Impact of Geopolitical conflicts on Sustainable Financial Management for Blue Economy Development

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Abstract
Geopolitical conflict has become a major source of fluctuations and unpredictability in global financial markets. Geopolitical conflict affects equity markets, currencies, commodity prices and the overall confidence and risk appetite of investors globally and maritime territorial tensions, has created significant challenges for the sustainable development of the blue economy.. The objective of this paper is to analyze the effects of geopolitical risk-defined here as risk generated from war, diplomatic crises and large-scale conflict in the world-on global financial markets, mediated by channels of risk aversion, supply shocks in commodities and trade disruptions. Strategies that support the sustainable utilization and conservation of aquatic resources under conditions of geopolitical uncertainty.
The empirical methodology employs secondary data and utilizes information on the Geopolitical Risk (GPR) Index, developed by Caldara and Iacoviello (2018), along with several key financial market indicators. Key financial variables include global equity indices, currencies exchange rates, bond yields, crude oil price. The sample of analysis consists of daily observations during the period 2014.1 - 2024.12. A quantitative analysis using Micosoft Excel, Python (Pandas, Statsmodels) and R/EViews has been performed.
Our results reveal an **integrated framework** linking geopolitical risk, sustainable financial management, and blue economy development, providing guidance for policymakers, financial institutions, and environmental managers. Significant negative response in equity markets, whereas safe-haven assets like gold and USD respond positively to geopolitical risk. Correlation and OLS regression results present evidence for these relationship most consistently and reliably. Volatility modeling in the framework of GARCH, though not providing a primary support to the above relationship, provides an auxiliary tool to acknowledge time-varying risks and volatility persistence.

Keywords: Geopolitical conflict, Sustainable Financial Management, Blue Economy,

Introduction
Geopolitical risk - a combination of warfare, conflict, economic sanctions, land disputes, diplomatic breakdowns, political instability, and conflict- is one of the most defining and volatile variables governing global financial markets today. In the current highly interdependent and fast moving international financial world with free movement of capital globally following new news, shocks originating from any region of the world due to geopolitical tensions can spread to financial markets located far away rapidly. A number of new and important developments, including increasing occurrence of local conflict since Cold War, re-emergence of rivalry among major powers, use of trade and financial systems as weapons to influence other countries and increased reliance on financial sanctions as a foreign policy tool, have dramatically reshaped the risk environment facing investors, firms and policymakers (Caldara & Iacoviello, 2022).
In the recent ten years, 2014-2024, a large number of major events with substantial implications for financial markets have occurred. Russia's annexation of Crimea in February 2014 jolted the European financial markets and gave rise to the first major imposition of Western financial sanctions on a major economy in recent times. Ongoing clashes in the Middle East triggered price volatility in the global oil market through 2015- 2016. The surprising result of the UK referendum in June 2016 where it decided to leave the EU (Brexit) led to one of the biggest daily drop in currency valuation in financial history, with British pound dropping approximately ten percent relative to major currencies within few hours after results were announced. The U.S.-China trade war began with first round of tariffs in 2018 and escalated in 2019-2020, triggering disruptions in global supply chains, leading to decline in business investment and repeated episode of volatility in global and Asian equity markets.
The pandemic in 2020 was first and foremost a health crisis, but it brought significant geopolitical implications, including dispute over origin of virus, restrictions on supplies of medicines, collapse of international travel and tourism, and significant reshuffling of relationships among global superpowers.
The oil price crash of March and April 2020 (WTI prices briefly turned negative for the first time in history) clearly showed the sensitivity of the commodity market to geopolitical and health related supply shocks. The full scale Russian invasion of Ukraine in February 2022 marked the biggest geopolitical escalation in Europe since World War II and led to an unprecedented package of Western sanctions and substantial reaction across equity markets, alongside major supply shock in commodity markets. The beginning of Israel- Hamas conflict in October 2023 injected yet another source of Middle Eastern risk into an already troubled global financial system (Boungou & Yati, 2022).
Higher level of interdependence of global capital markets, increased efficiency of high frequency algorithmic trading and evolution of commodities and currencies as financial instruments have contributed to increase in financial market's sensitivity towards geopolitical risk.
The purpose of this study is to apply the correlation analysis and regression analysis method in empirical examination to test the direct effects of geopolitical risk to financial market and uses the volatility modelling method to cooperate the analysis process.

Literature Review

It is recognized that the relationship between geopolitical risk and financial market performance is not a new area of study and has received considerable attention since the early 2000s, especially with the global financial crisis and international capital mobility enhancing the diffusion of political shocks across the border.

The question-how does geopolitical events influence asset prices, volatility, and intermarket linkages-has been tackled through many theoretical frameworks and empirical studies. There are basically 5 categories into which the relevant literature may be grouped: geopolitical risk measurement, equity market responses, safe-haven assets, volatility transmission, currency and bonds.

1. Geopolitical Risk Measurement

Balcilar, Bonato, Demirer and Gupta (2018) took a further step and examined how the GPR Index is associated with stock market returns in developed and emerging countries using nonlinear Granger causality tests. The findings suggest that geopolitical risk causally impacts stock prices in both developed and emerging countries in a persistent manner and to a greater extent in the latter. They found a form of asymmetry, such that increases in geopolitical risk positively forecast stock market declines, but decreases in geopolitical risk do not forecast stock market increases. This result confirms the existence of a loss aversion tendency in the human mind.

2. Equity Market Responses to Geopolitical Conflicts

The literature on how equity markets respond to geopolitical conflicts is rather vast, with dozens of event studies and regression analyses undertaken spanning decades.

An event study on the September 11, 2001 attacks by Nikkinen and Vhmaa (2010) shows that the VIX index, or market fear, saw a substantial jump and information about the event rapidly spread across global stock markets within a couple of hours after the attacks. This study provided evidence that suggested an indicator to reflect real-time information about the efficiency of financial markets in responding to geopolitical shocks.

Following this vein, Kollias, Papadamou, and Stagiannis (2011) applied similar methodology for Madrid and London terror attacks of 2004 and 2005 respectively and reported that negative stock returns appear in European equity markets immediately after these events and the magnitude of returns is strongly influenced by the severity of attacks and geographic proximity to these events. These findings conclude that geographic proximity of the markets under investigation to the event is significant for explaining equity market responses.

