

Geopolitical Risk and Sectoral Heterogeneity in the Brazilian Stock Exchange

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Abstract

This paper investigates the heterogeneous sensitivity of Brazilian sectoral stocks to global geopolitical shocks between 2012 and 2025. Using the GPR Threat and GPR Act indices, alongside NPDC and GIRF methodologies, the analysis focuses on the responses of the Consumption, Oil and Gas, Financial, and Non-Energy Commodity sectors. The results reveal that while geopolitical threats historically pressured returns, the post-COVID-19 period exhibits a positive cumulative impact on most sectors. These findings suggest that specific sectors in emerging markets, distant from conflict zones, can serve as strategic hedges.

Keywords: Geopolitical Risk; Brazilian Stock Exchange; GIRF and Connectedness.

JEL Codes: G11, G15, F30, C32

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1 Introduction

Since the COVID-19 pandemic, the globalized system that connects economies worldwide and promotes free-trade has been called into question. One of the major consequences is the increase in tensions and competition among states, elevating geopolitical risk.

The impacts of geopolitical risk on the economy were extensively studied by [Caldara and Iacoviello \(2022\)](#). The authors created three indices that measure the intensity of this type of danger, by collecting words associated with war, nuclear threats, peace treaties, revolutions, terrorist acts and others in eleven important newspapers for English speakers. With this measure, they showed for United States data, for the period 1985 to 2019, that elevated geopolitical risk is associated with the deterioration of real activity, diminished stock returns, and higher credit spreads.

Building upon an earlier working-paper version of this index, [Cheng and Chiu \(2018\)](#) studied geopolitical shocks in 38 emerging markets, with results that suggest an important role of those events on sectors of real economic activity, which makes it equally compelling to investigate the effects of this type of shock on the stock market, since [Berkman et al. \(2011\)](#) showed that geopolitical events have a significant impact on financial market returns and volatility.

The literature on this subject is vast, and has been increasing since Russia's invasion of Ukraine, especially in evaluating the heterogeneous effects associated with emerging markets that result from geopolitical shocks. [Umar et al. \(2022\)](#) showed that the intensity and direction of the GPR effect on asset returns essentially depends on the type of market and market conditions in developing countries, including the level of dependence on trade-related activities, and also whether the countries import or export oil and gas as evaluated by [Boubaker et al. \(2022\)](#).

Following this approach, [Zhang et al. \(2023\)](#) found that GPR has a greater impact on stock market volatility in emerging countries at peace, and [Yilmazkuday \(2024\)](#) showed that the impact of geopolitical risk on the economy and its corresponding financial market is directly associated with its proximity to the conflict.

However, it is important to note that the majority of these studies use the head-

line GPR index as a variable, not exploring the potential difference in asset and equity volatility and returns of the distinct nature of geopolitical risk, as captured by the disaggregated indices also constructed by [Caldara and Iacoviello \(2022\)](#), the GPR Threat and GPR Act. The use of these sub-indices was adopted only by [Ma et al. \(2022\)](#), [Ali et al. \(2023\)](#) and [Yilmazkuday \(2024\)](#), resulting in an additional dimension of heterogeneity in the impacts of this type of shock on the financial markets, namely, that the influence of GPR Threats is more substantial than associated with the GPR Acts. However these studies focus their models only on developed countries.

Since geopolitical shocks have heterogeneous effects for firms in emerging markets ([Pringpong et al., 2023](#)), it is expected that the returns on bonds and equities of companies listed in developing stock exchanges also present distinct gains.

Based on these premises, and contributing to the growing literature on geopolitical risk effects in emerging markets, this article evaluates separately the Net Pairwise Directional Connectedness as proposed by [Diebold and Yilmaz \(2014\)](#) between the GPR Act and GPR Threat and four indices of the Brazilian Stock Exchange that capture important sectors of the economy, namely oil and gas, non-energy commodities, financials, and cyclical consumption. The choice of this specific framework is justified by its ability to empirically disentangle the direction and scale of volatility transmission without the ordering bias of traditional recursive approaches. Consequently, this method allows us to precisely quantify the spillover effects, revealing the differing intensity of connectedness in Brazil's financial market when controlling for distinct types of geopolitical risk.

Furthermore, to evaluate the dynamic effects on asset pricing, this study utilizes the Generalized Impulse Response Function (GIRF) presented by [Pesaran and Shin \(1998\)](#) to measure the impact of both geopolitical indices on the returns of the selected sectoral equities. The primary justification for adopting this methodology relies on its capacity to accurately capture the sign and direction of the responses over time without suffering from ordering bias.

The results indicate that, on an average trading day in the post-COVID-19 period, a one-standard-deviation shock to either the GPR Act or Threat indices

generates a net positive effect on the returns of three of the four evaluated assets. Conversely, when isolating periods of acute crisis within this same timeframe, the model reveals that a one-standard-deviation increase in the GPR Threat index leads to a negative cumulative impact on the returns of all indices, except for the equity representing the oil sector. This behavior—where geopolitical threats exert a more harmful impact on equities than materialized acts—is consistent with the findings of [Ma et al. \(2022\)](#), [Ali et al. \(2023\)](#), and [Yilmazkuday \(2024\)](#).

The contributions of this paper are twofold: First, we present an analysis of the impacts of geopolitical shocks on sectors indices of the Brazilian Stock Exchange, unlike the majority of the studies that focus only on the broad market indices. Second, we present a new possibility of hedge strategy for portfolios that are concerned with geopolitical risks, showing that some countries sectors benefit upon the occurrence of the shocks, and not only precious metals, as shown by [Baur and Smales \(2020\)](#) and [Będowska-Sójka et al. \(2022\)](#).

The rest of the paper is organized as follows. Section 2 discusses the data used in this work. Section 3 presents the Net Pairwise Directional Connectedness model, and the Generalized Impulse Response Function. Our empirical results are provided in Section 4. The last section concludes.

2 The Data

To analyze the heterogeneous effects of geopolitical shocks on the returns of the Brazilian Stock Exchange, we use the GPR Threat and GPR Act indices created by [Caldara and Iacoviello \(2022\)](#), in addition to four sectoral indicators, all at a daily frequency starting from January 3, 2012, to December 30, 2025.

These indicators comprise the *IMAT*, *ICON*, and *IFNC* indices, as well as the *PETR4* equity. The *IMAT* aggregates the returns of non-energy commodity companies, such as VALE3 (mining), CSNA3 (steel industry), SUZB3 (pulp and paper), and BRKM5 (chemical industry). The *ICON* combines the returns of a variety of large Brazilian companies associated with cyclical consumption, such as ABEV3 (food and beverage), MGLU3 (retail), RENT3 (car rental), and RADL3 (pharmacy).

Meanwhile, the *IFNC* represents the returns of the country’s financial institutions, such as ITUB4 (commercial bank), BPAC11 (investment bank), and PSSA3 (insurance company). ¹

Due to the lack of such an index related to oil companies, and the huge importance of this sector in the Brazilian economy and stock market, the evaluation of this area’s reaction to geopolitical shocks will be analyzed by using *PETRA4*, the stock of the biggest national company that represents almost the entire market capitalization of this sector on the B3.

The control variables used in our model are the CBOE VIX, the BRL/USD exchange rate and the continuous front-month Brent crude oil futures prices. The inclusion of these variables is grounded in the empirical literature on geopolitical risk (Caldara and Iacoviello (2022); Zhang et al. (2023)). The VIX is included to isolate global financial market uncertainty, allowing the model to distinguish geopolitical shocks from general market panic. The BRL/USD exchange rate controls for domestic macroeconomic absorption. Finally, Brent crude oil prices control for energy supply shocks often associated with geopolitical crises.

