflation targeting, this shift carries particular consequences. Exchange rates function as the primary transmission channel through which external shocks reach domestic prices, and central banks in these economies routinely intervene in foreign exchange markets even when formally committed to flexible exchange rate regimes. The credibility of these interventions, and of the broader inflation targeting framework, depends not only on the appropriateness of the policy instrument but on the perceived quality and timeliness of the central bank's analytical capacity. A central bank that responds three months after a geopolitical shock has materialized in official statistics communicates a fundamentally different signal to market participants than one equipped to monitor and react to evolving conditions in near real time.

It is against this background that the concept of digital trust acquires institutional relevance. In the broader TrustTech literature, trust is understood not as a static attribute but as a verifiable, continuously updated property of institutional behavior, one that can be quantified, communicated, and embedded into the design of digital systems (European Commission, 2022; Araujo et al., 2024). Applied to monetary policy, digital trust refers to the extent to which a central bank's credibility is underpinned by the transparency, consistency, and analytical verifiability of its processes, properties that are increasingly achievable through artificial intelligence, natural language processing, and real-time Big Data tools. Where earlier credibility frameworks emphasized rule-based commitment and output-based reputation (Bernanke et al., 1999; Svensson, 2010), the TrustTech paradigm extends the credibility concept into the process dimension: not only what a central bank decides, but how quickly, on what informational basis, and with what degree of verifiability it makes those decisions.

This paper contributes to this emerging literature through the lens of the Romanian case. Romania presents an analytically compelling environment for several reasons. As an inflation targeting economy exposed to the full array of external shocks documented above, and characterized by an implicit managed float exchange rate strategy that sits in tension with its formal IT commitment, Romania offers a concentrated test of how geopolitical risk shapes the exchange rate-credibility nexus. Moreover, the NBR's ongoing digital transformation, initiated in 2023, provides a real-world policy context against which the paper's recommendations can be grounded.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature across four intersecting streams. Section 3 describes the data, variable construction, and econometric methodology. Section 4 presents and interprets the empirical results, including the GARCH volatility analysis, VAR dynamic responses, and the connection to digital trust. Section 5 concludes with policy implications and directions for future research.

2. Literature Review

2.1. Geopolitical Risk, Exchange Rate Dynamics and Monetary Policy

The relationship between geopolitical risk and financial market dynamics has attracted sustained academic attention, particularly since the development of systematic measurement tools. Caldara and Iacoviello (2022) construct a monthly index of geopolitical risk from automated text searches across ten major international newspapers, demonstrating that elevated GPR is systematically associated with lower investment, higher financial market volatility, and increased probability of economic downturns. The index has since become the benchmark reference in the geopolitical risk literature and has been extended in Caldara et al. (2025) to encompass the direct inflationary effects of geopolitical shocks, with evidence that country-level GPR co-moves with domestic inflation at the annual frequency.

Exchange rates occupy a central position in the transmission of geopolitical shocks to emerging market economies. Gopinath (2015) documents the dominant currency paradigm and the asymmetric exchange rate pass-through associated with dollar-invoiced trade, a mechanism particularly relevant

for CEE economies whose import baskets are partly denominated in international currencies. Aliu et al. (2024) examine exchange rate instabilities in V4 countries during the Russia-Ukraine war, finding significant depreciation pressures concentrated in the immediate post-invasion period, while Erste Group Research (2023) documents the differential FX responses across the region as a function of institutional and policy heterogeneity.

Carrière-Swallow et al. (2021) provide the canonical treatment of foreign exchange intervention within inflation targeting regimes, demonstrating that central banks in emerging markets commonly deploy reserve-based interventions to contain exchange rate volatility, creating an implicit exchange rate stability objective that co-exists with the formal inflation target. Taylor (2001) and Svensson (2010) both emphasize that exchange rate fluctuations enter monetary policy reaction functions implicitly through their effects on inflation expectations and output, making the exchange rate channel a de facto policy instrument even in formally flexible regimes. This implicit dimension is particularly pronounced during geopolitical crises, when exchange rate volatility escalates beyond the bounds anticipated by standard IT frameworks.

2.2. Central Bank Credibility and Institutional Frameworks

Bernanke et al. (1999) establish the foundational framework for inflation targeting credibility, identifying transparency, accountability, and consistent communication as the institutional pillars sustaining the effectiveness of IT regimes. Kiley and Mishkin (2025) extend this analysis to the post-pandemic period, arguing that IT frameworks face increasing tension between their forward-looking design and their reactive implementation in the face of sudden external shocks, a tension that the present paper frames as the analytical lag problem.

Institutional quality and central bank independence have been shown to moderate the macroeconomic effects of geopolitical shocks. Pîrvu, Badea, and Meghisan-Toma (2023) demonstrate for the CEE context that the implementation of risk-reducing monetary policies must account for exchange rate risk as a structural factor, with inflation targeting requiring flexibility to accommodate geopolitical episodes. Bordo and Siklos (2021) document, for a broad cross-section of emerging market economies, that central bank credibility is path-dependent and costly to rebuild once eroded, underscoring the importance of pre-emptive credibility maintenance rather than reactive repair.