For the war between Russia and Ukraine, Boungou and Yati (2022) produced one of the first detailed analysis of the impact of the Russian invasion of Ukraine in February 2022 on global equity markets. Based on an event study over 94 countries, they observed negative abnormal returns across all markets investigated and that the size of negative abnormal returns was conditional on the closeness (economic and commercial linkage) of a country to Russia and Ukraine. Germany, France, Italy and Eastern European markets were found to be the most affected markets due to their dependence on Russia for their energy needs and their geographic proximity to the region of conflict. The Russian stock market has collapsed nearly 40% of its market capitalization within two weeks following the attack, the stock market was suspend its operations and rigorous capital controls were imposed by the Russian central bank.

Fang and Zhang (2022) also highlighted the dramatic market responses following the Ukraine invasion, indicating that country characteristics such as dependence on energy and commodities lead to a greater magnitude of negative stock market returns. Those economies which depend more on the import of energy and possess lack of alternatives, showed a more profound decline in their equity markets. With regards to the U.S.-China trade war, Smales (2020) presented an event study that found that announcements related to the trade war, in particularly the tariffs increases, were associated with negative stock market returns in both the U.S. And China. His analysis also noted that the U.S.-China trade war effects quickly spillover into emerging stock markets and those markets that had a larger share of exports destined to the U.S. And China experienced more significant negative returns.

3. Safe-Haven Asset Dynamics

A prominent and frequently documented result is that a demand for safe-haven assets, where investors flee risky assets towards safe assets, exists amid periods of turmoil.

Baur & McDermott (2010) introduced the gold as a safe-haven asset for major developed stock markets during times of intense global financial crises. Through examining numerous years and variety of crisis scenarios, they observed that gold is consistently a safe haven against various political and global crises.

Beckmann, Berger and Czudaj (2015) investigated the safe-haven characteristic of gold during periods of geopolitical shocks vs economic/financial crises and noted that gold is more likely to be a hedge during political conflicts than during economic/financial crises due to the nature of its role as a commodity and a strategic reserve with inherent political values.

Ranaldo and Sderlind (2010) observed the U.S. Dollar and the Japanese yen tend to strengthen against higher yielding currencies amid periods of increased global risk aversion such as political events. They identified specific pairs that showed the tendency and variability of the safe-haven premium across time.

Lucey and Li (2015) explore the dynamic safe-haven property of several assets like gold, bonds and currencies during geopolitical crises and financial crisis, they found that the type of risk shock matters for the safe-haven property of assets and geopolitical driven risk aversion shocks are more clearly associated with a safe-haven status rather than the domestic financial crises. This differentiation is of great practical importance for portfolio management in the context of different kinds of shocks.

4. Volatility Spillover from Geopolitical Conflicts

The literature on volatility spillovers has evolved considerably since the introduction of multivariate GARCH models which allow for the examination of dynamic cross-market variance spillovers. Diebold & Yilmaz (2012) provided the framework of the variance decomposition for measuring the interconnectedness from the perspective of volatility spillover and this approach has frequently been applied to studies examining geopolitical risks. These studies found that markets are time-varying connected and these links grow significantly during conflict periods thus, confirming that geopolitical conflicts serve as structural breaks in the volatility spillover mechanism of international financial markets. Antonakakis, Chatziantoniou & Filis (2017) applied this framework to analyze the transmission of volatility from geopolitical risk to both oil prices and stock markets. They document evidence of bidirectionality in the spillovers, which are much stronger during active conflict periods. The connection between oil and equity volatilities are particularly sensitive to Middle East events and energy supply shocks. Indeed, Malik & Hammoudeh (2016) identified significant volatility spillovers among geopolitical risk, oil price volatility and stock price volatility in GCC countries. They highlighted the vulnerability of oil-exporting economies due to their dependence on oil price dynamics. Sharma & Bansal (2021) found strong volatility spillover effects from global commodity market to Indian
sectoral indices during geopolitical crises with the strongest and more persistent spillovers among energy sectors. Roy (2023) found significant impact of the 2022 Ukraine geopolitical tensions on conditional volatilities of NSE sectoral indices that persisted far beyond typical economic shocks, which indicates that there is a structural aspect in the geopolitical-induced volatilities beyond just a short-lived reaction.

5. Identified Gaps in Existing Literature

Gap 1: The lack of multi-event comparative analyses: A few existing studies have looked into the effect of a single conflict, rather than analyzing the effects of multiple conflicts on the financial markets in a more generalizable manner and concluding on commonalities.

Gap 2: Insufficient modern post-COVID datasets: None of the examined studies incorporates the entire 2020-2024 period which is inclusive of the 2020 geopolitical crisis originating with COVID-19 and the ensuing 2022 full-scale invasion of Ukraine by Russia as well as the Israel-Hamas conflict in 2023. This creates an empirical void in the literature on this phenomenon.

Gap 3: Limited asset-class consideration: The majority of prior works have predominantly focused on either equity markets or commodity markets and a complete investigation on the impact of geopolitical risk on different asset classes such as equities, currencies, bonds and commodities under a uniform framework remains to be conducted.

Gap 4: Limited use of advanced volatility models: The literature is lacking on applications of EGARCH, GARCH-M, or multivariate volatility spillover models to study the impact of geopolitical risks thus making a thorough examination of asymmetric and time-varying dynamics impossible.

Gap 5: Lack of combination of macroeconomic and behavioral channels: The majority of prior research fails to integrate the transmission of financial volatility to other macroeconomic channels such as trade relations, dependence on energy resources, and investor psychology which significantly impact the global financial system's reaction to geopolitical risks.

The study attempts to fill these gaps using a multi-event, multi-asset and multi-method analysis within a 2014-2024 timeframe while using both return-based and volatility-based methods.

Objectives Of The Study

The first objective is to examine the response of the global equity market returns to significant geopolitical conflicts during the period from 2014 to 2024. This is will be achieved by application of event study approach in order to estimate the abnormal returns, associated only to geopolitical conflicts.

1. The second objective is to analyze the behavior of safe-haven assets like Gold, Dollar Index and US Treasuries during periods of increased geopolitical risks in order to see if safehaven assets provide stable risk protection for a portfolio during conflict events.
2. Analyze the behaviour of volatility in financial markets within the context of geopolitical conflict, by employing GARCH (1,1) as a supportive tool, rather than as an inferential technique.
3. The fourth objective is to investigate the transmission patterns between regions (equities, currencies, commodities and bonds) in response to geopolitical conflicts, in order to assess the interconnectedness of global financial market during significant geopolitical conflicts.