Table 1: Descriptive statistics of the dataset variables

Asset Name	Symbol	Mean	St. Dev.	Skewness	First Quartile	Median	Third Quartile
Brent Crude Oil	BRENT	0.0003	0.0223	-0.44	-0.0095	0.0008	0.0109
Geopolitical Risk Act	GPR ACT	101.7616	62.9665	1.52	57.9363	90.7557	132.2790
Geopolitical Risk Threat	GPR THREAT	130.2965	69.8444	2.14	83.2281	117.9576	161.3339
Consumption Index	ICON	0.0002	0.0146	-1.18	-0.0072	0.0006	0.0081
Financial Index	IFNC	0.0005	0.0168	-0.32	-0.0089	0.0006	0.0098
Basic Materials Index	IMAT	0.0004	0.0172	-0.45	-0.0093	0.0003	0.0098
Petrobras PN	PETRA4	0.0001	0.0290	-0.99	-0.0132	0.0007	0.0143
Brazilian Real / US Dollar	BRL/USD	0.0003	0.0089	0.15	-0.0044	0.0002	0.0049
CBOE Volatility Index	VIX	17.6591	6.5328	2.90	13.4200	16.0500	20.0000

Table 1 above presents the descriptive statistics for our dataset. The difference in the standard deviation of *PETRA4* (0.0290) compared to *ICON* (0.0146), *IFNC* (0.0168), and *IMAT* (0.0172) is noteworthy. A possible explanation is that the stock of an oil and gas company responds to both domestic and international shocks, causing its volatility to be higher than that of equities more directly associated with the cyclical component of the Brazilian economy, such as *ICON* and *IFNC*.

¹The complete list of all assets comprising these indices is provided in the Appendix.

From the same table, the positive skewness (right-skewed) of GPR Threat, GPR Act, and the VIX (2.14, 1.52, and 2.90, respectively) is also worth highlighting. This indicates that global uncertainty and geopolitical tensions are not normally distributed, rather, they are characterized by sudden, extreme upward spikes.

The set of financial variables were all used in log first differences, and the GPR indices as well as the CBOE VIX in levels. ²

Table 2: Correlation matrix of the model variables

	BRENT	GPR ACT	GPR THREAT	ICON	IFNC	IMAT	PETRA4	BRL/USD	VIX
BRENT	1.000	-	-	-	-	-	-	-	-
GPR ACT	-0.025	1.000	-	-	-	-	-	-	-
GPR THREAT	-0.009	0.375	1.000	-	-	-	-	-	-
ICON	0.165	0.009	0.011	1.000	-	-	-	-	-
IFNC	0.172	0.018	0.017	0.758	1.000	-	-	-	-
IMAT	0.278	-0.014	-0.007	0.498	0.491	1.000	-	-	-
PETRA4	0.375	-0.001	-0.005	0.481	0.594	0.460	1.000	-	-
BRL/USD	-0.167	-0.008	-0.015	-0.317	-0.370	-0.121	-0.267	1.000	-
VIX	-0.077	-0.048	0.101	-0.108	-0.092	-0.090	-0.089	0.085	1.000

Table 2 presents the unconditional correlation matrix. The domestic sectoral indices (ICON, IFNC, IMAT) and PETRA4 exhibit positive correlations among themselves, reflecting systematic market risk. Conversely, the static correlations between the geopolitical risk indices and the Brazilian equity sectors are virtually zero. This lack of linear dependence highlights that geopolitical shocks are episodic and non-linear. Consequently, it justifies the need for dynamic, time-varying frameworks to capture sudden volatility spillovers during specific crisis windows.

3 The Methodology

3.1 Empirical and Model Specification

To investigate the transmission of geopolitical shocks to the Brazilian stock market, we utilize a Vector Autoregression (VAR) framework. The model can be written as:

²All series used in this paper are stationary, based on the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. These unit root tests were performed in the R programming environment using the `adf.test` and `pp.test` functions. The complete test results are available upon request.

$$x_t = \sum_{i=1}^p \Phi_i x_{t-i} + \epsilon_t \quad (1)$$

where x_t is an $N \times 1$ vector of endogenous variables, Φ_i are $N \times N$ coefficient matrices, and ϵ_t is a vector of correlated error terms with a variance-covariance matrix. Assuming covariance-stationarity, we can rewrite the system as an infinite moving average (MA) representation:

$$x_t = \sum_{i=0}^{\infty} A_i \epsilon_{t-i} \quad (2)$$

The model is estimated with one lag ($p = 1$) and a forecast horizon of 10 days ($H = 10$). Since the nature of geopolitical threats and acts involves rapid and unusual events, we utilize a rolling estimation window of 100 days.

3.2 Generalized Impulse Response Functions

To evaluate the dynamic impact of geopolitical shocks on asset returns without an ordering bias, we use the generalized impulse response approach as proposed by [Pesaran and Shin \(1998\)](#). The scaled generalized impulse response function (GIRF) of a shock to the j -th equation at time t , on the predicted values of the system at horizon H is defined as:

$$\psi_j^g(H) = \sigma_{jj}^{-\frac{1}{2}} A_h \Sigma e_j, \quad n = 0, 1, 2, \dots \quad (3)$$

where σ_{jj} represents the j -th diagonal component of the variance-covariance matrix Σ , and the e_j denotes a selection vector with unity as its j -th element and zeros elsewhere.. This approach allows us to monitor the sign, magnitude and direction of the returns of Brazilian sector indices to geopolitical innovations.

3.3 Variance Decomposition and Network Connectedness

We also examine the network topology of the system to calculate volatility connectedness, through generalized forecast error variance decomposition (GFEVD) introduced by [Diebold and Yilmaz \(2014\)](#). The fraction of the H -step-ahead forecast error variance of variable i in response to shocks in variable j is given by:

$$d_{ij}^g(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} e_i' A_h \Sigma A_h' e_i} \quad (4)$$

Since the shocks are not strictly orthogonal in the generalized framework, the sum of the contributions to the variance of the forecast error does not necessarily equal one. Therefore, we normalize the entries by the row sum:

$$\tilde{d}_{ij}^g(H) = \frac{d_{ij}^g(H)}{\sum_{j=1}^N d_{ij}^g(H)} \quad (5)$$

The result is that this matrix permits us to conceptualize the system as a weighted, directed network. To calculate the transmission of shocks between two variables, we measure the Net Pairwise Directional Connectedness (NPDC):

$$NPDC_{ij} = \tilde{d}_{ji}^g(H) - \tilde{d}_{ij}^g(H) \quad (6)$$

With this result, we can dynamically identify whether a sector acts as a net receiver of geopolitical shocks, assessing the potential of equities as geopolitical hedges.

4 Empirical Results

4.1 Volatility Spillovers and Connectedness

Figures 1 to 8 show the Net Pairwise Directional Connectedness between the GPR Threat and GPR Act and the Brazilian Stock Exchange indices. The gray columns represent the time interval of 22 important geopolitical shocks that have occurred since 2012.

As we can see, there are several moments when the unusual volatility in the forecast error of the *ICON*, *IMAT*, *IFNC* and *PETR4* is associated with the movements of the GPR indices. It is important to note that the NPDC does not spike during all episodes of geopolitical shocks, indicating that those assets can preserve their fundamentals even during some international crises, which correspond to a good property for a hedge strategy.

If we analyze by event, there is a significant heterogeneity in the asset reactions to the GPR indices. Only the beginning of the pandemic caused a considerable and direct variance in the forecast error in all graphs, followed by the assassination of the Iranian Major-General Qasem Soleimani in 2020 (6 occurrences), and the announcement of North Korean nuclear weapons, the Russian invasion of Ukraine, and finally the military tension involving Iran and Israel in October 2024 (all with 4 occurrences).

Nonetheless, there is a huge difference of interpretation when the spike observed associated with an event finds itself in a negative territory. In that case, based on the framework of the Generalized Forecast Error Variance Decomposition, the incursion of the NPDC into negative values associated with a specific geopolitical shock means that the asset did not exhibit a significant volatility during the period of extreme movements in the GPR indices, as we see with *PETR4* during the assassination of the Iranian General Soleimani, displaying good hedge characteristics.

Finally, we can observe that GPR Threats induce a more intense variance of the forecast error on *PETR4* than the GPR Act, in line with [Ma et al. \(2022\)](#), [Ali et al. \(2023\)](#) and [Yilmazkuday \(2024\)](#). Those authors argue that the negative impacts on the economy in response to uncertainty as observed by [Bloom \(2009\)](#)

can be extended to the type of unpredictability associated with geopolitical risk, specifically the threat category, since during an increase in intimidation between countries and other global actors, investors and households become substantially intimidated with the future, preferring to relocate some parts of their portfolio, toward safer assets (Salisu et al., 2022) resulting in an increase of volatility in stock exchanges, causing a larger forecast error variance in the model.