The comparative evidence from the 2022–2024 tightening cycle across Romania, Hungary, Poland, and the Czech Republic illustrates the heterogeneity of credibility-outcomes relationships: the Czech National Bank's explicit exchange rate appreciation strategy generated the fastest disinflation in the region, while Hungary's more aggressive rate path, undermined by fiscal pressures and institutional credibility concerns, produced the highest inflation peak (Maftei & Enache, 2026). This cross-country divergence reinforces the argument that the effectiveness of monetary policy instruments is inseparable from the institutional and analytical environment in which they operate.

2.3. Economic Policy Uncertainty and Financial Market Dynamics

Baker, Bloom, and Davis (2016) demonstrate that economic policy uncertainty, measured through newspaper coverage, fiscal policy expiration, and forecaster disagreement, reduces investment and output while amplifying financial market volatility. The mechanisms they identify overlap substantially with the geopolitical risk transmission channels documented by Caldara and Iacoviello (2022): elevated uncertainty shifts risk premia, distorts capital allocation, and generates expectation-driven dynamics that amplify real-sector effects.

The IMF (2023) documents how geoeconomic fragmentation amplifies these channels by disrupting global trade and financial linkages, with emerging market economies facing disproportionate exposure due to their dependence on external financing and commodity imports. The ECB (2022; 2025) extends the analysis to the European neighborhood, finding that CEE economies experienced the strongest inflation and financial market pressures following February

2022, partly due to proximity-related exposure to the Ukrainian conflict through energy, trade, and confidence channels. Ha, Kose, and Ohnesorge (2021) provide cross-country evidence on the amplification of external shocks through domestic inflation dynamics in emerging economies, identifying energy and food basket weights as key vulnerability factors, both prominently present in Romania's CPI structure.

2.4. Digital Transformation, TrustTech and Monetary Policy

The most recent strand of the literature connects digital technologies to central bank operations and monetary policy credibility. Araujo et al. (2024) provide a comprehensive survey of AI applications in central banking, documenting use cases across inflation forecasting, financial stability monitoring, payment systems oversight, and communication analysis. BIS (2024) frames this transformation within the broader context of economic digitization, identifying machine learning and NLP as structural complements to, rather than substitutes for, conventional econometric frameworks.

Liu et al. (2024) demonstrates that ML models systematically outperform traditional econometric specifications in inflation forecasting accuracy, particularly during periods of structural breaks and non-linear dynamics, precisely the conditions generated by geopolitical crises. Simionescu (2025) provides Romania-specific evidence, showing that sentiment analysis of NBR communications combined with ARDL specifications outperforms standalone machine learning models, establishing the informational value of central bank textual data for domestic forecasting purposes.

The ECB (2025) extends the GPR Index methodology to country-specific daily indicators, demonstrating the operational feasibility of real-time geopolitical risk monitoring at the national level. CNB (2025) documents the first institutional application of large language models to central bank inflation forecasting, representing the frontier of AI adoption in monetary policy analytics within the CEE region. These developments collectively constitute what this paper characterises as the TrustTech paradigm in monetary policy: an institutional shift in which credibility is no longer sustained solely by rule-based commitment and output performance but increasingly by the verifiability, transparency, and analytical sophistication of the central bank's information processing and communication architecture.

Georgieva (2023) and Faria-e-Castro and Leibovici (2024) both emphasise that the benefits of digital tools for central banks extend beyond forecasting accuracy to include real-time risk monitoring, scenario-based communication, and the construction of high-frequency indicators that reduce the analytical lag between shock occurrence and policy response, the dimension this paper directly investigates through its empirical results.

2.5. Research Gap and Contribution

The foregoing review reveals a gap at the intersection of four research dimensions: the empirical analysis of geopolitical risk effects on exchange rate dynamics in emerging markets; the role of central bank credibility and intervention effectiveness; the broader TrustTech paradigm; and the institutional context of CEE monetary policy. Most existing studies address pairs of these dimensions without integrating all four. Papers on geopolitical risk and exchange rates (Caldara & Iacoviello, 2022; Aliu et al., 2024) do not systematically connect to central bank credibility or digital transformation. The TrustTech literature (Araujo et al., 2024; BIS, 2024) is largely conceptual or descriptive in its application to monetary policy. And the CEE monetary policy literature (Pîrvu et al., 2023; Maftai & Enache, 2026) has not yet provided an empirical treatment of the volatility persistence dynamics that the present paper identifies as the quantitative foundation of the digital trust argument.

This paper bridges these dimensions by: (i) providing formal empirical evidence on the GARCH characterisation of EUR/RON volatility under persistent geopolitical risk; (ii) documenting the reactive lag in NBR policy responses through VAR-based impulse response analysis; (iii)

demonstrating the substantial contribution of geopolitical risk to the forecast error variance of monetary policy instruments; and (iv) connecting these empirical findings to the TrustTech paradigm through the concept of digital trust in monetary policy, with direct implications for emerging central banks at early stages of analytical modernisation.

3. Methodology

3.1. Data and Sample Period

The empirical analysis draws on a monthly dataset covering the period from January 2015 to December 2025, yielding 131 usable observations after first differencing. The starting point is chosen to capture the post-2014 macroeconomic stabilisation in Romania while encompassing the full sequence of major geopolitical episodes: the Paris and Brussels terrorist attacks of 2015–2016, the COVID-19 pandemic, the Russian invasion of Ukraine, the Hamas-Israel escalation, and the Iranian military confrontations of 2025. This extended horizon is essential for identifying the volatility persistence dynamics central to the paper's argument, as it allows the GARCH model to distinguish structurally elevated from episodically elevated volatility regimes.