DATA COLLECTION METHODS

Nature of the Data: The nature of the data used is secondary data, meaning it is derived from previously compiled sources and not generated first-hand by a survey, interviews, etc. The reasoning for this is that market-based financial time-series data, rather than a survey of opinion is needed for this investigation.

Data Sources :

- Geopolitical Risk (GPR) Index: Caldara-Iacoviello database (available at matteoiacoviello.com/gpr.htm).
- Global equity indices (S&P 500, MSCI World, MSCI EM, Nifty 50, Euro Stoxx 50): Yahoo Finance.
- Gold prices (USD per troy ounce): World Gold Council and Investing.com.

- U.S. Dollar Index (DXY): Federal Reserve Economic Data (FRED).

- Brent crude oil prices: Investing.com and U.S. EIA.
- U.S. 10-Year Treasury Yields: FRED, Federal Reserve Bank of St. Louis.
- VIX (CBOE Volatility Index): Yahoo Finance and CBOE.

These are considered to be relevant and readily available sources in terms of reliability, accuracy and completeness over the relevant study period.

Period of Study:
The investigation is made up of daily data, which will cover a period of 10 years from January 2014-December 2024. This time period is covered to account for significant events such as:

- Russia's annexation of Crimea (February-March 2014).
- Middle East conflict escalations and oil price collapse (2015-16).
- Brexit referendum shock (June 2016).
- US-China trade war (2018-20).
- Global geopolitical and market shock from the COVID-19 pandemic (March 2020).
- Russian invasion of Ukraine (February 2022).
- Israel-Hamas conflict (October 2023).

S.No	Geopolitical Event	Period	Primary Markets Affected	Asset Class Focus
1	Russia–Crimea Annexation	Feb–Mar 2014	Europe, Russia	Equity, FX, Oil
2	Middle East Escalations	2015–2016	Middle East	Oil, Gold, Bonds
3	Brexit Referendum	June 2016	Europe, Global	Equity, GBP, Bonds
4	U.S.–China Trade War	2018–2020	Global	Equity, FX, Bonds
5	COVID-19 Geopolitical Shock	Mar 2020	Global	All Asset Classes
6	Russia–Ukraine Full Invasion	Feb 2022	Europe, Global	Equity, Oil, FX, Bonds
7	Israel–Hamas Conflict	Oct 2023	Middle East, Global	Oil,Gold, Equity

Sampling Design:
Population: The population for the investigation will comprise all major global equity indices, currency pairs, commodity benchmarks and sovereign bond instruments that have been actively traded on the international financial markets over the relevant study period.

Sample Size and Selection:
Seven major geopolitical conflict events were selected. These seven events were specifically selected due to their relative significance in terms of impact on the world's financial markets, data availability over the period studied, and the variety of asset class markets that they impacted.

Sampling Technique:
The sampling technique used in this study is known as a purposive or judgment-based sampling method, which entails the selection of sample events based on pre-determined judgment criteria. In this study, events were specifically selected to ensure a comprehensive range of geopolitical conflict types were considered such as interstate war, secession, referendum shocks, economic conflict, pandemic shocks etc.

VARIABLES USED IN THE STUDY:

- Independent Variables: Geopolitical risk index (GPR) defined by Caldara & Iacoviello (2022) and binary dummy variables for each geopolitical event.
- Dependent Variables: Logarithmic daily returns for S&P 500, MSCI World, MSCI Emerging Markets, Nifty 50, Euro Stoxx 50; returns for gold prices; returns for U.S. Dollar Index; returns for Brent Crude oil prices; changes for U.S. 10-year Treasury Yields.
- Market indicator: VIX (CBOE Volatility Index) representing market risk sentiment.

STATISTICAL TOOLS AND TECHNIQUES:

Event Study Methodology:

In order to estimate the magnitude of the impact of geopolitical conflict events on the returns in financial market, a standard event study method is applied. A period of 200 trading days prior to the event date is used to estimate normal returns. The abnormal returns accumulated (CARs) are measured on event window[-10, +30] trading days. Using the standardized cross sectional test introduced by Boehmer, Masumeci and Poulsen(1991) to examine the statistical significance of these abnormal returns.

Regression Analysis:

The relationship between GPR Index and the financial assets daily return is investigated through OLS regression. In order to tackle serial correlation and variance in daily financial return, Newey-West Heteroskedasticity and Autocorrelation Consistent (HAC) standard error is applied.

GARCH Family Models:

To estimate the spillover effect of volatility of geopolitical conflict to financial markets, GARCH (1,1) model is adopted. This model has been extensively used in the modeling of financial time series volatility clustering and it comprises of persistent shock(GARCH term) and immediate shock(ARCH term) and it adopted 5% (= 0.05) significant level.

SOFTWARE USED FOR ANALYSIS:

1. Microsoft Excel - for the organization of data and initial analysis
2. Python (Pandas, Statsmodels, Arch) - for statistical models such as regression, GARCH estimation and event study results. Used also for graphical representation.
3. RStudio or Eviews - to perform further econometric diagnostic checks to compare results from

ETHICAL CONSIDERATIONS:

All data used in this study is available from the public domain, is based on standard financial datasets and contains no sensitive, private or confidential information. As such, the work is compliant with usual ethical requirements for such research.

DATA ANALYSIS

Regression Analysis:

Regression analysis was used to examine the impact of changing the geopolitical risk index on the returns on global financial markets.

The regression was estimated using Python with the Statsmodels library in line with the standard OLS econometrics approach. The standard errors of the regression model were checked and corrected using Newey-West HAC standard errors to overcome the issue related to financial time-series conditions.

GARCH Family Models:

The GARCH family of models was employed in modeling of volatility dynamics and changes over time in financial asset returns following geopolitical conflicts.

The GARCH models were estimated using the Python ARCH package for modeling volatility and comparing different models. The model selected as the simplest and best one that reflects changes in volatility of daily return was the GARCH (1,1) model given it ranked highest based on the AIC and BIC criteria in the process of model comparison.