On the other hand, Caldara and Iacoviello (2022) have shown that the realization of adverse events (associated with the GPR Act index), such as a terrorist attack, the beginning of a war or a regime change, leads to a resolution of uncertainty, causing a smaller impact on the economy and on the stock market, as seen in the *PETR4* graphs.

4.2 Dynamic Responses to Geopolitical Shocks

After analyzing the connectedness between the GPR indices and the Brazilian assets, we apply the Generalized Impulse Response Function to evaluate how an innovation of one standard deviation in the geopolitical indices affects the returns of the sectoral equities in the next ten days after the shock. To analyze the balance of this response, to understand if the variable displays a positive or a negative cumulative impact, we integrate the curves associated with our plots.

These eight figures are presented in the appendices of this paper. They follow the same structure of the plots of the previous section, relating each Brazilian stock exchange index to either GPR Act or GPR Threat.

As reported in Table 3, the *IMAT* did not present good hedge qualities, since the average cumulative response associated with it, in both periods studied in this paper, is negative. Considering that the index was log-differenced, a one-standard-deviation shock to the GPR Threat on a normal trading day before the Covid-19 crisis implies a -0.045% impact on the return of this index, a substantial value. A hypothetical explanation is that the companies grouped in the index are sensitive mainly to China's economic activity. Since China is the second-largest economy in the world, the rising geopolitical risk results in a slowdown in the Asian country, and could diminish the demand for Brazilian non-energy commodities, mainly used

Table 3: Normalized Net Impact of Geopolitical Shocks on Sectoral Returns (Pre and Post Covid-19)

Sector	Shock	Crisis Days	Calm Days	Hedge Days (%)	Average Impact		
					Total	Crisis	Calm
Panel A: Pre-Covid Period (2012 – Feb/2020)							
ICON	Act	99	1816	67.68%	0.071%	-0.001%	0.075%
ICON	Threat	99	1816	53.37%	-0.005%	-0.032%	-0.003%
IFNC	Act	99	1816	60.78%	0.053%	0.034%	0.054%
IFNC	Threat	99	1816	44.70%	-0.015%	-0.059%	-0.012%
IMAT	Act	99	1816	51.44%	-0.017%	-0.062%	-0.015%
IMAT	Threat	99	1816	41.31%	-0.045%	-0.060%	-0.045%
PETR4	Act	99	1816	54.93%	0.047%	0.038%	0.047%
PETR4	Threat	99	1816	44.07%	-0.091%	-0.272%	-0.081%
Panel B: Post-Covid Period (Mar/2020 – 2025)							
ICON	Act	121	1334	56.77%	0.060%	0.199%	0.047%
ICON	Threat	121	1334	52.71%	0.048%	-0.040%	0.056%
IFNC	Act	121	1334	59.59%	0.061%	0.101%	0.057%
IFNC	Threat	121	1334	47.01%	0.058%	-0.096%	0.072%
IMAT	Act	121	1334	38.76%	-0.013%	0.126%	-0.025%
IMAT	Threat	121	1334	40.07%	-0.040%	-0.036%	-0.040%
PETR4	Act	121	1334	54.30%	0.045%	0.109%	0.040%
PETR4	Threat	121	1334	47.15%	0.031%	0.098%	0.025%

in the construction sector.

Similar to the results of [Ma et al. \(2022\)](#), [Ali et al. \(2023\)](#) and [Yilmazkuday \(2024\)](#), it is observable from Panel A of Table 3 that the impact of a rising uncertainty from a global perspective, captured by the GPR Threat index, is associated with a negative impact on the returns of all indices before the Covid-19 crisis. On the other hand, during the same period, with the exception of *IMAT*, all the assets showed a positive reaction associated with a one-standard-deviation shock in the GPR Act, aligning with the argument of uncertainty resolution, as presented by [Caldara and Iacoviello \(2022\)](#).

It is curious to note that for the period after the Covid-19 crisis (Table 3, Panel B), the *ICON*, *IFNC* and *PETR4* have all presented positive responses associated with the volatility of both geopolitical indices. In general, we conjecture that after February 2020, the developed economies that were characterized by stability and predictability, started to deal with some aspects that were restricted to underdeveloped economies, like wars on their own continent (Europe), the resurgence of

commercial protectionism and the rise of populist parties and policymakers. Therefore, the risk perception of investors could have changed, benefiting some emerging markets, especially those with significant distance from the conflicts (Yilmazkuday, 2024).

When evaluating the assets, the positive impact associated with *ICON* in response to one standard deviation in the GPR indices, could be explained by the minor impact of geopolitical shocks on the consumption of durable goods in Brazil (Barros Jr et al., 2023), since a substantial portion of the companies included in this index are producers and retailers of this type of product.

Turning to *PETR4*, the positive response documented in Table 3 could be associated with the fear of shortages linked to supply shocks following the occurrence of geopolitical tensions, especially those that occur in the Middle East and Russia. Considering the increase in oil production after the discovery of the pre-salt layer, and the protected position of the oil fields in Brazil, it is feasible to imagine that *Petrobras* could elevate its share in response to an energy supply shock, positively impacting the returns of *PETR4*.

5 Conclusions

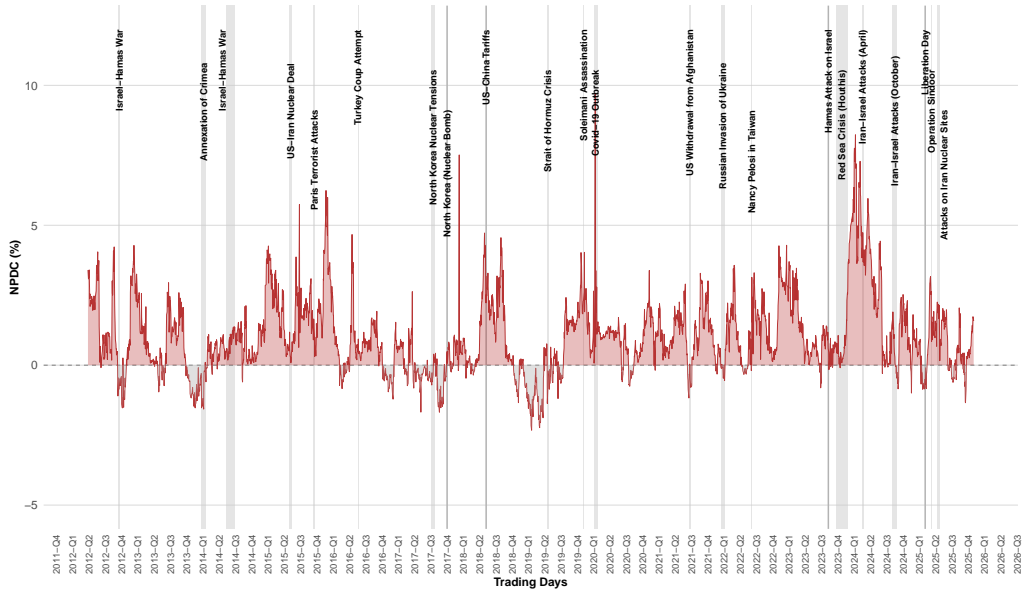
In this paper, we evaluate the sensitivity of four Brazilian assets, which represent and aggregate different sectors of the economy, to variations in geopolitical risks and shocks, measured by Caldara and Iacoviello (2022) GPR Threat and GPR Act indices. As observed, by using the Net Pairwise Directional Connectedness, those assets showed sensitivity to geopolitical shocks, presenting in some cases an increase of 5% in their forecast error variance in a day or period of variation on the GPRs.

After analyzing the impacts of geopolitical tensions on some sectors of the Brazilian Stock Exchange, we apply the Generalized Impulse Response Function to measure the dynamic responses of those assets against fluctuations in GPR Threat and GPR Act. The results showed that, especially after the Covid-19 pandemic, the *ICON*, *IFNC* and *PETR4* exhibit a positive cumulative impact on an average market day in response to a shock of one standard deviation in the geopolitical indices.