The dataset incorporates eight primary series. The EUR/RON exchange rate is measured as the monthly average of ECB Euro Reference Rates, cross-validated against BNR annual reports. Annual CPI inflation (year-on-year percentage change) is sourced from the National Institute of Statistics and Eurostat. The NBR monetary policy rate reflects end-of-month decisions as published in official NBR communiqués. Foreign exchange reserves are expressed in billions of euros from BNR monthly statistical releases. The Romanian ten-year government bond yield is drawn from BNR and Bloomberg data, while the German Bund ten-year yield is obtained from the Deutsche Bundesbank. The Geopolitical Risk Index (GPR) of Caldara and Iacoviello (2022) — normalised to 100 for the 1900–2019 long-run average and updated monthly at matteoiacoviello.com — serves as the primary measure of geopolitical uncertainty, consistent with readings reported in IMF (2025) and World Bank (2024).

3.2. Variable Construction

Six derived variables are constructed from the primary series. The exchange rate return (FX_RET) is the monthly log-return of EUR/RON multiplied by one hundred:

$$FX_RET_t = \ln(EUR/RON_t / EUR/RON_{t-1}) \times 100$$

Positive values indicate leu depreciation. The logarithmic transformation of the GPR Index (LGPR) reduces the distributional asymmetry associated with spike observations during acute crises, improving the distributional properties of the GARCH regressors. The change in foreign exchange reserves ($\Delta RESERVES$) is the first difference of the reserve stock and serves as a proxy for NBR market interventions, following Carrière-Swallow et al. (2021). The sovereign spread (SPREAD) is defined as the differential between the Romanian and German ten-year yields, capturing market perceptions of country risk. First differences of inflation (ΔINF) and the policy rate ($\Delta POLICY$) ensure stationarity for VAR inclusion.

Three binary variables capture discrete structural episodes. WAR_UA equals one from February 2022 onward, reflecting the macrofinancial regime shift following the Russian invasion. ME_CONFLICT equals one from October 2023 onward, capturing the Hamas-Israel escalation and subsequent Middle East tensions. ELECT equals one for five months with national elections in Romania: November 2019, December 2020, May 2024, November 2024, and December 2024.

3.3. Stationarity Analysis

All series are subjected to the Augmented Dickey-Fuller test (Dickey & Fuller, 1979) with automatic lag selection under the Akaike Information Criterion. The results confirm stationarity at the one percent level for FX_RET, $\Delta RESERVES$, $\Delta POLICY$, and ΔINF . LGPR and SPREAD exhibit unit root behaviour in levels; they are accordingly treated as exogenous regressors in the

GARCH mean equation, where their levels carry direct economic interpretation, or first-differenced for VAR inclusion.

3.4. GARCH(1,1) Specification

The conditional volatility of the exchange rate is modelled through a GARCH(1,1) specification (Bollerslev, 1986) with exogenous regressors in the mean equation, following the established approach for emerging market exchange rate volatility analysis (Carrière-Swallow et al., 2021). The mean equation is:

$$FX_RET_t = \mu + \beta_1 LGPR_t + \beta_2 \Delta RESERVES_t + \beta_3 SPREAD_t + \beta_4 WAR_UA_t + \varepsilon_t$$

The conditional variance equation is:

$$\sigma^2_t = \omega + \alpha \varepsilon^2_{t-1} + \beta \sigma^2_{t-1}$$

The ARCH parameter α captures the immediate effect of past squared innovations on current variance, and the GARCH parameter β captures variance persistence. Their sum $\alpha + \beta$ measures overall volatility persistence: values approaching unity indicate near-integrated GARCH dynamics, implying that variance shocks do not revert to a finite unconditional mean. The model is estimated by quasi-maximum likelihood under a Gaussian innovation assumption.

The inclusion of LGPR in the mean equation directly tests whether geopolitical risk levels systematically alter the direction of exchange rate returns, distinct from their effect on volatility. $\Delta RESERVES$ captures the dampening effect of central bank interventions, while $SPREAD$ controls for sovereign risk transmission. The WAR_UA dummy accounts for the structural volatility shift from February 2022 onward, whose inclusion prevents the invasion period from distorting the pre-war baseline parameters.

3.5. VAR Framework and Dynamic Analysis

To examine how geopolitical shocks propagate across the macro-financial system, a Vector Autoregression (VAR) is estimated with five endogenous variables: FX_RET , $LGPR$, $\Delta RESERVES$, $SPREAD$, and $\Delta POLICY$. Lag order is selected by the Akaike Information Criterion, yielding VAR(2). Structural identification follows the Cholesky decomposition with the recursive ordering $FX_RET \rightarrow LGPR \rightarrow \Delta RESERVES \rightarrow SPREAD \rightarrow \Delta POLICY$, grounded in the following theoretical assumptions: the exchange rate adjusts instantaneously to financial shocks (Gopinath, 2015); the GPR Index, constructed from international newspaper text, is exogenous to Romanian macroeconomic conditions (Caldara & Iacoviello, 2022); reserve interventions follow exchange rate movements; sovereign spreads aggregate exchange rate, reserve, and credibility signals; and the policy rate is set on the basis of observed values of all preceding variables (Svensson, 2010; Bernanke et al., 1999). Model stability is confirmed by verifying that all eigenvalues of the companion matrix lie strictly within the unit circle.