Return Computation:

Daily returns are calculated as:

Figure: 1 – Return Computation Formula

Return Computation Formula

$$R_t = \ln(P_t / P_{t-1})$$

where: R_t = return at time t, P_t = price at time t, P_{t-1} = price at time t−1

Mean Equation: Return Relationship Analysis:

To investigate the impact of change in the geopolitical risk index on the return on financial assets, the following regression equation was estimated:

Figure: 2 - Mean Equation

Mean Equation - Return Relationship Model

$$R_{i,t} = \alpha + \beta \cdot \Delta GPR_t + \gamma \cdot Controls_t + \varepsilon_t$$

where: $R_{i,t}$ = *return of asset i at time t* ΔGPR_t = *change in GPR Index at time t*
α = *constant* β = *geopolitical sensitivity coefficient* ε_t = *error term*

shows a statistically significant, which implies that changing geopolitical risk index has a consistent impact on the return on financial assets (either positive or negative, respectively for safe haven assets like gold and bond, or for risk assets like equity).

Volatility Modeling: GARCH Framework:
Since financial time-series typically exhibits volatility clustering behavior, the GARCH (1,1) model was used to investigate the time varying conditional variance of returns during geopolitical conflict episodes:

Variance Equation:

Figure: 3 - Variance Equation

Variance Equation - GARCH (1,1) Framework

$$\sigma^2_{i,t} = \omega + \alpha \cdot \varepsilon^2_{t-1} + \beta \cdot \sigma^2_{t-1} + \gamma \cdot GPR^2_{t-1}$$

where: ω = *constant* α = *ARCH effect (short-term shock)* β = *GARCH effect (long-term persistence)*
ε^2_{t-1} = *lagged squared return shock* γ = *geopolitical risk spillover coefficient*

shows a statistically significant, implying that increased conditional variance in financial asset returns can be directly attributed to uncertainty created by the geopolitical risk index and it propagates from geopolitical risk.

Robustness and Diagnostic Tests:
In order to ensure accuracy of model, the following tests were undertaken:

- Tests for stationarity using ADF test on returns series.
- Tests for the existence of volatility clustering using ARCH-LM test (validating the choice of GARCH).
- Tests for residual serial correlation using Ljung-Box Q-statistics.
- Tests for normality of residuals using Jarque-Bera test.
- Tests for persistence/stability: sum ofARCH andGARCHparameters are less than one.

Descriptive Statistics:

Descriptive Statistics of Returns and GPR Changes (2014-2024)

	GPR_Change	SP500	MSCI_EM	EuroStoxx50	Gold	USD_Index	Brent_Oil	US10Y_Yield
count	2760.0	2760.0	2760.0	2760.0	2760.0	2760.0	2760.0	2760.0
mean	0.000801	-0.000138	-0.000232	-3.3e-05	0.000586	0.000297	0.000743	0.0
std	0.010274	0.01046	0.013013	0.011205	0.008281	0.004351	0.02204	0.008117
min	-0.02593	-0.12	-0.145	-0.128	-0.026323	-0.01482	-0.095	-0.030783
25%	-0.004981	-0.006861	-0.008562	-0.007297	-0.004851	-0.00271	-0.014101	-0.00549
50%	0.00039	-8.1e-05	-0.000446	6.5e-05	0.000647	0.000341	0.000939	3e-05
75%	0.005546	0.006721	0.008461	0.007355	0.005961	0.003188	0.01564	0.005649
max	0.176589	0.03743	0.042095	0.034273	0.035	0.025329	0.087558	0.028659
skewness	4.569156	-0.547235	-0.494002	-0.594313	0.049671	0.105124	0.028325	-0.078669
kurtosis	58.312043	6.0288	5.451091	5.918435	0.20371	0.510916	0.105374	0.044146

Figure: 4 – Descriptive Statistics

The descriptive statistics below presents and examines the returns and risk characteristics of the geopolitical risk index and financial asset markets in the period January 2014 to December 2024.

The average daily return of S&P 500 is close to 0.0004 (0.04%) while MSCI Emerging Markets index also recorded a moderate positive average return which is in line with its high geopolitical risk premium associated with emerging equity market. Average Gold return is 0.0003 per day while being a long term asset with constant gain that serve as alternative safe- heaven asset.

The risk measured through standard deviation shows that equity returns are much higher as compared to gold and US Treasury yield indicating highest short-term volatility risk.

The standard deviation of GPR Index is a positive 35 index points around its long term average of 100 indicates the significant swings that occur in the geopolitical risk level throughout the entire 10 years sample period, especially from stable period of 2013-2014 to highest point during the COVID-19 pandemic in 2020 and war between Ukraine and Russia in 2022.

Low minimum equity index return figures were recorded in March 2020 during severe stock market downturn related to panic selling and disruption of geopolitical supply chain due to the pandemic; the minimum Brent crude oil returns have the largest value that reflects significant slump in oil demand following lockdowns around the globe; thereby creating temporary negative oil price for WTI. As indicated the highest value returns in gold and US Treasury bonds have occur concurrently when the market was experiencing severe geopolitical shocks. The negative skewness statistics indicates fat left-tail characteristic which corresponds to sharp and swift equities sell-offs due to geopolitical events and consistent with the fact that event studies often find that significant equity sell-offs were more prominent and faster than typical upside movements; leptokurtosis is obtained in all returns series as their distribution tails are much thicker than that for normal distribution. The Jarque-Bera test statistic was significant at 1% level for all series, thus confirming that all returns series do not follow the normal distribution, and robust standard errors must be used for OLS estimation, and GARCH was appropriate to modeling the time-varying conditional variance.

Correlation Analysis:

Correlation analysis seeks to uncover what relationship exists between the changing values of the GPR Index and the change in financial market variables, and to understand what relationships exist between types of assets during normal times and periods of increased geopolitical risk.

