

Geopolitical Uncertainty and Gold Market Volatility

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Abstract. *This paper investigates whether geopolitical risk (GPR) affects gold returns and volatility over time in an increasingly multipolar world with growing geopolitical tensions and increasing de-dollarization. Given recent interest in gold as a safe haven asset and tool for portfolio diversification, this study seeks to confirm whether GPR influences these aspects of gold returns and volatility. Thus, we use a generalized econometric framework that incorporates both traditional and augmented volatility models with daily gold prices and the GPR Index. Our approach follows that of GARCH (1, 1) (with GPR integrated into the modelling specification) and GARCH - X (where GPR becomes a covariate). We also employ the Akaike Information Criterion and the Bayesian Information Criterion, in addition to using several tests on the residuals, to select a sufficient model. Lastly, we augment our methodology to improve its predictability by using Gaussian Process Regression (GPR), an ML technique useful for forecasting volatility with potentially nonlinear patterns and measuring forecasting out-of-sample. We show that GPR is negligibly significant for predicting mean gold returns, but is effective at capturing variations in conditional volatility and does improve prediction relative to our benchmark when there's significant uncertainty over politics. We infer that diversification against geopolitical events afforded by gold is beneficial for portfolio managers given the shift in monetary power and geopolitical strategic reserve changes around the world.*

Keywords: Geopolitical Risk; Gold Volatility; GARCH-X Models; Gaussian Process Regression; Safe-Haven Assets; Volatility Forecasting; Global Financial Uncertainty.

Introduction

Gold has deep ties not only to finance but also to global politics and power. When people seek to hold onto wealth in the face of financial stress, political instability, war or general economic uncertainty, gold's traditional safe-haven status as an anchor of stability becomes salient. Moreover, gold can be deployed to project geopolitical power. In the 21st century, the rise of great-power competition, shifting patterns of international trade and the rapid fragmentation of the global money system have thrust gold back into the foreground. Gold has long served as a hedge in volatile and unpredictable markets. Today, it's in the process of becoming a contested key piece in a world financial reordering.

With regard to the world order, a dynamic of competing opposing views is at play: the continuation of U. S. Global financial dominance versus the rise of power centers - most clearly the BRICS+ countries. The U. S. Dollar is the principal currency in the global monetary system. This arrangement grants Washington substantial strategic power, allowing it to impose sanctions far and wide and control capital flows worldwide. Yet, this dominance has led to pushback from emergent countries rising through the world order. The most obvious resistance is de-dollarization and proposals emanating from BRICS+ and allied economies for alternative gold-backed trade payment and currency arrangements that'd break dependency on the U. S. Dollar system. The initiatives are still fledgling, forming part of a larger push towards building a multipolar monetary order free of Washington influence and sanctions. This rise has been accelerated by changing global demographics and structure: while the G7 economies bemoan aging populations and economic stagnation, BRICS countries exhibit more youthful demographics and their share of

global GDP growth continues to expand. As BRICS economies continue to gather economic heft, they'll gather the wherewithal to disrupt current financial practices. In recent years, BRICS economies have increased gold acquisitions as part of efforts to diversify reserves and hedge against depreciation of their currencies and dollar risk. To this end, we examine two central research questions: first, does gold volatility have anything to do with gold's geopolitics? Second, do AI machine learning methods do a better job than the traditional methods of modeling and forecasting gold volatility? To them, gold isn't a hedge merely against inflation or a financial crisis but an embodiment of monetary sovereignty and a first - class reserve asset for the new multipolar world order.

To date, market sensitivity to the geopolitics of gold volatility hasn't been systematically monitored. My Geopolitical Risk Index (GPR) tracks the market's sensitivity to a wide range of such variables and spikes in uncertainty generated by wars, sanctions, trade wars and political stalemates and breakdowns typical of today's environment. Recent events like the COVID-19 pandemic, the Russia - Ukraine war, U. S. China trade conflict and debate over the new One Belt One Road trade routes show that breakdowns of global governance structures spill over into gold volatility. And more recently, issues involving the expansion of the BRICS+ group, de - dollarization and digital gold currency instruments signal that the geopolitical contest over financial systems has not been episodic but is instead systemic.

There's widespread awareness of gold's safe - haven status. However, it's not clear that geopolitical risk specific drive gold volatility daily. With research more focused on the macro - economic variables, that's, interest rates, inflation and exchange rates, instead of direct shocks to the volatility of daily trading prices, it would appear that traditional GARCH (e. g. , ARCH, GARCH, EGARCH, IGARCH) and GJR (GJR - GARCH) volatility models are inadequate for modeling today's non - linear and fast - changing geopolitics. This gap has led researchers to use more novel artificial intelligence (AI) machine learning approaches to supplement or outperform them during times of high geopolitical uncertainty.