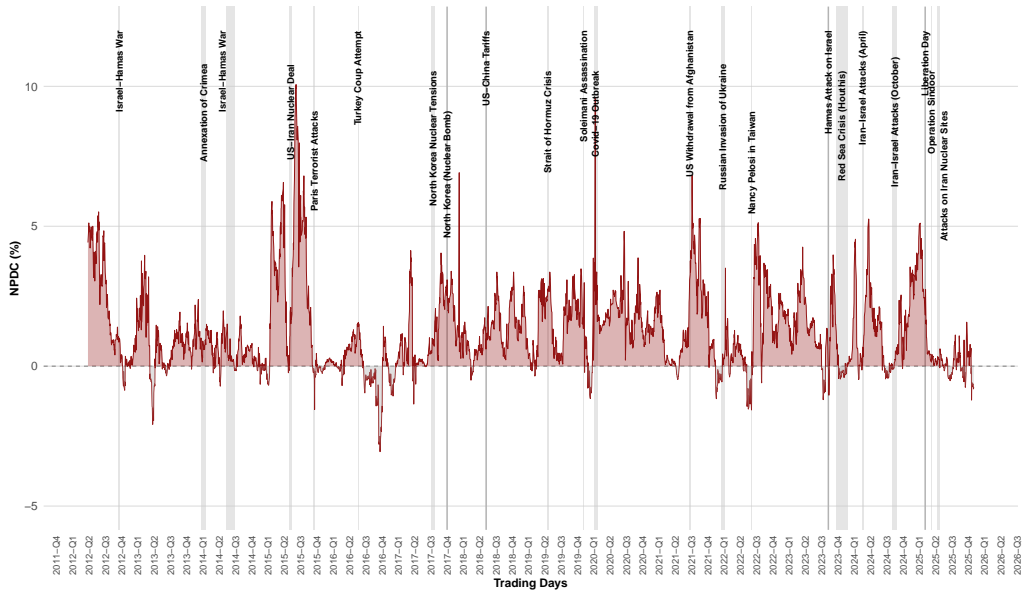
These findings contribute to the range of studies on the financial impacts of geopolitics in emerging markets, and the research on hedge strategies in response to international, political and military crises. Unlike the majority of those investigations, which focus mainly on precious metals (([Baur and Smales, 2020](#)) and [Będowska-Sójka et al. \(2022\)](#)), we showed that sectors of an emerging market, with significant distances from the conflicts, can add value to portfolios that seek for protection from geopolitical shocks.

Finally, the methodology of evaluating the connectedness and dynamic responses of sectoral assets, unlike the majority of other studies that use as endogenous variables the aggregate stock exchange indices, opens new possibilities for future research that seek to understand the heterogeneous impacts of geopolitical risks and shocks on financial markets in emerging countries.

6 Appendix

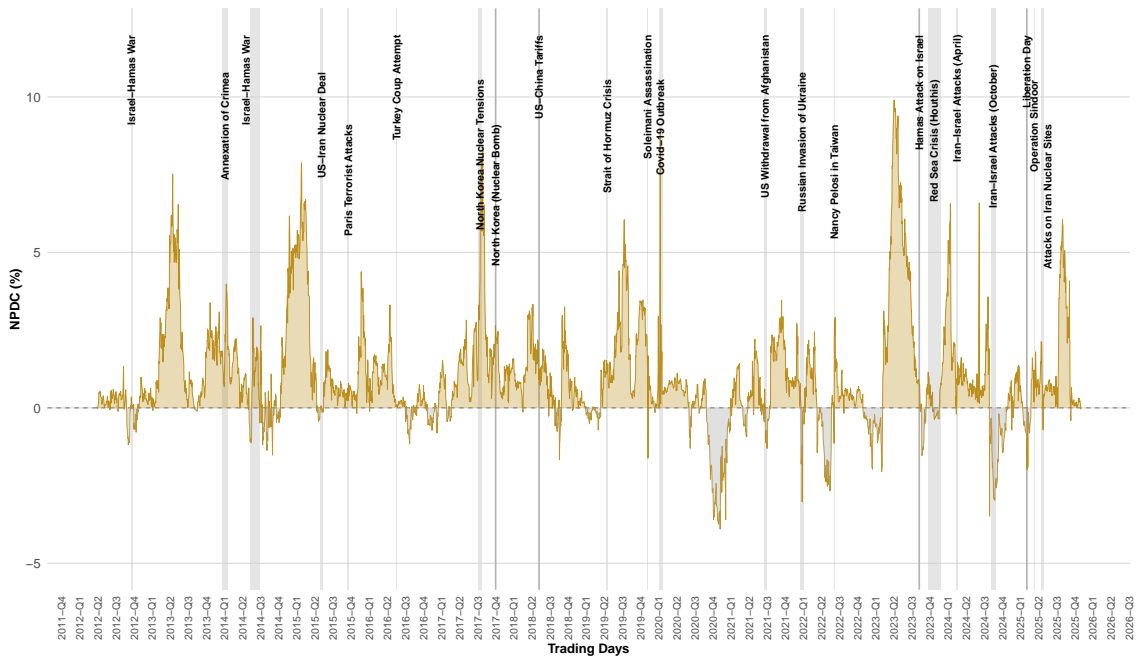


(a) GPR Threats → ICON

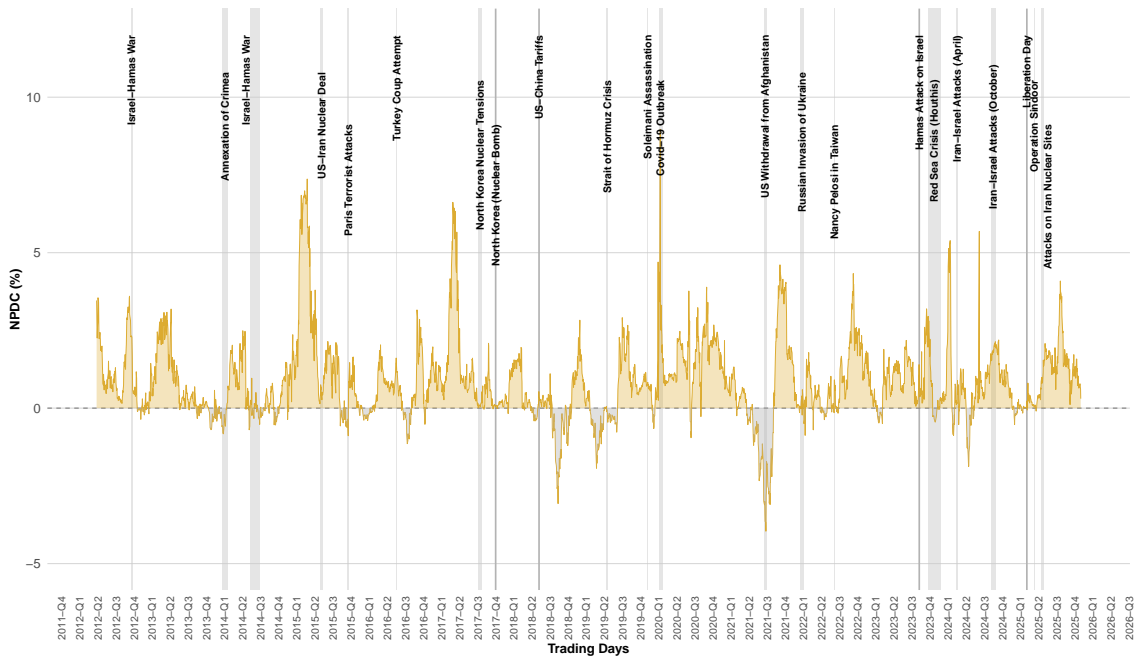


(b) GPR Acts → ICON

Figure 1: Net Pairwise Directional Connectedness (NPDC) between Geopolitical Risk indices and the Consumption Sector (ICON). The shaded regions represent major geopolitical events.