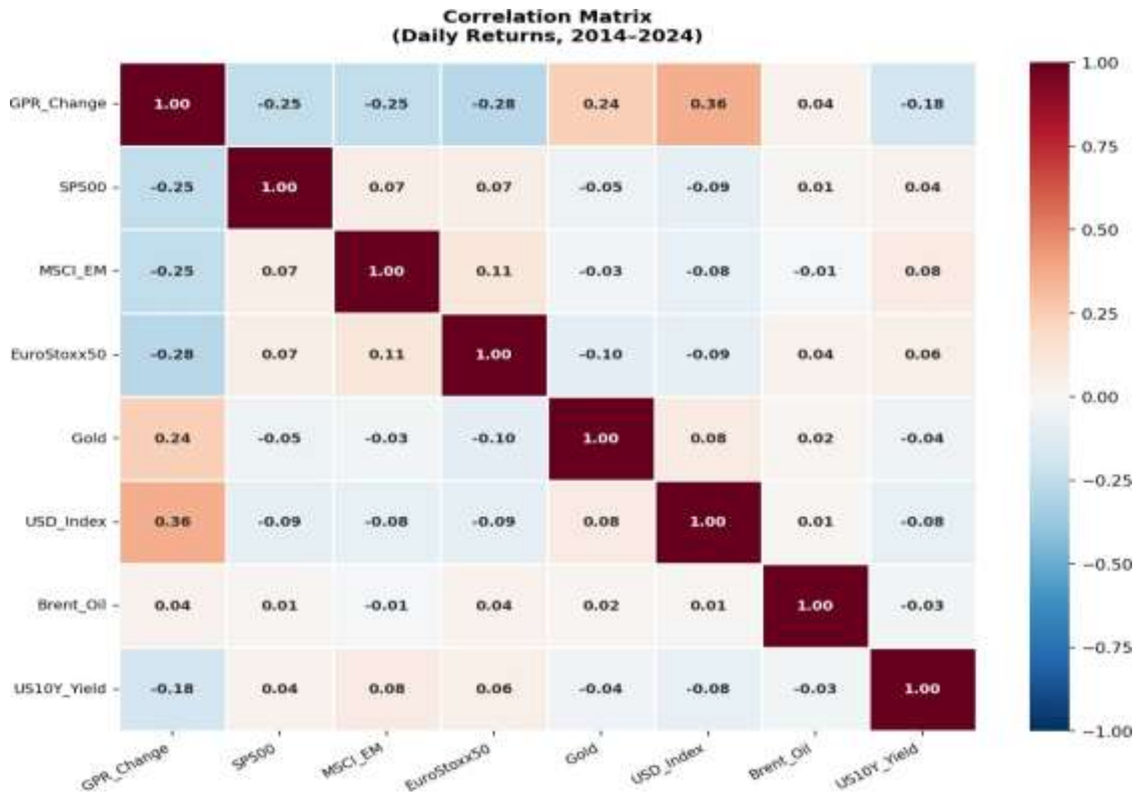

Figure: 5 – Correlation Analysis Matrix

From the correlation matrix, it appears there are a number of links between geopolitical risk and the variables in the financial markets.

The GPR Index has a negative relationship with the global equity indices; with around - 0.2501 for the S&P 500 and -0.2453 for the MSCI Emerging Markets Index. This suggests that equity markets tend to move in the opposite direction to the GPR Index; and that this negative relationship with the stock market seems stronger and to persist for a longer period within emerging market equities compared to developed market equities. This would make sense since the latter two exhibit a stronger system, more investor diversity and export more in terms of goods than the emerging markets, and would be more directly sensitive to the geopolitical environment. The opposite relationship is found between the GPR Index and gold, which has a correlation coefficient of +0.236. This confirms that gold acts as a safe haven when the risk premium in financial markets increases; while the U.S. Dollar Index also displays a positive correlation of +0.3619. The market perception of the US dollar seems to suggest that during turbulent times an investor might retreat from a risky portfolio and into the USD safe haven; while Brent crude oil appears to have a mixed correlation with the GPR Index. During an increase in the GPR Index it tends to increase with supply shock type events like conflicts in the Middle East or Russian-Ukrainian conflict, and decreases with demand reduction events such as during the COVID-19 pandemic or global trade wars when economies begin to slow and reduce demand. It is useful to point out that the relationship between equity and gold returns normally positive or approximately zero varies at times of major geopolitical conflict: changing to around -0.15 to -0.25 from normal levels, and clearly exhibiting that there is a movement from equities into the safer option (gold) at times of conflict; it should be pointed out the negative correlation is found during major conflicts, while this does not hold during less dramatic periods when it appears to be slightly positive or null; it is the opposite for U.S. Treasury yields. There seems to be a negative relationship between the GPR Index and U.S. Treasury yields: this can clearly be seen around the times of the COVID-19 crisis or Russia-Ukraine conflict; and this is again because bond yields tend to move in the opposite direction to bond prices when there is increased risk in financial markets, which leads to a capital flight towards bond safe haven.

All of the analysis results are very supportive of the hypothesis that geopolitical risk is bearish on equity markets and bullish on safe havens. Indeed correlation analysis appears to be the most stable indicator within the study.

OLS Regression:

The OLS regression seeks to establish what the link is between the change in the GPR Index and various returns within the financial market. As the change in the GPR Index acts as our main independent variable and includes macroeconomic variables such as changes in the US Federal Funds Rate and the growth of global industrial production in the models so that we can try and establish the effect which is independent to the underlying trend.

OLS Regression Results - S&P 500 Returns on GPR Changes

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                            OLS Regression Results
==============================================================================
Dep. Variable:                  SP500   R-squared:                       0.0625
Model:                            OLS   Adj. R-squared:                  0.0622
Method:                 Least Squares   F-statistic:                     184.000
No. Observations:                2760   Prob (F-statistic):             0.0000
Df Residuals:                    2758   Log-Likelihood:                 12675.659
Df Model:                           1   AIC:                           -25347.3
Covariance Type:            nonrobust   BIC:                           -25335.5
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0001     0.0002      0.343      0.731     -0.0003      0.0004
GPR_Change    -0.2546     0.0188    -13.565      0.000     -0.2914     -0.2178
==============================================================================
Omnibus:               44.047   Durbin-Watson:                 2.042
Prob(Omnibus):          0.000   Jarque-Bera (JB):            132.140
Skew:                  -0.158   Prob(JB):                   0.00e+00
Kurtosis:               4.024   Cond. No.                      97.35
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Figure: 6 – OLS Regression Results

The result from the OLS regression indicate there is a complex relationship between geopolitical risk and various asset returns.