We employ Gaussian process regression to three forms of GARCH - X (1,1), testing three hypotheses: (i) Do geopolitical risks influence gold returns in general? (ii) Do geopolitical risks contribute more volatility to daily prices than traditional distributions? (iii) Do asymmetry, long - memory or exogenous risk factors improve on traditional GARCH specifications? (iv) Can AI methods predict gold volatility with greater accuracy than econometric methods?

In sum, our analysis finds substantial evidence that U. S. -associated geopolitical risks predict gold volatility and further clarifies the complex relationship between gold and geopolitical developments. We also contribute to the volatility literature by systematically assessing traditional econometric versus machine learning approaches within the context of extreme uncertainty. In addition, our findings position gold volatility within the broader geoeconomic shifts, characterized by the waning of US global financial hegemony, rivalry within the dollar system for hegemony and gold's increasingly prominent position within a multipolar monetary reconfiguration. Gold's volatility is no mere financial outcome but an evolving signal of worldwide, systemic upheaval. As sanctions proliferate, BRICS economies seek refuge outside dollar trading and the question of a gold - backed currency is increasingly discussed, gold volatility has become a constituent element in this contest, reflecting not just day - to - day shocks but a larger power struggle over the future direction of global finance. Indeed, some analysts, including Stephen Jen, former manager of the IMF's largest gold fund, argue that while some volatility is natural, most recent fluctuations can be traced to such geopolitical tensions, notably those involving Russia. While one should dismiss neither such concerns nor any tendency towards market euphoria, volatility does serve as a

barometer of geopolitical instability. As such, miners acting as indicators of fear and uncertainty are also shielding us against volatility in a world that appears to have descended into chaos. In general, geopolitical uncertainty translates into increases in the demand for safe - haven assets like gold as well as inflation expectations, as traders worry about potential supply disruptions or further sanctions against economies producing key resources. The underlying reason is that turmoil caused by wars and terrorism are seen as bad news by investors, creating higher transaction volumes and increased uncertainty, thus raising gold market volatility (Gupta et al., 2024). Because gold is free of counterparty risk and its supply is limited, it's a reliable and secure asset during times of political instability. Many instances prove gold's sensitivity to geopolitics, gold prices spiked after September 11, 2001, the COVID-19 pandemic began in early 2020 and Russia invaded Ukraine in February 2022. At first glance, there's nothing to link gold volatility to the geopolitics of gold. Geopolitical events haven't been taken into consideration when trying to forecast gold volatility in past studies. However, in addition to their empirical modeling of gold returns, the author addresses the two key questions outlined previously.

Literature review

An increasing amount of literature now describes gold as a hedge against multiple risks, encompassing financial, geopolitical and macroeconomic risks (Kyriazis, 2025). Recently, gold prices and gold volatility reached unprecedented levels.

This article reviews empirical studies, peer - reviewed literature and relevant authorities on how gold price volatility is linked to geopolitical risks, BRICS economic dynamics, U. S. Hegemony and foreign affairs. It reviews historical as well as recent empirical evidence showing that wars, conflicts and diplomatic crises trigger demand for gold. It discusses implications of increased cooperation among emerging economies and the shift away from dollar dominance on commodities prices. It analyzes the economic and political influence of the United States and its effect on investor behavior and demand for safe haven assets. Empirical studies based on new techniques (econometric models, machine learning methods) on gold performance in uncertain times are critically assessed. In this review, peer - reviewed journals are cited, this builds upon and reiterates findings that have already been published. A critical assessment is offered. A broad and up - to - date discussion will be given that may interest an academic reader on the role of gold in an era of changing geopolitical dynamics and economic power.

The literature confirms that increasing geopolitical tensions and global conflicts profoundly affect gold prices and volatility. Geopolitical risk (GPR) is the threat, realization and escalation of unfavorable events connected to tensions that detrimentally affect the peaceful course of war, terrorism and disputes among nations and political actors (Caldara & Iacoviello, 2022). The GPR Index is a measure of geopolitical risk developed by Caldara and Iacoviello (2022), using text from news reports about geopolitical threats and acts. The GPR index is now extensively used by scholars studying this topic. The literature generally points to a rise in safe - haven behavior by investors, leading to a surge in demand for gold and other safe assets when GPR levels are high. For example, using data over the period 1986-2017, Elsayed and Helmi (2021) conclude that increases in global tensions in geopolitical conflict events lead to higher global financial volatility and the movement into safe haven assets such as gold. Similarly, Baur and Smales (2020) show that increased geopolitical risk leads to increased gold return volatility, while Huang et al. Confirm this result.