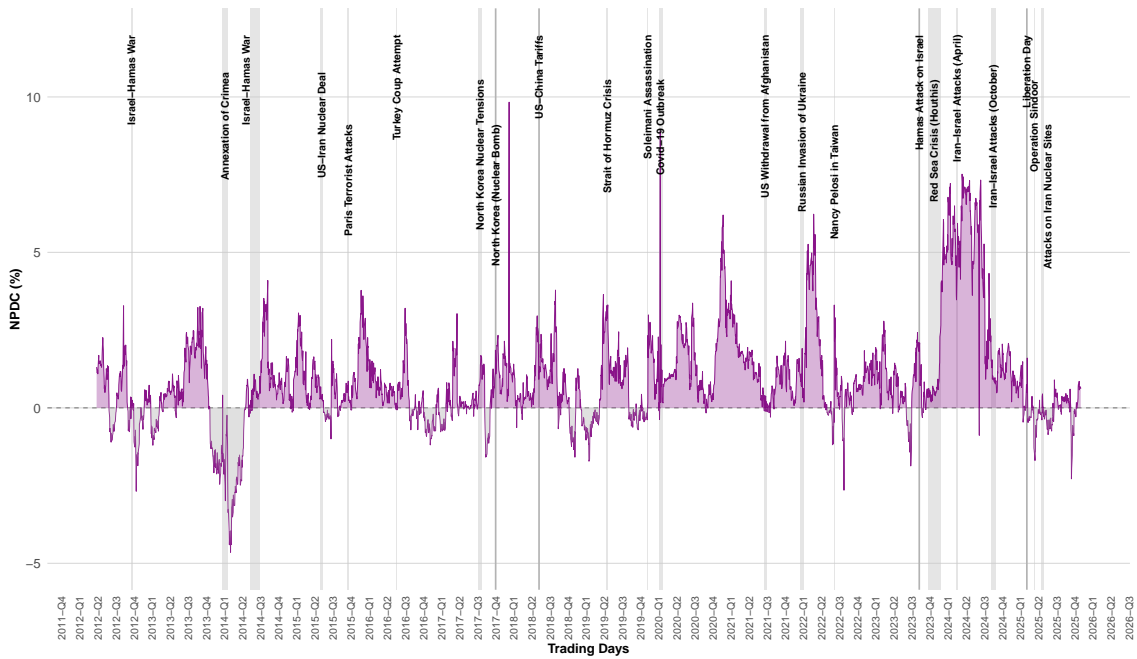


(a) GPR Threats → IMAT

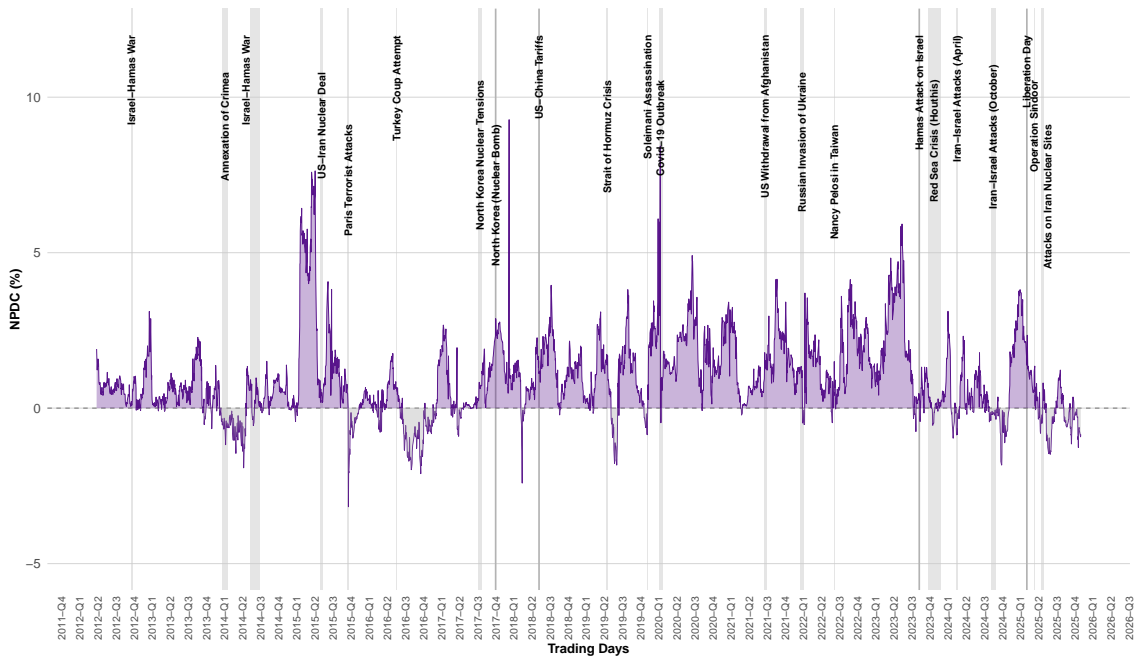


(b) GPR Acts → IMAT

Figure 2: NPDC between Geopolitical Risk indices and the Basic Materials Sector (IMAT), evaluating the transmission of uncertainty to commodity demand.