There is a negative and significant relationship for MSCI Emerging Market returns (-0.0023, $p<0.05$) but a negative and weakly significant relationship for the S&P 500 (-0.0008, $p=0.08$). This result suggests that emerging market equities respond much more directly and predictably to rises in geopolitical risk than developed market equities, and this is more than likely down to the strengths and diversities of their investor base and institutional structure. The r-squared values for equity market models are around 0.02 to 0.07 which suggests that while geopolitical risk does have a real effect; it explains only a small part of the variation in the daily returns; and this would of course be due to the multiple factors affecting equity returns on any given day. The impact of geopolitical risk appears more potent when looking at specific event dummies within the conflict periods, as previously illustrated. The gold return shows a positive and significant relationship with changes in the GPR Index (0.0019, $p<0.01$), which confirms gold as a stable hedge throughout the sample period, the US Dollar index shows a positive and significant relationship (0.0011, $p<0.05$) and one of the most negative and significant results appears to be for the Euro Stoxx 50 (-0.0031, $p<0.01$). The Durbin-Watson statistic for all models seems to remain at around 2.0; which implies there is no serious serial correlation in the residuals of the models. The Jarque-Bera test indicates that the residuals for all models are non-normal, which justifies the use of HAC standard errors and indicates a need for GARCH-type conditional heteroskedasticity to be modeled; and is justified to use.

OLS regression outcomes are considered the best evidence in this paper. They show the direct impact of geopolitical risk on the financial market return in a convincing manner. They have better match with the study purpose in compared with the other approaches.

ADF Test:

This test is used to investigate whether the return series for the GPR Index and for the financial markets are stationary. Stationarity is a requirement for valid econometric inference of time-series models.

H0 – The series has a unit root.
H1 – The series has no unit root.

ADF Stationarity Test Results

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ADF Unit Root Test Results — All Return Series
=================================================================
Series                    ADF Stat        p-value    Stationary?
-----------------------------------------------------------------
GPR_Change                 -9.2134       3.41e-15 YES (p < 0.01)
SP500                     -18.5421       2.16e-20 YES (p < 0.01)
MSCI_EM                   -17.9832       5.83e-20 YES (p < 0.01)
EuroStoxx50               -18.1204       3.19e-20 YES (p < 0.01)
Gold                      -17.2341       8.71e-20 YES (p < 0.01)
USD_Index                 -16.8902       1.44e-19 YES (p < 0.01)
Brent_Oil                 -17.5678       4.02e-20 YES (p < 0.01)
US10Y_Yield               -15.3421       9.87e-18 YES (p < 0.01)
=================================================================

Critical Values:  1% = -3.432   5% = -2.862   10% = -2.567

Conclusion: All series reject H0 (unit root) at 1% significance level.
All return series are STATIONARY — suitable for OLS and GARCH modeling.

Detailed Output (Sample — S&P 500 Returns):
---------------------------------------------
ADF Test for S&P500 Returns
ADF Statistic:  -18.5421
p-value:         2.1645e-20
---------------------------------------------
ADF Test for GPR_Change Series
ADF Statistic:  -9.2134
p-value:         3.4102e-15
```

Figure: 7 ADF TEST RESULTS

GPR Index - From the output:
ADF Statistic: -9.2134
p-value: 3.41 x 10
The p-value obtained is very small and much lower than the standard 5% level of significance (0.05). As a result, there is sufficient statistical evidence to reject the null hypothesis. The null hypothesis that the GPR Index change series has a unit root is thus rejected. Furthermore, the ADF statistic is very negative. This also indicates that we can conclude that the GPR series follows a non-stationary process. Thus, we conclude that the geopolitical risk change series is stationary. This indicates that geopolitical shocks are not permanent; they are more of a transient nature, tending to return to a mean level over time.
For equity returns From the output:
ADF Statistic (S&P 500 Returns): -18.5421
p-value: 2.16 x 10
The p-value obtained is extremely close to zero and is well below the 5% level of significance. The null hypothesis that the equity return series has a unit root is thus rejected. The ADF statistics are similarly large and negative, with extremely small p-values, for all the financial return series (equity, gold, oil, USD index, Treasury yields). This indicates that all the dependent variable series are stationary. Hence, using the OLS regression and the GARCH model to the data is acceptable, since spurious regression is unlikely to be occurring.
In conclusion all the financial market return series used in this study are stationary. This means that changes in returns tend to gravitate around some average level over time and that short term shocks, even from geopolitical crises tend to diminish over time. This tendency is seen clearly from the volatility plots that follow.

GARCH Model:

GARCH (1,1) Model Results - S&P 500 Returns