Gold even surged higher than U. S. Stocks and bonds, alongside the U. S. Dollar - the other traditional safe haven asset - which indicates great panic on the part of investors. Indeed, over the

past 30 years, gold has provided positive returns during high - fear times associated with rising geopolitical risks and often when stock and bond prices fell. The Gulf War and the Iraq War saw significant increases in gold prices driven by war concerns, followed by sharp falls once hostilities abated. A European Central Bank analysis notes that gold consistently serves as a safe haven during extreme periods of geopolitical risk or policy uncertainty. It indicates that gold has performed better in high - risk periods since 1990 compared to other assets. The analysis noted that gold performed better in war, conflict or diplomatic crisis periods than gold, stocks, bonds, U. S. Treasuries and the dollar. This makes gold a reliable haven during periods of geopolitical stress, to the extent that even the mere risk of war can trigger demand. Almost 60 percent of asset managers expect gold to be the top - performing asset in a "full - blown trade war" scenario, according to a recent survey.

For the most part, researchers investigate the impact of geopolitical flashpoints on gold price movements through econometric modeling, using the volatility generated around these events, which are frequently modeled using GARCH family models. Mitsas et al. (2022) employ an EGARCH(1,1) model for monthly returns of commodity markets, including gold. They find that an increase in the geopolitical threat indices raises gold's return volatility. Furthermore, they document that geopolitical shocks exert an asymmetric impact, meaning that negative shocks - such as unanticipated increases in conflict - tend to push gold market volatility up more than positive geopolitical developments decrease volatility. In their research, the authors report significant increase in gold and silver volatility following adverse geopolitical events. The study concludes that political uncertainty is a main driver of fluctuations in gold price, solidifying its role as a measure of global instability. Therefore, investors and policymakers should pay close attention to geopolitical risk indicators because unexpected events may lead to sharp fluctuations in the price of gold.

Given recent examples discussed, Wu (2025) focuses on the volatility of the gold price at the global market during unstable U. S. -China relations. Using a bivariate GARCH - MIDAS model with U. S. -China Tension (UCT) index and its interaction with other volatility measures, such as global economic policy uncertainty (EPU) and standard geopolitical risk index, Wu indicates that escalating tensions between the U. S. And China are more significant sources of gold price volatility than global economic policy uncertainty and the standard geopolitical risk index. The research also indicates that short - term gold returns are more responsive to uncertaintyproxies at the international level, such as global geopolitical and economic risks, than to uncertainty proxies at the U. S. Level, reinforcing the idea of gold as an international asset whose performance responds to global risk than just the risk of a particular country. Baker, Bloom and Davis (2016) found that spikes in global policy uncertainty are linked to movements in gold prices and major geopolitical news increases intraday volatility. The literature consistently finds that global events have a significant, though not always predictable, influence on relationships among countries, leading investors to seek safe assets such as gold, which in turn impacts its price and volatility. The most notable result is the safe - haven characteristic of gold during such global instability.

Methodology

This is done using econometrics and machine learning techniques. The empirical setting draws on the family of GARCH models, emphasizing the GARCH(1,1) model but also introducing a GARCH - X variant that places the Geopolitical Risk (GPR) index into the variance equation as an exogenous variable. In other words, the aim of this paper is to determine how gold price volatility reacts to geopolitical tension, considering the asymmetries and persisting shocks commonly observed in financial time series. GARCH - X and machine - learning methods are used because

of recent progress. While GARCH models have become the preferred method to handle the heteroskedasticity often observed in financial data, they are frequently unable to deal with structural breaks or nonlinearities intrinsic to economic and financial realities. However, Gaussian process regression (GPR), a type of Bayesian nonparametric method, can deal with more flexible scenarios (Rasmussen and Williams, 2006). It can capture more complicated nonlinear dependencies between the predictor inputs and the output variable without making several rigid assumptions. This paper combines interpretability in econometrics and machine learning's power for forecasting. We use daily time series of gold prices and the Geopolitical Risk Index for the period January 2014 to May 2025.