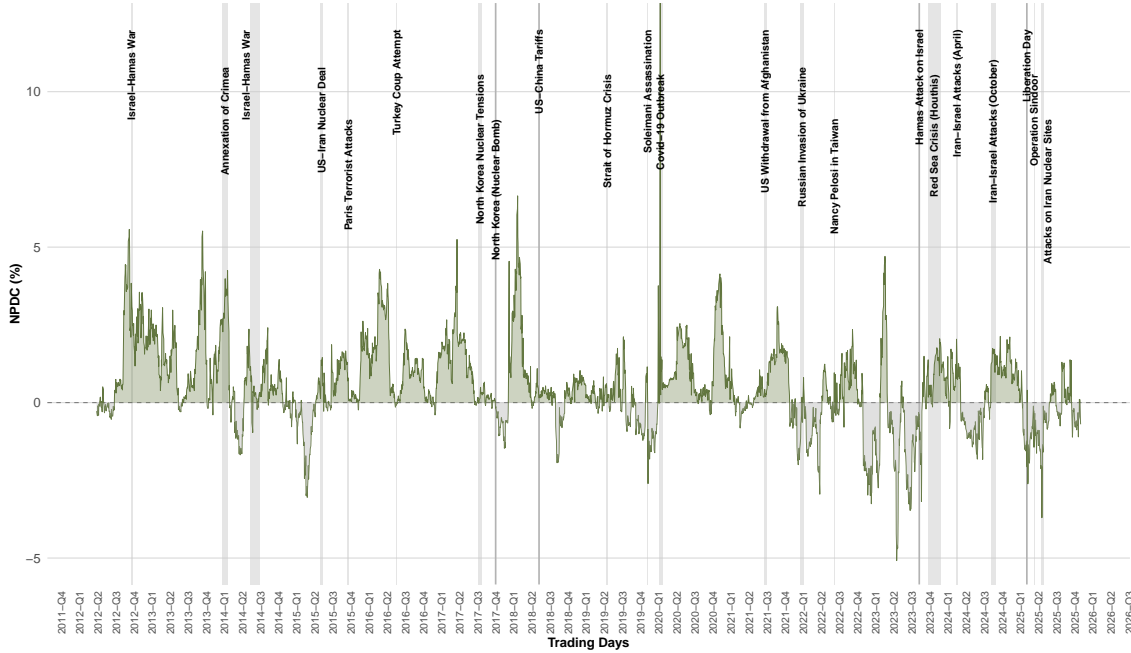


(a) GPR Threats \rightarrow IFNC

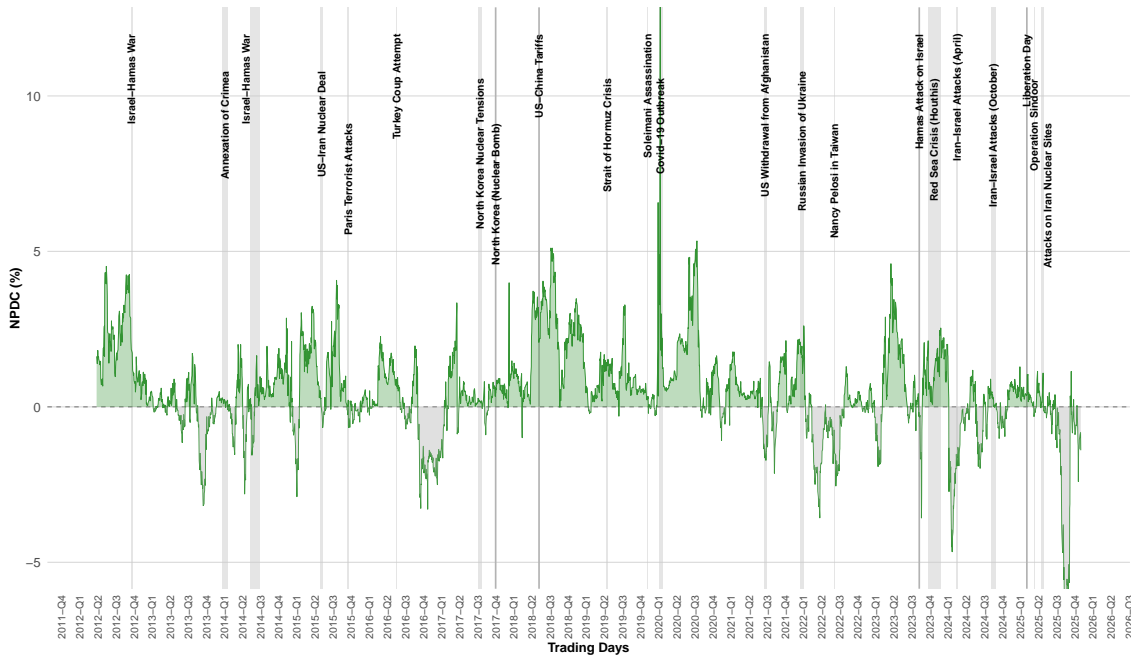


(b) GPR Acts \rightarrow IFNC

Figure 3: NPDC between Geopolitical Risk indices and the Financial Sector (IFNC), highlighting periods of credit contagion and capital flight.

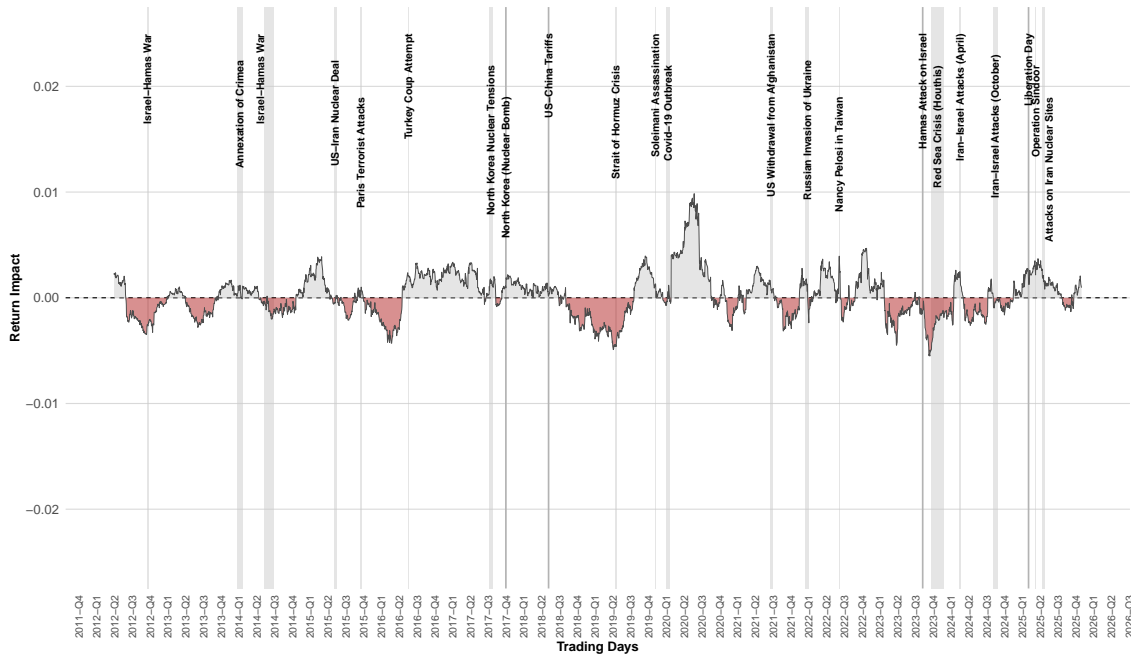


(a) GPR Threats \rightarrow PETR4

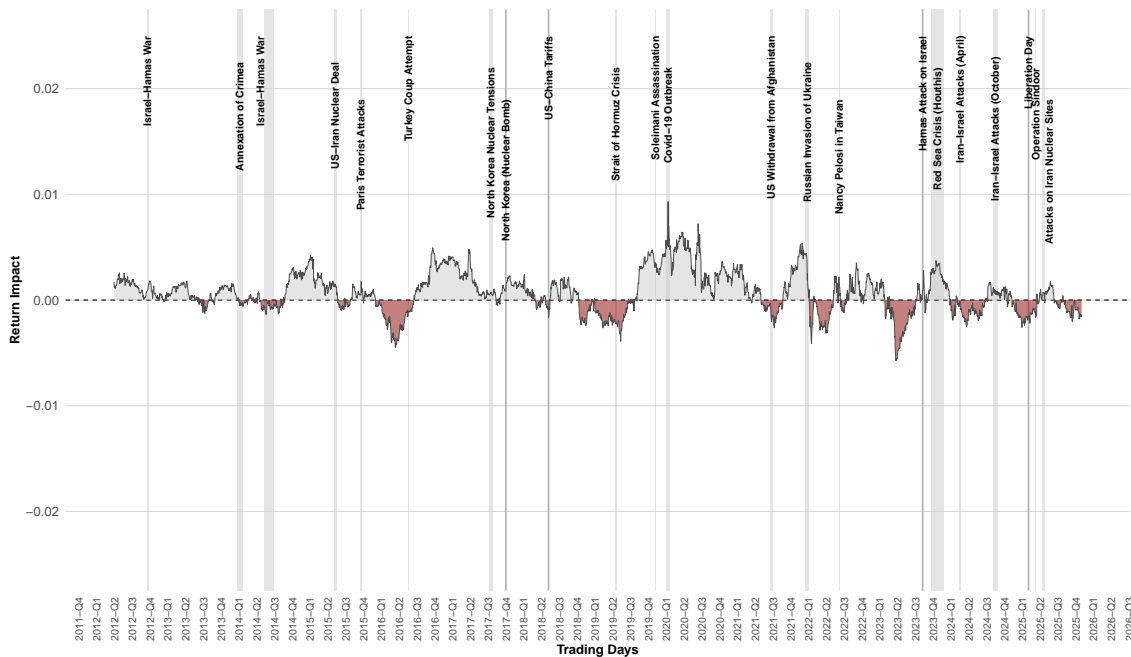


(b) GPR Acts \rightarrow PETR4

Figure 4: NPDC between Geopolitical Risk indices and Petrobras (PETR4). The connection illustrates the potential of the asset as an energy shield during geopolitical crises.