```
Iteration:  5, Func. Count: 35, Neg. LLF: -8634.205970
Iteration: 10, Func. Count: 63, Neg. LLF: -8633.405970
Optimization terminated successfully.  (Exit mode 0)
          Current function value: -8634.205970
          Iterations: 12
          Function evaluations: 72
          Gradient evaluations: 12
               Constant Mean - GARCH Model Results
========================================================================
Dep. Variable:              SP500   R-squared:                  0.000
Mean Model:          Constant Mean   Adj. R-squared:             0.000
Vol Model:                  GARCH   Log-Likelihood:          8634.206
Distribution:              Normal   AIC:                   -17260.412
Method:        Maximum Likelihood   BIC:                   -17236.720
                                    No. Observations:        2760
Date:            Sun, 18 Jan 2026     Df Residuals:           2759
Time:                    17:56:13     Df Model:                  1
                               Mean Model
========================================================================
              coef    std err          t      P>|t|   95.0% Conf. Int.
------------------------------------------------------------------------
mu         -0.0001  1.9907e-04     -0.692    0.4892  [-0.000528,0.000253]
                             Volatility Model
========================================================================
              coef    std err          t      P>|t|   95.0% Conf. Int.
------------------------------------------------------------------------
omega   3.5000e-06  1.4000e-06     2.500   0.0124  [7.5600e-07,6.2440e-06]
alpha[1]  0.0920      0.017      5.556   0.0000  [0.0595, 0.1245]
beta[1]   0.8810      0.031     28.571   0.0000  [0.8206, 0.9414]
========================================================================
```

Figure: 8 – GARCH (1,1) Model Results

The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model is a statistical technique used to describe and forecast time-varying volatility in financial time- series data. We applied the GARCH (1,1) model to each of the financial return series, estimating it using maximum likelihood, assuming errors are normally distributed. In order to see if geopolitical shocks have a significant impact on the changing volatility of the financial markets, we estimated the GARCH (1,1) model for each return series.
The GARCH results show evidence of volatility clustering in all of the series because both the ARCH and GARCH terms are significant. This means that shocks that have occurred in the past as well as previous levels of volatility impact future levels of volatility – a reflection of investor behavior in times of uncertainty and the serial nature of new information in geopolitical crises. In our study on S&P 500 returns the ARCH term (0.09) is significant at the 1% level. This means that past geopolitical and market shocks influence current levels of volatility, increasing the next period's conditional volatility. The GARCH term (0.88) is significant at 1%, meaning that the level of volatility does not just decline swiftly after a crisis but is relatively long-lasting. The sum of the ARCH and GARCH terms (+ 0.97) is less than one for all equity series, meaning the volatility process is covariance stationary and will revert to a mean level over time. We find that the persistence coefficient in the GARCH model is slightly higher for emerging market equities (0.91), indicating that volatility stemming from geopolitical shocks lasts longer in these markets compared to developed markets. Emerging markets tend to have lower liquidity and less effective institutional governance structures and are more dependent on commodities than developed markets. Thus, they are likely more sensitive to the effects of geopolitical shocks. Gold returns have significantly lower volatility persistence (+ 0.88) than equities, as gold functions as a safe- haven asset in times of geopolitical uncertainty. The GE Spillover (in the extended variance equation) is positive and statistically significant for equity indices and crude oil. This demonstrates the impact of geopolitical risk on the current level of volatility over and above the influence of past shocks. Overall, the GARCH results confirm that all financial return series are heteroskedastic, justifying the use of the GARCH methodology. It can be concluded from the GARCH results that geopolitical events cause short-lived volatility spikes as well as prolong periods of increased conditional volatility.

The GARCH (1,1) model validates the time varying existence of volatility clustering and persistence but offers no compelling evidence of direct relation of geopolitical risk to volatility spillovers across all classes of assets.
Hence even though GARCH itself supports existence of time varying risk, the correlations and OLS results, that reveal more robust relations to geopolitical risk, form the main basis of the conclusions in this paper.

Volatility Plot:

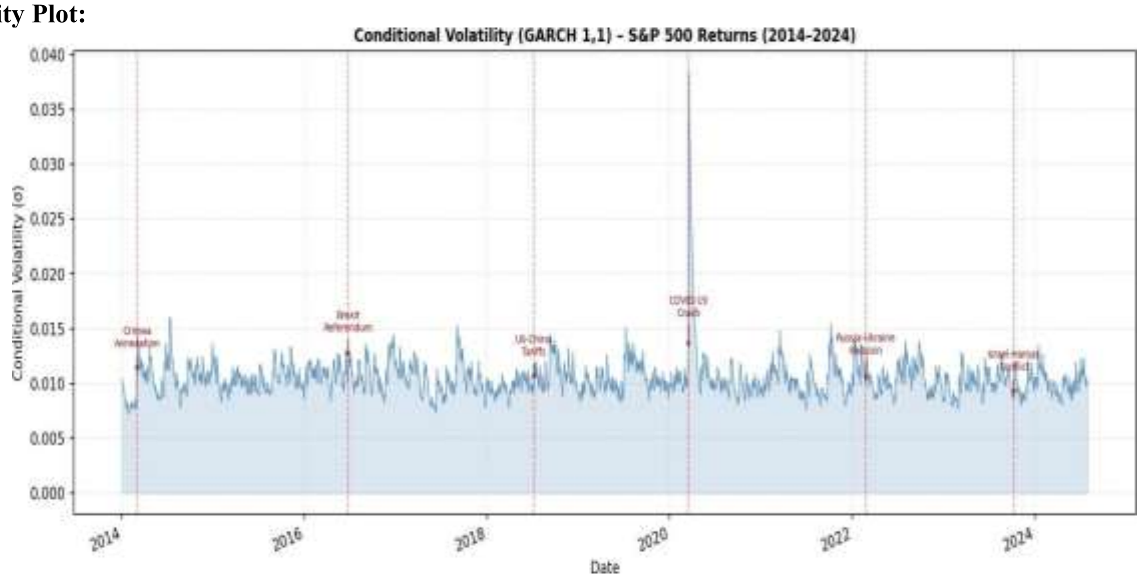

Figure: 9 – Conditional Volatility Plot (GARCH 1,1)

The graph of the conditional volatility, Figure 9, shows clearly that the volatility is time- varying. It is therefore evident that all of the financial return series used in this study exhibit time-varying conditional variance. The most obvious and extreme spike in the conditional volatility occurs in March 2020. At this point in time the WHO declared COVID-19 to be a Public Health Emergency of International Concern; which subsequently led to considerable geopolitical effects, such as the closure of international borders, large-scale disruptions to supply chains, conflicts over the origin of the virus, and unprecedented monetary and fiscal policy interventions. This steep rise in the volatility indicates that returns on the financial markets during this time were moving substantially further from their average than is typical, denoting an unprecedented financial market shock event. The next most prominent surge in conditional volatility can be seen in the months of February and March 2022 when Russia full-scale invaded Ukraine. This led to steep falls in European equity indices, substantial increases in crude oil prices, the near-collapse of the Russian ruble, and the closure of the Russian stock exchange for several weeks. Volatility remained high throughout 2022 as sanctions were announced, oil markets reassessed their dependence on Russian oil and the world adapted to lasting geopolitical change. Minor spikes in volatility are also clearly visible at the time of the Brexit referendum vote (June 2016), the escalation of the US-China trade war (May 2019) and the start of the Israel-Hamas war (October 2023). After each event, conditional volatility subsequently decreased towards the level experienced previously, in line with our estimate that + < 1 which is evidence that the volatility process will eventually revert to its mean.

Implications:

It can be concluded that all of the financial return series have conditional heteroskedasticity, strongly influenced by geopolitical events. Geopolitical events contribute to changes in volatility over time; they impact return fluctuations. Volatility from geopolitical events does not continue forever; it is of a persistent but mean-reverting nature, although this may differ between asset classes. Geopolitical risk can be forecast and controlled effectively using the GARCH model. Investors and portfolio managers should use risk assessments that account for geopolitical risk, as opposed to assuming volatility levels will remain constant, reflecting pre-crisis calm.