Data on gold prices were obtained from Investing. Com, showing the daily market valuation of gold. All data were prepared and analyzed in Python. The Geopolitical Risk Index was developed by Caldara and Iacoviello (2022) through the automated text analysis of geopolitical terms from major international newspapers, providing a general index of geopolitical instability across the world. We convert gold prices into continuously compounded returns by taking the first log difference of the price series and multiplying by 100. As displayed in Figure 1, the log returns appear stable since an augmented Dickey - Fuller test rejects the null hypothesis of a unit root at the 1% significance level. In line with typical financial time series, the return series displays characteristics such as volatility clustering and high kurtosis. Hence, volatility shocks in the series persist for some time: when gold returns are volatile, they tend to remain so for a long time. This points to gold acting as a memory asset when events destabilize markets. Financial markets don't throw off political shocks or shocks stemming from financial crises straight away. Instead, these events may persist for weeks or months in market memory. One prominent example is the volatility persistency experienced in the aftermath of the first wave of international sanctions against Russia in 2022, the stress from the geopolitical crisis did not end with a single event but lasted a protracted period. The GARCH - X model does highlight several notable changes in the results when GPR is included in the variance equation. Hence, it can capture the newer methods and new views on gold behavior. The GARCH(1,1) model of Bollerslev (1986) is formulated as:

$$r_t = \mu + \varepsilon_t, \varepsilon_t = \sigma_t z_t$$

$$\sigma_t^2 = \omega + \alpha \varepsilon_t^2 + \beta \sigma_{t-1}^2$$

where:

r_t is the return at time t

σ_t^2 is the conditional variance

$z_t \sim N(0,1)$,

$\omega > 0, \alpha \geq 0, \beta \geq 0$.

The GARCH - X models are used to integrate geopolitical risk into volatility dynamics. The variance equation in the GARCH - X models includes the GPR index as another independent variable affecting volatility.

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma GPR_t$$

The inclusion of the GPR index in the variance equations is based on both theory and practice. Theoretically, this approach aligns with prior studies indicating that global political uncertainty (especially related to power conflicts, such as that of the current global power vs China or Russia) prompts risk aversion from investors and boosts the volatility of stock markets (Caldara & Iacoviello, 2022). In practice, GPR can assist in correcting potential omissions of variables

(omitted - variable bias) as well as improve volatility predictions during such geopolitical events as the Ukraine war, the ongoing U. S. -China trade war or BRICS nations' attempts at de-dollarizing (Salisu et al. , 2023)

Results and discussions

Figure 1 presents the time series plots for daily log returns of gold. The figure shows clear evidence of volatility clustering, where periods of low volatility are interspersed with periods of intense volatility. Volatility clustering is a key characteristic of financial time series and supports the use of GARCH - type models. The sample period is from January 2014 to May 2025, encompassing major episodes of global economic and political turbulence, including the COVID-19 outbreak in early 2020, the outbreak of the war between Russia and Ukraine in 2022 and increasing geopolitical tensions around the 2024 U. S. -China conflict, along with BRICS efforts. Meanwhile, the Gold return series shows signs of mean reversion and stationarity, according to the ADF test ($p < 0.01$).

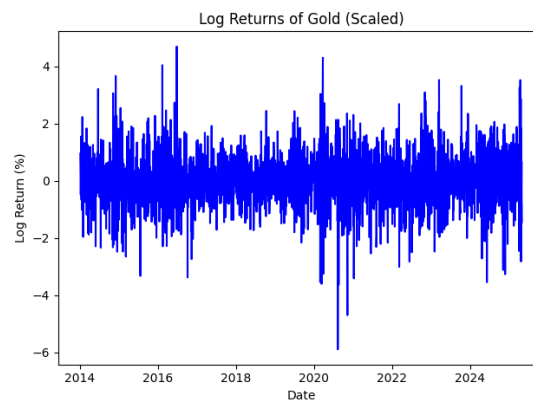


Figure 1: Log Returns of Gold (Scaled)

Source: Author's computation.

The time series of the Geopolitical Risk (GPR) index reveals an episodic behavior with marked increases during global crises. These jumps in the GPR index are much less frequent than the bursts in returns. The GPR jumps denote structural shocks in geopolitical risk that tend to affect financial markets. The ADF test also fails to reject the hypothesis that the GPR series is stationary at the 1% level.

Table 1. Summary Statistics

Statistic	Log Returns	GPR Index
Mean	~0.00033	~107.90
Std. Dev.	~0.00881	~33.77
Min	-0.05898	~58.42
Max	0.04693	~318.95
Observations	2946	2946
Skewness	-0.135	2.386
Kurtosis	2.875	10.964

Source: Author's computation.