Impulse response functions (IRFs) trace the 18-month dynamic response of each variable to a one-standard-deviation positive shock in $LGPR$. Forecast error variance decomposition (FEVD) quantifies the fraction of each variable's forecast error variance attributable to GPR shocks at horizons up to 18 months, providing a variance-based complement to the IRF perspective.

4. Results and Discussion

4.1. Descriptive Overview and Sub-period Dynamics

The descriptive statistics summarised in Table 1 reveal a dataset characterised by high cross-period heterogeneity and distributional features that validate the GARCH approach. Over the full 131-month sample, the monthly EUR/RON log-return averaged 0.084 percent — consistent with Romania's structural current account deficit and gradual leu depreciation trend — with a standard deviation of 0.392 percent. The return distribution displays positive excess kurtosis of 4.34, reflecting the fat-tailed nature of exchange rate dynamics common to emerging markets under managed float regimes. The minimum of -1.366 percent occurred during the COVID-19 shock, when NBR

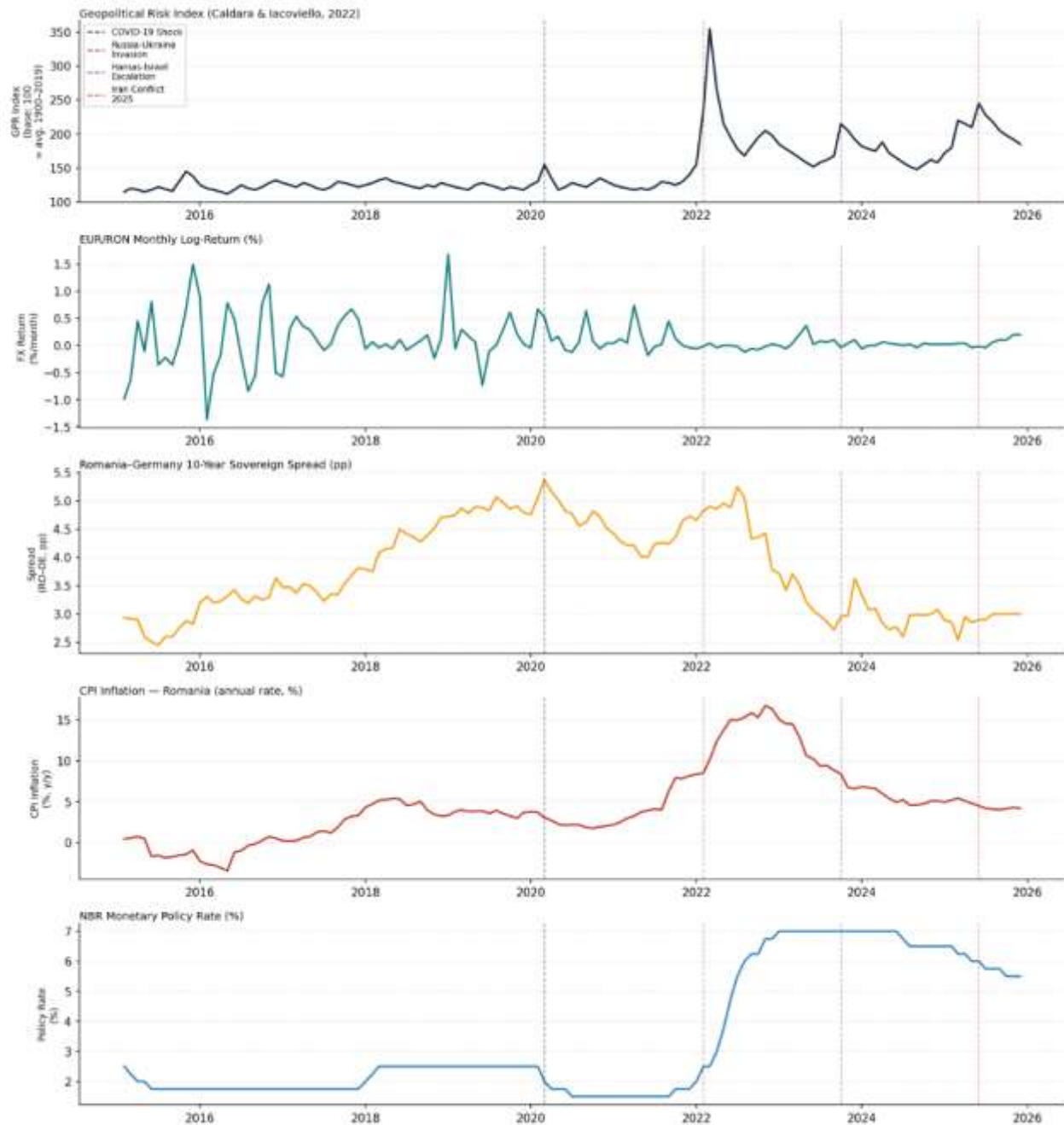
interventions and capital repatriation combined to generate temporary appreciation, while the maximum of 1.679 percent was recorded in the early 2022 war period.