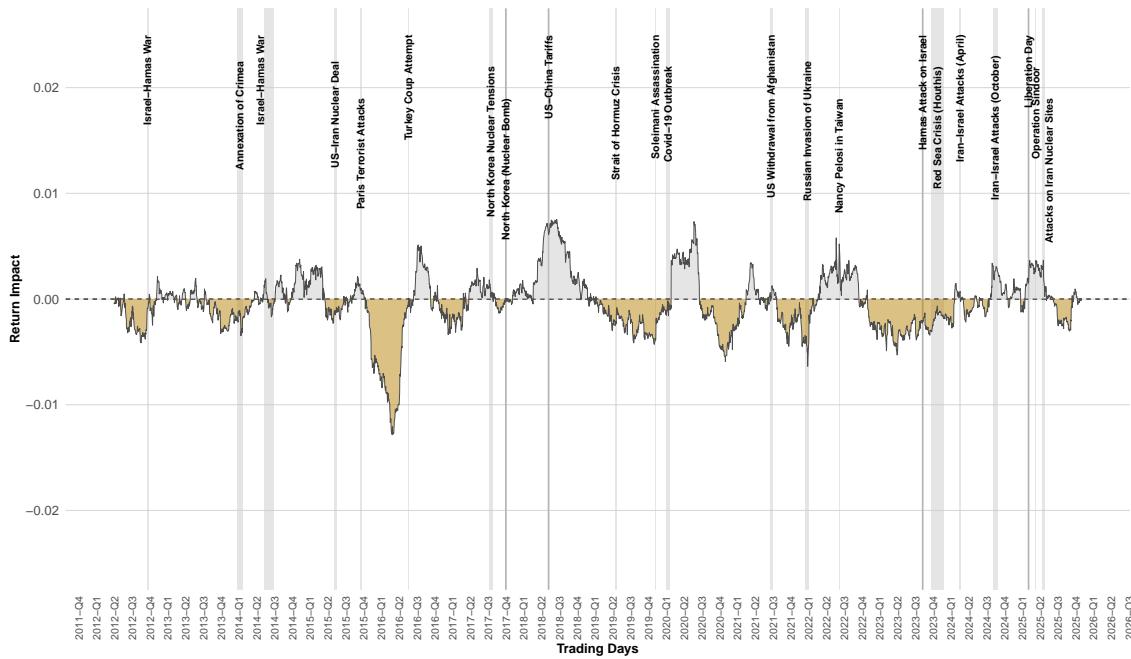


(a) GPR Threats vs ICON

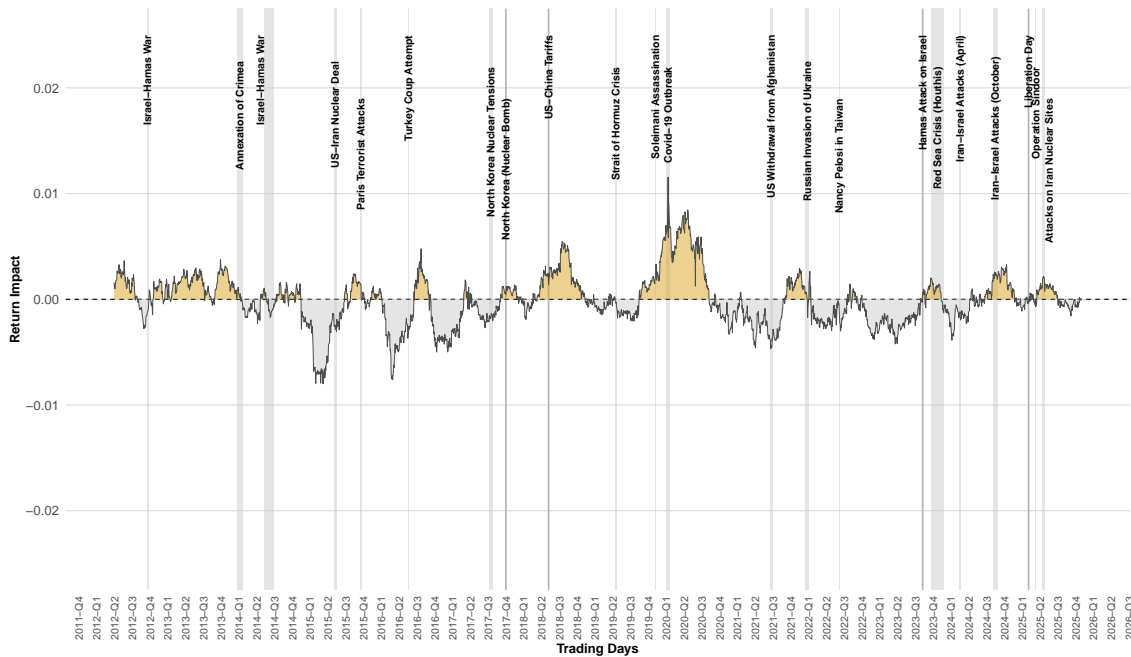


(b) GPR Acts vs ICON

Figure 5: Rolling Generalized Impulse Response Function (GIRF) evaluating the return impact of a one-standard-deviation shock in Geopolitical Risks on the ICON index.