Table 1. The most frequent value for the returns series of Gold is close to zero, with much less dispersion ($\sigma \approx 0.0088$) than that for the GPR index ($\sigma \approx 33.77$). The GPR series is characterized by considerable positive skewness (skewness ≈ 2.39). This suggests that geopolitical risk typically stays at moderate levels and only rarely flares up dramatically. For reference, the GPR (greed, panic and risk) index also presents a high excess kurtosis (≈ 10.96), reflecting the fat tails of low - probability but high - impact geopolitical crises.

The GARCH - X(1,1) model suggests that the returns for gold are persistent ($\alpha + \beta \approx 1$ under Student's t - distribution). This implies that shocks to volatility can linger in the series for considerable periods. In other words, when gold returns become volatile, they stay volatile for a lengthy period. This feature suggests gold's role as a memory asset when global events destabilize the markets. The market doesn't discard political shocks or shocks originating from financial crises immediately. Instead, these events can linger for weeks or months in the market memory. An example is the high volatility persistency that continued for some time following the first wave of international sanctions against Russia in 2022, the geopolitical stress wasn't resolved with a single event but persisted over a significant span.

The GARCH - X model reveals noteworthy changes in the results when including the GPR index in the variance equation. The coefficient of the GPR index (γ) is positive at the 1% level across Student's t - distribution. The estimates of γ are consistently positive and statistically significant across all distribution assumptions. This is consistent with our H_1 , which argues that shocks to geopolitical risk increase gold volatility. Therefore, gold volatility appears not to be only triggered by shocks related to the financial markets themselves but also by external geopolitical uncertainties. This finding is significant in today's shifting global political paradigm. The coordinated actions of BRICS nations and discussions around de - dollarization and U. S. Financial hegemony lead to recurrent spikes in geopolitical risk. The volatility of gold in these circumstances is not just random fluctuation but a systematic consequence of geopolitical competition among rising multipolar blocs. As countries try to reshape trade flows, commodity supplies and reserve diversification policies, financial havens like gold feel the spillover effects of instability. Gold is crucial in such a scenario because it's sovereign risk - free and not beholden to any nation.

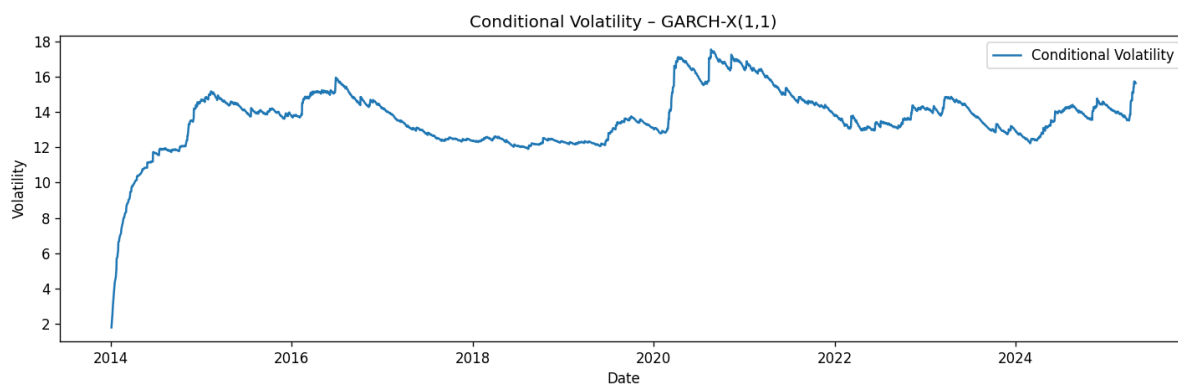


Figure 2. Conditional Volatility_GARCH-X(1,1)

Figure 2 plots the GPR index for the complete sample. Notice sharp increases around three geopolitical events: early 2020 (outbreak of COVID-19), February - March 2022 (start of the Russia - Ukraine war) and March - April 2024 (geopolitical tensions increase over BRICS currency de - dollarization, growing US - China war of words over Taiwan). These evidence

suggest that geopolitical risk is an important exogenous factor impacting gold volatility and warrant the use of GPR as an outside factor in the variance equation.