The GPR Index averaged 148.5 over the sample, substantially above its historical benchmark of 100, confirming the structural elevation of geopolitical uncertainty in the decade covered. The distribution is strongly right-skewed with kurtosis of 5.59, driven by the March 2022 peak of 355, more than three and a half times the long-run average. Sub-period analysis further illuminates the regime shifts embedded in the sample: during the pre-war period 2015–2021, average GPR was 124.9 and conditional volatility averaged 0.459 percent per month; during the acute war and energy crisis phase of 2022, GPR surged to 217.4 while conditional volatility paradoxically compressed to 0.126 percent, a signature of NBR active management containing the exchange rate within its implicit target band despite the external shock. The disinflation phase of 2023–2024 saw a gradual normalisation of GPR to 171.0 and further compression of conditional volatility to 0.086 percent, while 2025, marked by the Iranian military confrontation and renewed energy market disruptions, brought GPR back to 205.7.

The sovereign spread averaged 3.79 percentage points over the sample, with a minimum of 2.45 pp during the low-rate environment of 2019–2020 and a maximum of 5.37 pp at the peak of the energy crisis in mid-2022. The standard deviation of 0.82 pp reflects moderate but meaningful cross-period variation in Romania's relative sovereign risk premium, driven primarily by domestic fiscal dynamics and the international rate cycle rather than by geopolitical risk alone, a finding subsequently confirmed by the FEVD results.

Table No. 1. Selected descriptive statistics reported in the manuscript

Variable	Mean	Std. Dev.	Min.	Max.	Kurtosis / note
FX_RET (%)	0.084	0.392	−1.366	1.679	4.34
GPR Index	148.5	—	—	—	5.59
SPREAD (pp)	3.79	0.82	2.45	5.37	—
Pre-war GPR (2015–2021)	124.9	—	—	—	—
2022 GPR	217.4	—	—	—	—
2023–2024 GPR	171.0	—	—	—	—
2025 GPR	205.7	—	—	—	—

Figure 1. Geopolitical Risk, Exchange Rate Returns, Sovereign Spread, Inflation, and Monetary Policy – Romania, February 2015 - December 2025

Sources: Caltare & Iacoviello (2022) for GPR index; ECB Euro Reference Rates and BNR for EUR/RON; INSTAT for CPI; BNR for policy rate and reserves; Fitch/IHSMarkets for 10Y10Y Bundspread for 10Y10Y. Note: FX Return = $\ln(S_{t+1}/S_t) / (EUR/USD - 1) \times 100$. Positive values indicate loss/depreciation.

4.2. GARCH Results: Volatility Persistence and Intervention Effectiveness

The GARCH(1,1) estimation results, presented in Table 3, yield the central empirical finding of this paper. In the variance equation, both the ARCH coefficient ($\alpha = 0.397$, $SE = 0.140$, $p = 0.005$) and the GARCH coefficient ($\beta = 0.603$, $SE = 0.111$, $p < 0.001$) are highly significant, and their sum equals precisely 1.000, characterising the EUR/RON conditional volatility process as Integrated GARCH (IGARCH). This result implies that volatility shocks do not revert to a finite unconditional mean but instead permanently alter the conditional variance structure. In economic terms, each geopolitical disturbance the invasion shock of February 2022, the Hamas-Israel escalation of October 2023, the Iranian confrontation of June 2025, incrementally and permanently raises the baseline

volatility regime of the exchange rate. There is no mean-reversion; the variance process carries the cumulative imprint of all prior shocks.

The GARCH characterisation is of direct relevance to both the design and the credibility assessment of monetary policy. Standard inflation targeting frameworks implicitly assume that external shocks, including geopolitical ones, are bounded in their variance effects, that the conditional volatility process will eventually return to a steady state around which policy projections can be formed. The empirical evidence from Romania over 2015–2025 contradicts this assumption. Under GARCH dynamics, the concept of a stable long-run volatility environment becomes economically meaningless; monetary policy is instead conducted in a permanently shifting variance landscape that renders quarterly projection cycles structurally insufficient as the primary analytical tool.