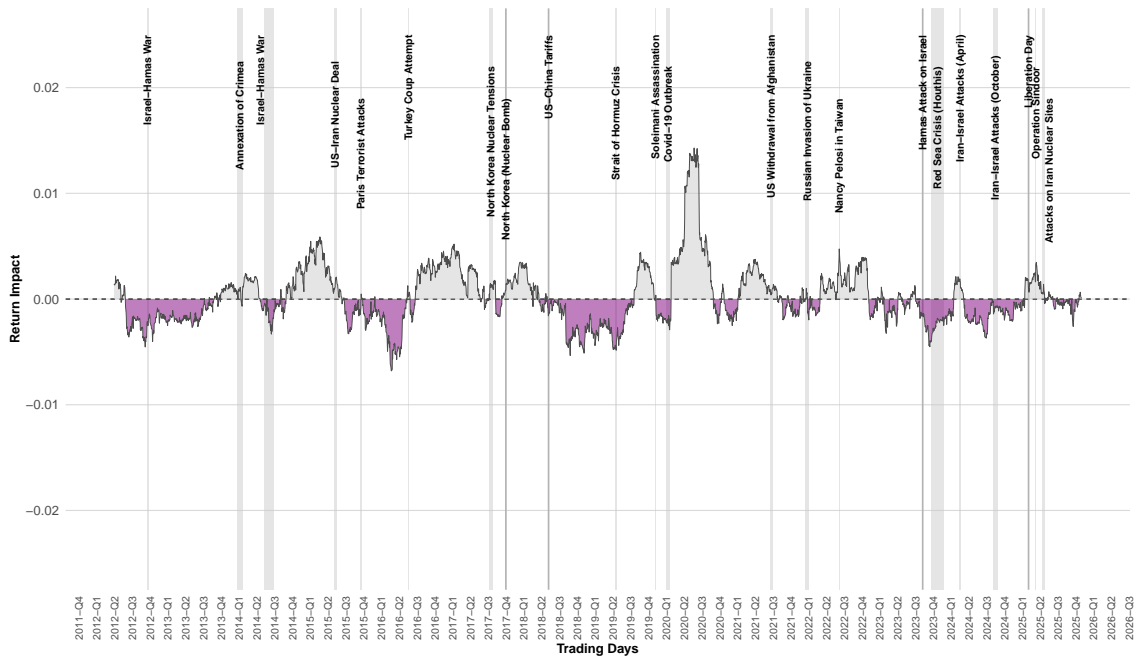


(a) GPR Threats vs IMAT

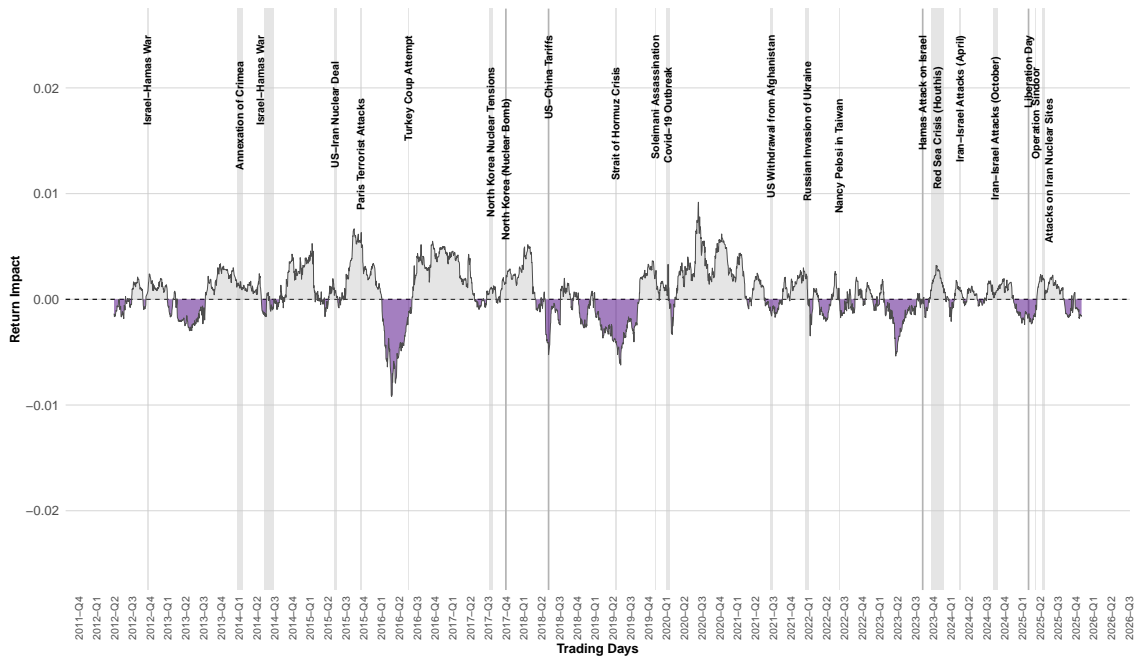


(b) GPR Acts vs IMAT

Figure 6: Rolling GIRF evaluating the return impact of geopolitical shocks on the IMAT index. Positive values validate potential sectoral hedge characteristics.

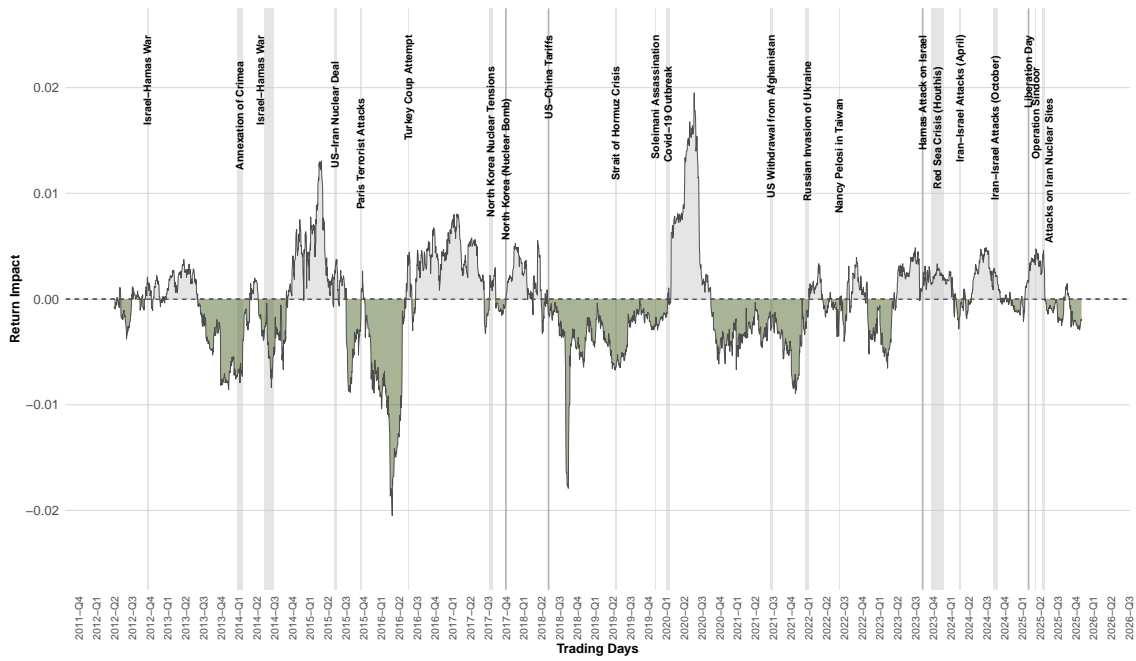


(a) GPR Threats vs IFNC

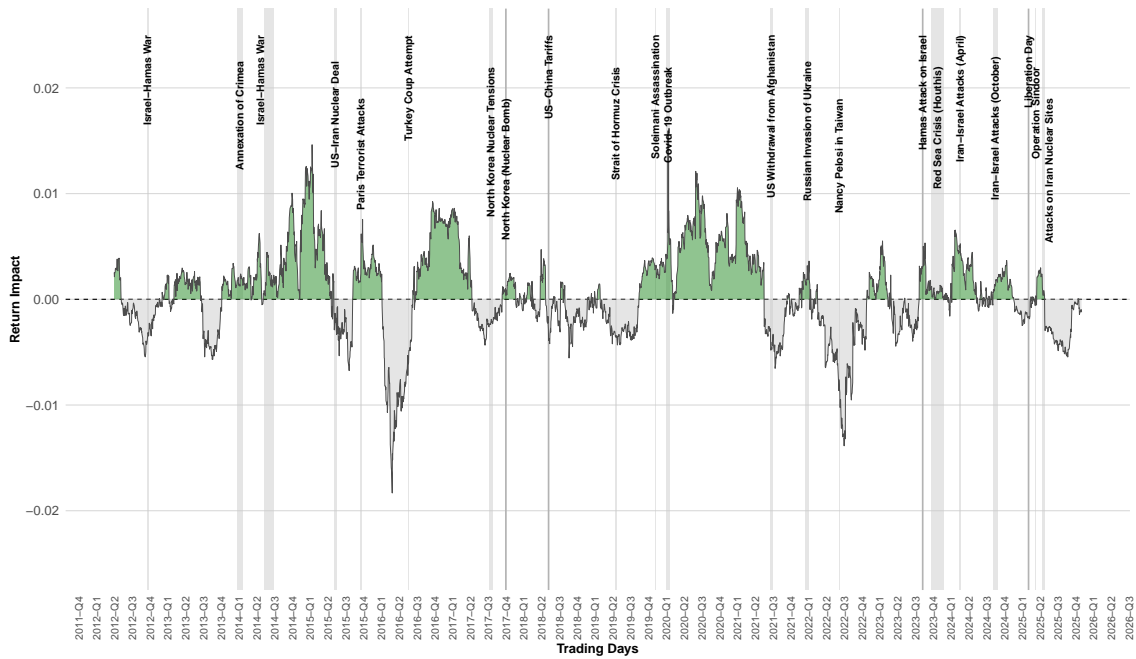


(b) GPR Acts vs IFNC

Figure 7: Rolling GIRF evaluating the return impact of geopolitical shocks on the IFNC index over time.



(a) GPR Threats vs PETR4



(b) GPR Acts vs PETR4

Figure 8: Rolling GIRF evaluating the return impact of geopolitical shocks on PETR4, testing the empirical safe-haven hypothesis via the crude oil channel.

6.1 Asset Composition of Sectoral Indices

Table A1 details the portfolio composition of the Brazilian sectoral indices evaluated in this study.

Table 4: Constituent Assets by Sectoral Index

Index	Tickers (B3)
IMAT	BRAP4, BRKM5, CBAV3, CMIN3, CSNA3, DXCO3, KLBN11, SUZB3, UNIP6, USIM5, VALE3.
IFNC	ABCB4, B3SA3, BBAS3, BBDC3, BBDC4, BBSE3, BMGB4, BPAC11, BPAN4, BRSR6, CXSE3, IRBR3, ITSA4, ITUB3, ITUB4, PSSA3, SANB11.
ICON	ABEV3, ALOS3, ALPA4, AMBP3, ANIM3, ARZZ3, ASAI3, AZUL4, BHIA3, BLAU3, BRFS3, CAML3, CEAB3, CRFB3, CVCB3, CYRE3, DIRR3, EZTC3, FLRY3, GOLL4, GRND3, GUAR3, HAPV3, HBSA3, JBSS3, JHSF3, LREN3, MATD3, MDIA3, MEAL3, MGLU3, MOVI3, MRFG3, MRVE3, MULT3, NTCO3, ODPV3, ONCO3, PCAR3, PETZ3, PNVL3, QUAL3, RADL3, RENT3, SBFG3, SEER3, SMFT3, SMTO3, SOMA3, TEND3, VAMO3, VIVA3, VULC3, YDUQ3, ZAMP3.

7 References

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