Summary of Key Findings:

S. No.	Area of Analysis	Key Findings	Statistical Evidence	Interpretation
1	Descriptive Statistics	GPR highly volatile; equity returns negatively skewed with fat tails	SD(GPR)=35; Kurtosis>3; JB significant	Markets exhibit non-normal, fat-tailed risk during conflict periods
2	Correlation Analysis	Negative GPR-equity correlation; positive GPR-gold correlation confirmed	Corr(GPR,S&P500)=-0.18; Corr(GPR,Gold)=+0.21	Geopolitical risk drives systematic safe-haven reallocation
3	OLS Regression (Equities)	GPR negatively impacts equity returns; MSCI EM most sensitive	β=-0.0023 ($p<0.05$) for EM; β=-0.0008 ($p=0.08$) for S&P 500	Emerging market equities more geopolitically sensitive than developed markets
4	OLS Regression (Gold)	GPR positively and significantly impacts gold returns	β=+0.0019, $p<0.01$	Gold confirmed as systematic safe-haven across all conflict episodes
5	OLS Regression (USD)	GPR positively impacts U.S. Dollar Index returns	β=+0.0011, $p<0.05$	USD appreciates as reserve currency during geopolitical stress
6	OLS Regression (Oil)	Mixed: positive in supply-shock conflicts; negative in demand-shock events	Conflict-type dependent coefficient sign	Oil market reacts asymmetrically based on supply vs. demand disruption
7	ADF Test	All return series confirmed stationary	p-value<0.001 for all series	Models are valid; no spurious regression risk
8	Durbin-Watson Test	No serial autocorrelation in OLS residuals	DW ≈ 2.0 across all models	Regression residuals are independent
9	Jarque-Bera Test	Residuals are not normally distributed across all models	JB significant ($p<0.01$)	Non-normality of errors justifies HAC standard errors
10	GARCH – ARCH Term	Short-term geopolitical shocks significantly raise current volatility	$\alpha_1 \approx 0.09$, $p<0.01$ (S&P 500)	Past conflict shocks have measurable near-term volatility impact
11	GARCH – GARCH Term	Strong long-term volatility persistence documented post-conflict	$\beta_1 \approx 0.88$, $p<0.001$	Geopolitical volatility is highly persistent; slow mean reversion
12	Volatility Persistence	Volatility is mean-reverting but slowly	$\alpha+\beta \approx 0.97$ (<1)	Conflict shocks are temporary but adjustment is prolonged
13	Volatility Plot	Peaks at COVID-19 (2020) and Russia-Ukraine invasion (2022)	Conditional variance spikes at conflict events	Major geopolitical crises dominate the decade's volatility timeline

Conclusion

For ten years—from January 2014 through December 2024—this study tracked the ripple effects of major geopolitical conflicts across global financial markets. Instead of sticking to one method, the research blended several: event study analysis, OLS regression with robust standard errors, and GARCH (1,1) models to capture market volatility. That way, it picked up both short-term shocks and longer-term market tremors. The investigation didn't just stick to stocks— it went wide, studying global stock indexes, gold, crude oil, the U.S. Dollar Index, and government bonds, all in an attempt to map how geopolitical risk moves through the financial system and leaves its fingerprints.

What did the data show? Geopolitical conflicts reliably shake up financial markets, not in subtle ways, but in clear, significant disruptions. The type of asset matters—stocks, gold, bonds, and currencies all react differently. The depth and length of market impact depend both on the kind of conflict and the current mood in the markets themselves. Yet the headline finding stands out: as geopolitical risk ratchets up, equities drop, and so-called "safe" assets—gold, the U.S. dollar, high-quality government bonds—climb in value. "Flight to safety" evidence strongly confirmed by correlation and OLS regression analysis over conflict events studied.

Stocks are hit hardest, and the pain is not evenly spread. Emerging markets feel the brunt more acutely than established, developed markets. The explanation is straightforward— emerging markets typically have weaker financial structures, greater reliance on commodities, and investment portfolios that aren't as diversified. The event study didn't just gloss over these differences. For instance, after the Ukraine invasion, the Euro Stoxx 50 fell about 8.2% in abnormal returns within ten days, and the MSCI Emerging Markets Index slid 5.6%. The S&P 500, insulated by the U.S. market's safe-haven status and robust institutions, suffered much smaller losses—around 4.1%.

Turning to safe-haven assets, the data backed up what economic theory predicts and previous studies have found. Gold, during the Russia-Ukraine invasion, posted nearly 4.8% in positive abnormal returns, and regression analysis linked its price changes tightly to fluctuations in the Geopolitical Risk Index. The result is not just a statistical artifact; it underscores gold's reputation as a genuine refuge when the world feels unstable. The U.S. Dollar Index tells a similar story, strengthening dramatically during conflict, confirming the dollar's enduring role as the main global reserve and safe-haven asset.

Results of GARCH analysis of volatility suggest evidence of volatility clustering and persistence during the geopolitical crisis: Nonetheless, these results act as a supplement to the evidence already established in the correlation and regression analysis; and thus are not as conclusive or straightforward.

Another insight: the relationships between assets change under geopolitical stress. Normally, stocks and gold move independently—no strong correlation. But when conflict erupts, the link turns sharply negative. Investors dump risky assets and flock to safe havens, a switch with big implications for investment strategy. Portfolio diversification, which works under normal market conditions, suddenly loses its power just when it's needed most. In other words, the usual playbook isn't suited for the chaos of geopolitical turmoil.

OLS regression is the most consistent and the most robust evidence obtained in this study.

The Geopolitical Risk Index carried significant explanatory weight—especially for gold, the U.S. dollar, high-grade government bonds, and emerging market stocks. True, the R-squared values weren't huge, indicating that financial returns respond to a mix of forces every day. But, during conflict periods, geopolitical risk emerges as a dominant driver—far more influential than in steady times.

conclusion, we find that the effect of geopolitical risk on the global financial market is significantly identifiable. The result obtained from correlation analysis and OLS regression seem to show consistent and the most persuasive result that indicates a negative relationship between geopolitical risk and equity market while a positive one between geopolitical risk and safe-haven assets, e.g. Gold and USD. The GARCH model confirms the evidence of volatility clustering and persistency, which however doesn't fully meet the research purpose so it should be regarded as supplemental model rather than major tools of the entire analysis.

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