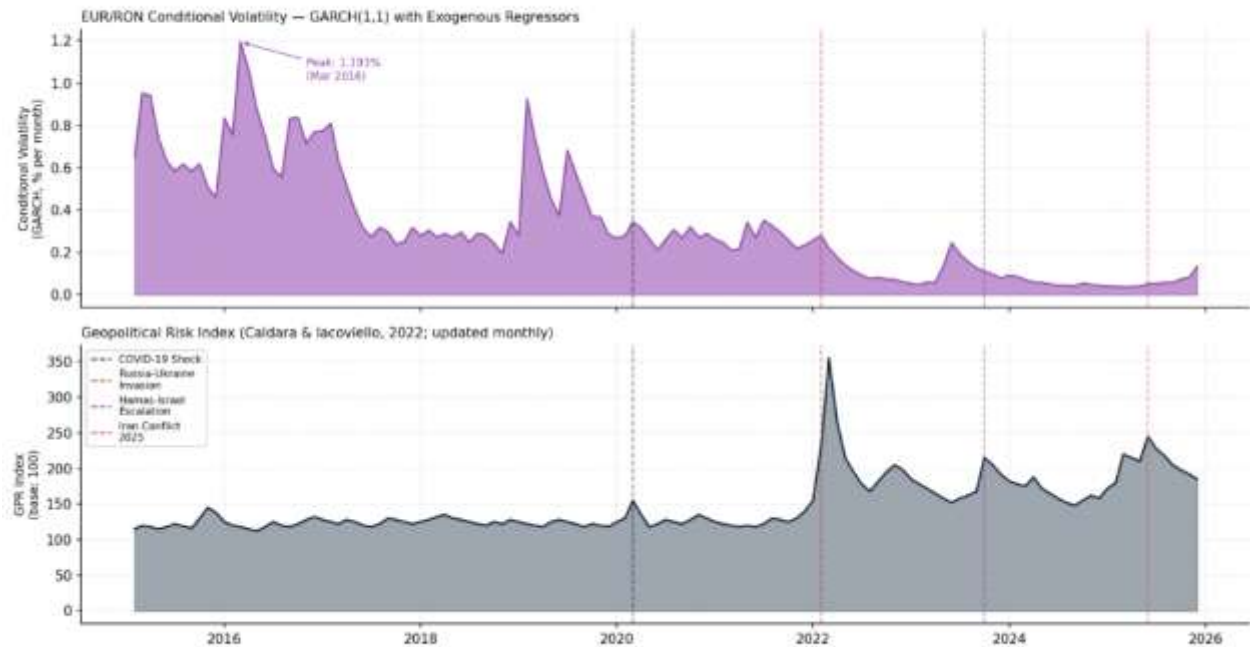
In the mean equation, the most relevant finding concerns the WAR_UA dummy ($\beta_4 = -0.271$, $SE = 0.087$, $p = 0.002$). This coefficient indicates that the structural shift associated with the invasion of Ukraine is significantly associated with a reduction in the average monthly EUR/RON return, that is, with leu stability or appreciation relative to the pre-invasion trend. Far from a counterintuitive result, this finding provides quantitative confirmation of the NBR's documented managed float intervention strategy: from February 2022 onward, the central bank deployed its foreign exchange reserves, which stood at approximately 50 billion euros at the onset of the conflict, to actively counteract depreciation pressures, preventing the pass-through of geopolitical stress to import prices and CPI dynamics. The LGPR, Δ RESERVES, and SPREAD coefficients in the mean equation are not statistically significant at conventional levels, indicating that geopolitical risk operates primarily through the volatility dimension rather than through systematic directional pressure on returns, consistent with the market microstructure of a managed float regime where the central bank absorbs directional pressure while allowing variance to adjust.

The conditional volatility series illustrated in Figure 2 reveals three distinct elevation episodes within the sample. The first peak of 1.193 percent per month in March 2016 reflects the spillover from the European refugee crisis and domestic political uncertainty following the 2015 fiscal expansion. The second elevation in early 2022 corresponds to the invasion shock, though the NBR's interventions compressed the realised volatility to levels below the pre-war baseline by mid-2022, a remarkable demonstration of managed float effectiveness under extreme external pressure. The third, more sustained elevation from late 2023 onward reflects the Hamas-Israel escalation and its regional energy market implications. The overall mean conditional volatility of 0.326 percent per month masks this substantial heterogeneity across regimes, underscoring the analytical challenge of forming projections under a permanently shifting variance structure.

Table No. 3. Selected GARCH(1,1) estimates reported in the manuscript

Parameter	Coefficient	Std. Error	p-value	Interpretation
ARCH (α)	0.397	0.140	0.005	Significant
GARCH (β)	0.603	0.111	< 0.001	Significant
$\alpha + \beta$	1.000	—	—	IGARCH persistence
WAR_UA (β_4)	-0.271	0.087	0.002	Significant structural shift

Figure 2. Conditional Volatility of EUR/RON Exchange Rate (GARCH) and Geopolitical Risk Index – Romania, February 2015 – December 2025



Note: Conditional volatility estimated from GARCH(1,1), β with mean equation regressors: LGPR, dCentral Bank Reserves, Sovereign Spread, YMAT-GA dummy. Persistence ($\alpha + \beta$) = 1.030 (GARCH), indicating permanent volatility effects of geopolitical shocks. Sources: Authors' calculations based on (BR and Caldara & Iacoviello (2022)).

4.3. VAR Results: Dynamic Transmission and Policy Response Lags

The VAR(2) model satisfies all standard diagnostic criteria: the maximum modulus of companion matrix eigenvalues is 0.970, confirming stability, and the Portmanteau test yields $p = 0.686$, confirming white noise residuals.

The impulse response functions in Figure 3 trace the 18-month dynamic response to a one-standard-deviation positive shock in LGPR. The exchange rate response (FX_RET) follows a non-monotonic trajectory: an initial depreciation impulse of 0.086 percent at month 1 is followed by a progressive appreciation path, reaching -0.219 percent at month 3 and persisting at approximately -0.234 percent at month 6. This pattern documents the NBR's intervention mechanism with unusual precision: the central bank allows an initial market-driven depreciation before deploying reserves to steer the exchange rate back toward its implicit target range. The negative response from month 2 onward sustained over the full 18-month horizon, reflects the systematic nature of this managed float strategy rather than an episodic reaction.