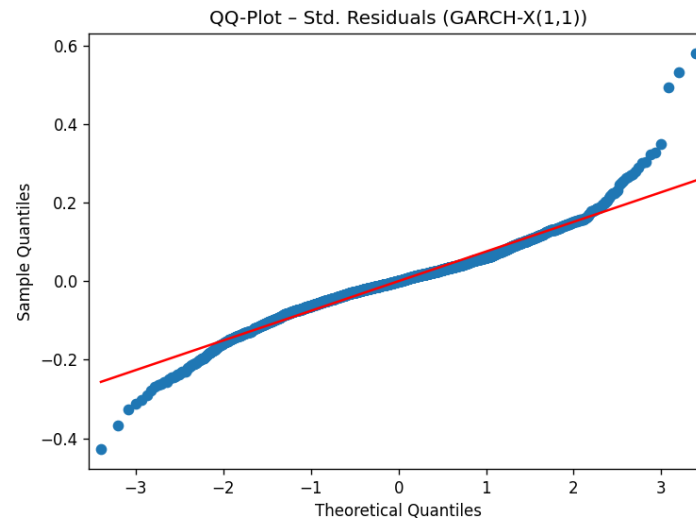


Figure 3. QQ_GARCH-X(1,1)

Source: Author's computation.

The residuals of GARCH - X(1,1) model aren't significant at usual levels, which confirms our model's effectiveness in capturing volatility clustering. However, Figure 7 (QQ - plot) reveals that the distribution of residuals appears to deviate from normal at tails (suggesting heavier tails), as usually observed for return series of financial assets.

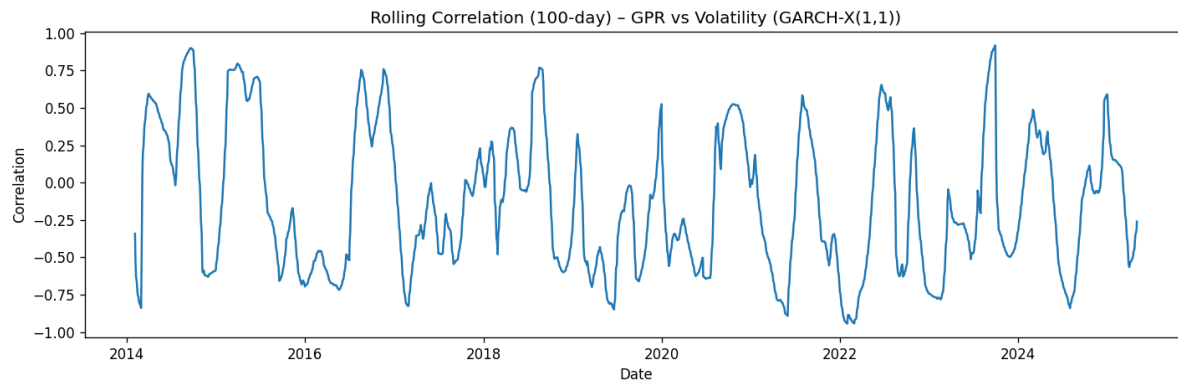


Figure 4. Rolling Correlation_GPR_vs_Vol GARCH-X(1,1)

Source: Author's computation.

GARCH - X(1,1) models show both a higher and varying correlation between the two asset classes over time, changing from positive to negative, reflecting the fact that gold only acts as a safe haven conditional on context. From early 2018 until early 2019, it faltered momentarily due to increased tensions over U. S. -China trade disputes, it temporarily deviated from being a proxy safe haven as global investors didn't continue to rely on gold, as they had temporary confidence in American leadership which drove correlations into negative territory. However, gold became more consistently positive and stable during 2024, spurred by the developing trend toward multipolarity where new Middle Eastern oil producers joining BRICS and new trade routes redirected gold's safe - haven function into a global hedge.

Conclusion

This study makes an attempt to clarify the causal linkages between geopolitical risk and gold volatility at a time of rapid global systemic change by employing a blend of econometrics and machine learning techniques in the analysis framework that embeds the analysis in the broad context of U. S. Dominance, BRICS attempts to decrease reliance on the dollar and the rise of a multipolar global system. This enables the examination of both emerging techniques and new strategic insights into gold behavior.

Overall, this paper argues that gold volatility isn't a problem of finance alone but also a political signal, it reflects both market mechanics and the fight for hegemony in declining US global dominance and rising aspirations for a new multipolar world. Given that artificial intelligence technology has improved the capacity to forecast trends, the article points out that in today's polarized and precarious world, economics, geopolitics and strategy have increasingly become conflated. To fully grasp gold volatility, we must move beyond the stock market and ponder the direction of the future international system.

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