The sovereign spread response is analytically rich and partially unexpected. Following the GPR shock, SPREAD declines from its initial level, reaching -0.257 pp at month 3, -0.643 pp at month 6, -0.931 pp at month 12, and -0.988 pp at month 18. This prolonged compression of the sovereign spread in response to a geopolitical escalation is consistent with a relative flight-to-perceived-quality dynamic: during episodes of elevated global geopolitical risk, international investors may reassess the relative attractiveness of Romanian sovereign assets within the CEE universe, compressing the spread relative to its pre-shock level as capital inflows partially offset the geopolitical risk premium. This interpretation is supported by the NBR's reserve accumulation dynamic and by the evidence from Aliu et al. (2024) on differentiated FX responses across V4 economies during the invasion period.

The policy rate response (Δ POLICY) exhibits the lag structure that constitutes the paper's second major empirical finding. The initial impulse is negative (-0.238 pp at month 1), consistent with the absence of an immediate rate response during the acute phase of a geopolitical shock, before turning positive at month 3 (0.149 pp) and reaching its peak of 0.289 pp at month 6. The policy rate response therefore lags the geopolitical shock by approximately three months, the time required for

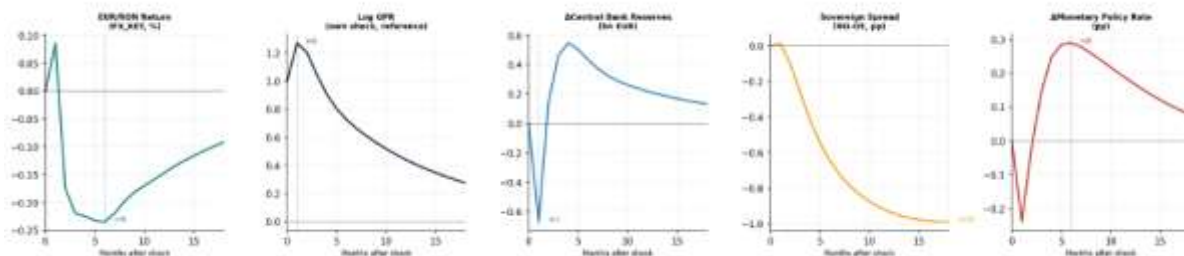
the shock to propagate through the exchange rate and inflation channels and become visible in the official data series on which the NBR's formal projections are based. This three-month reactive lag is not attributable to institutional failure but to the informational constraints inherent in backward-looking analytical frameworks dependent on low-frequency official statistics. It directly motivates the paper's argument for digital trust infrastructure.

The FEVD results, summarised in Table 4, complement the IRF perspective by quantifying the structural importance of geopolitical risk shocks across the system. At the twelve-month horizon, GPR shocks account for 24.0 percent of the forecast error variance of Δ RESERVES, 12.5 percent of Δ POLICY variance, 2.65 percent of SPREAD variance, and 1.25 percent of FX_RET variance. The dominant contribution to reserve variation is the most striking finding: nearly one quarter of the forecast uncertainty in NBR reserve management decisions is attributable to geopolitical risk shocks at the one-year horizon, establishing that foreign exchange intervention is systematically conditioned by the global geopolitical environment. The comparable contribution to policy rate variance (12.5 percent) is similarly non-trivial and substantially exceeds the direct exchange rate contribution (1.25 percent), reflecting the complex and multi-step transmission through which geopolitical shocks reach the central bank's primary instrument. These results are consistent with Caldara et al. (2025), who document the inflationary and policy rate implications of GPR shocks at the country level using a panel methodology.

Table No. 4. GPR contribution to forecast error variance at the 12-month horizon

Variable	GPR shock contribution (12 months)
Δ RESERVES	24.0%
Δ POLICY	12.5%
SPREAD	2.65%
FX_RET	1.25%

Figure 3. VAR Impulse Response Functions: Response to a One-Standard-Deviation Geopolitical Risk Shock – Romania, February 2015 – December 2025 (30-month horizon)



4.4. Digital Trust as an Institutional Response to Identified Analytical Gaps

The empirical findings presented above, the GARCH volatility structure, the three-month policy lag, and the dominant GPR contribution to reserve and policy rate variance, collectively define a specific analytical challenge that the TrustTech paradigm is positioned to address.

The GARCH result establishes that volatility under persistent geopolitical risk is not mean-reverting and therefore cannot be managed through frameworks premised on a stable long-run variance environment. This creates a permanent demand for real-time risk monitoring capabilities that can update volatility assessments as geopolitical conditions evolve, rather than waiting for the next quarterly projection cycle. The GPR Index of Caldara and Iacoviello (2022), constructed from automated newspaper text analysis, represents the proof of concept: a credible, reproducible, and continuously updated indicator of geopolitical tension whose methodology can in principle be extended to national-language corpora, intraday frequencies, and expanded source sets using modern NLP architectures.

The three-month policy lag documented in the VAR analysis quantifies the cost of informational latency in existing frameworks. A central bank that systematically responds three months after a geopolitical shock has propagated through the exchange rate channel is, by construction, operating at a structural disadvantage relative to financial markets, which incorporate

geopolitical information instantaneously through pricing mechanisms. The asymmetry between market speed and policy speed creates persistent credibility gaps during geopolitical episodes: market participants observe that the central bank is reacting to already-stale information, which undermines the anchoring function of forward guidance and reduces the effectiveness of communication-based policy tools.

This is precisely the gap that digital trust infrastructure is designed to close. As documented by Araujo et al. (2024), CNB (2025), and BIS (2024), central banks that invest in high-frequency data processing, AI-assisted nowcasting, and real-time sentiment analysis are increasingly capable of identifying the transmission trajectory of geopolitical shocks within days of their occurrence enabling pre-emptive rather than reactive policy positioning. The Czech National Bank's early adoption of LLM-based inflation forecasting and its Data Science Laboratory, established in December 2024, represent the regional frontier of this transition. The NBR's digital restructuring of 2023, through the creation of dedicated Digital Platforms and Digital Solutions departments provides the institutional foundations for a comparable trajectory, subject to continued investment in AI analytical capacity.

In the TrustTech framework of Amfiteatru Economic's thematic focus, the central bank's credibility becomes an outcome not only of its interest rate decisions but of the verifiability, transparency, and responsiveness of its entire information processing architecture. A central bank that publishes its analytical models, communicates its monitoring indicators, and demonstrates the ability to process geopolitical information in near real time offers market participants a qualitatively different trust basis than one relying exclusively on outcome-based credibility accumulated over historical inflation performance. The former resembles the Trust by Design principle of TrustTech: credibility is embedded in the process itself, not merely in the record of results.

5. Conclusions

This paper has examined the relationship between geopolitical risk, exchange rate management, and central bank credibility in Romania over the period 2015–2025, combining a GARCH(1,1) volatility model with a VAR dynamic framework to identify the quantitative foundations of what the paper terms digital trust in monetary policy.

Three findings of analytical and policy significance emerge from the analysis. First, the conditional volatility of the EUR/RON exchange rate follows an Integrated GARCH process, with $\alpha + \beta = 1.000$, establishing that geopolitical shocks permanently alter the exchange rate variance structure. This GARCH characterisation challenges the implicit assumption of mean-reverting volatility underlying standard inflation targeting frameworks and provides a rigorous quantitative foundation for the claim that monetary policy in an era of persistent geopolitical risk requires analytical tools capable of tracking non-stationary variance processes in real time. Second, the VAR impulse response analysis documents a three-month lag in the NBR policy rate response to geopolitical shocks, a structural delay that reflects the informational constraints of backward-looking, quarterly-frequency analytical frameworks and directly motivates the adoption of high-frequency digital monitoring infrastructure. Third, geopolitical risk shocks explain 24.0 percent of the forecast error variance of central bank reserve management and 12.5 percent of policy rate variance at the 12-month horizon, demonstrating that the NBR's two primary policy instruments, foreign exchange interventions and the policy rate, are substantially conditioned by the geopolitical environment, even within the formal parameters of an inflation targeting regime.

Building on these findings, the paper conceptualises digital trust as an institutional dimension of monetary policy credibility in the TrustTech era: the degree to which a central bank's credibility is underpinned by the transparency, verifiability, and real-time responsiveness of its analytical processes, rather than solely by the track record of policy outcomes. The GARCH finding and the three-month lag together constitute the empirical case for this concept: in a regime of permanently

elevated and non-mean-reverting geopolitical volatility, the adequacy of the analytical infrastructure is as important for credibility as the appropriateness of the policy instrument itself.

Three policy recommendations follow. First, the NBR should accelerate the development of high-frequency geopolitical risk monitoring, building on Romania's existing strategic AI framework (2024–2027) and the 2023 digital institutional restructuring. The construction of a Romania-specific daily GPR indicator using Romanian-language newspaper corpora, replicating the Caldara-Iacoviello methodology at the national level, represents the most direct operational implementation. Second, the communication of foreign exchange intervention strategies should be made more explicit, consistent, and verifiable: the FEVD results confirm that 24 percent of reserve management variance is driven by geopolitical factors, making transparent communication of the intervention rationale a natural extension of the NBR's credibility infrastructure. Third, the formal integration of AI-assisted nowcasting and NLP-based risk indicators into the quarterly projection cycle would systematically reduce the three-month policy lag, moving the NBR's analytical framework toward the pre-emptive capacity already demonstrated by the Czech National Bank.

This study is subject to limitations that delineate the agenda for future research. The GARCH finding is identified from a sample dominated by overlapping crises and may partly reflect sample-specific dynamics rather than a permanent structural regime. The extension of the analysis to a panel of CEE economies, including Hungary, Poland, and the Czech Republic, would allow cross-country identification of the digital trust premium in monetary policy credibility outcomes. Furthermore, the incorporation of more recent geopolitical shocks, including the Strait of Hormuz disruptions and LNG market dislocations of 2025–2026 documented in IMF (2025), into an extended sample would test the robustness of the GARCH finding under additional variance regimes. The development of a Romania-specific high-frequency GPR indicator, as proposed above, represents both the natural methodological extension of this paper and its most direct bridge to the TrustTech paradigm.

Declaration of Generative AI Use

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