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Geopolitical Risk Spillovers: Evidence from G20 Countries

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ABSTRACT

The repercussions of geopolitical risks encountered by a nation extend beyond its borders and can have a ripple effect on neighboring and even distant countries. These geopolitical risks, stemming from a mix of political, geographical, and geopolitical factors, can influence other nations through international tensions, security concerns, trade disputes, acts of terrorism, armed conflicts, natural disasters, and political instability. The paper aims to investigate the dynamic relationships between geopolitical risk indices of G20 countries using spillover analysis based on the Time-Varying Parameter Vector Autoregression (TVP-VAR) model. For this purpose, the geopolitical risk indices calculated by Caldara and Iacoviello (2022) have been utilized. The analysis results indicate that the transmission of geopolitical risks is primarily directed from advanced Western countries (such as the US, the UK, and Germany) to other countries in the sample. Particularly, it has been identified that China and Russia have been transmitting geopolitical risks to other countries, especially after 2010. Furthermore, the time-varying total spillover index captures hightened geopolitical risks episodes. Indonesia, Argentina, and Mexico stand out as the countries receiving the highest level of geopolitical risk spillover. Since geopolitical risks are closely related to economic growth, trade, and financial markets, the analysis results will provide valuable insights for policymakers and market participants.

1. Introduction

Geopolitical risks are the possible effects of social, political, and economic variables of a particular country or region on the world economy. Geopolitical tensions between countries, military confrontations, economic sanctions, trade disputes, natural disasters, and pandemics are just a few of the many potential causes of geopolitical hazards. Geopolitical concerns have a number of detrimental consequences on the stock market and the actual economy. Increased risks, for instance, may have an impact on the stability of financial markets, disrupt international supply chains, drive up energy costs, and slow economic development. In rare situations, they can also cause economic recessions. They can also cause volatility in foreing exchange rates and commodities prices. Therefore, for companies, investors,

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and policy makers working in today's globalized economy, recognizing and controlling the causes of geopolitical risks is crucial.

Since geopolitical risks are intricate and varied, there is no established approach for calculating them. However, a number of methodologies and frameworks, including country risk assessments, scenario analysis, expert opinions, and quantitative models, are available to evaluate the possible impacts of geopolitical risks on the global economy. In conclusion, there is no solitary approach to evaluating geopolitical threats. The possible effects of these risks on the world economy, however, can be better understood by combining different methodologies. Indeed, a number of organizations produce and disseminate the Geopolitical Risk Index (GRI) such as; Eurasia Group, IHS Markit, Marsh & McLennan, and Fitch Solutions. These organizations evaluate numerous geopolitical variables and create indices to gauge risk levels and their effects on specific regions or countries.

A recent GRI suggested by Caldara and Iacoviello (2022) evaluates the effect of geopolitical hazards on the US economy. The GRI is based on a statistical model that takes into account information from a variety of sources, such as news stories, economic indicators, and financial market data. It is intended to represent how global events, including things like military wars, trade disagreements, and political instability, affect the American economy. The index is created by giving weights to various geopolitical events according to how they could affect the US economy. A single measure of geopolitical risk is created by combining these weighted components. Geopolitical risks' impact on the US economy as a whole and financial markets in the US was studied by Caldara and Iacoviello in 2022. The index has shown to be a valuable tool for spotting times of increased geopolitical risk and foretelling how these risks would affect the US economy. The GRI is exclusive to the US economy, hence it may not be directly comparable to other geopolitical risk indices that are created for various areas or nations. This is a crucial distinction to make. Caldara and Iacoviello have calculated a geopolitical risk index for 44 countries using a similar approach they applied to the United States.

Although there are several transmission channels between geopolitical risks of countries, trade and financial linkages between countries, political contagion effects, security risks, and commodity prices come to the fore as the most significant transmission channels. These channels are important in the transmission and spillover of geopolitical risk across nations. For instance, geopolitical risks might spread through modifications to trade laws or supply chain disruptions. Also, trade limitations or tariffs imposed by one nation may result in lower exports and slower economic growth in other nations that depend on that nation as a trading partner. On the other hand, financial connections like international investments or bank loans can help geopolitical hazards spread. For instance, a financial crisis in one nation's financial system can spread to other nations' financial systems via channels including capital flight, asset price falls, and tighter lending. Political contagion, in which civil discontent, political instability, or regime change in one nation can result in comparable occurrences in other countries or areas, is one way that geopolitical risks can spread. For instance, political demonstrations in one nation may spur corresponding demonstrations in other nations or areas. Security hazards like terrorism or armed war may potentially propagate geopolitical risks. For instance, a terrorist attack or armed war in one nation might have an impact on nearby nations or regions, increasing security threats and causing economic disruptions. Commodity prices can be impacted by geopolitical threats, which may then affect pricing in other nations. For instance, geopolitical conflicts that cause delays in oil supply or price hikes might result in greater fuel costs and less economic activity in other nations that depend on oil imports. The complexity and interconnectedness of geopolitical risk, as well as the possibility of dangers in one nation or region having an impact on other countries or regions, are all highlighted by these transmission channels.

This study is conducted with the objective of investigating the transmission of geopolitical risk among G20 countries. Hence, we employ a spillover analysis that relies on the TVP-VAR approach to examine the evolving relationships in geopolitical risk among these countries. As far as our knowledge extends, the paper represents one of the initial endeavors to examine the spillover of geopolitical risk across countries through the application of spillover analysis using the TVP-VAR spillover analysis. The paper comprises five sections. In Section 2, a concise literature review is provided, while the econometric framework is given in Section 3. Empirical results are given in Section 4, and Section 5 serves as the conclusion.

2. Literature Review

Geopolitical risks tend to propagate gradually from one country to another. Understanding the spillover among the geopolitical risks becomes a priority for institutional investors and company executives in order to develop risk management strategies, while for governments, it is important for designing security policies. Balli et al. (2022) applied the spillover analysis suggested by Diebold and Yılmaz (2012) using the monthly series of GRI indexes of countries from 1985 to 2017 to measure the spillover effects of geopolitical risks among 19 countries. The results showed significant spillover of GRI in the countries examined and indicated that connections such as trade and geographical proximity substantially explained bilateral GPR spillover.

Hasan et al. (2018) examined the transmission of geopolitical risks and identify the bidirectional and country-specific determinants of the transmission using data from January 1985 to December 2016 for 19 countries. By employing the spillover analysis suggested by Diebold and Yılmaz (2012), they obtained the result of significant geopolitical risk spillover among the countries included in the sample. Elsayed and Helmi (2021) examined geopolitical risk's effects on the stock stock return and volatility in the Middle East and North Africa countries via the ADCC-GARCH model. The data from May 31, 2005, to May 31, 2018, were utilized for 11 MENA countries. The findings indicate that there is no relationship between geopolitical risk and return spillovers among MENA financial markets. On the other hand, the time-varying analysis results provide evidence of the total contagion index being highly responsive to major political events. Additionally, the findings suggest that the interconnectedness among MENA countries is not strong in terms of return and volatility spillover but highlight that Gulf Cooperation Council markets are more interconnected with each other.

Cevik et al. (2020), examines the relationship between crude oil prices and stock market returns in Turkey taking into account volatility spillovers. Using weekly data from 1990 to 2017 and time varying causality-in-mean and causality-in-variance tests and taking into account structural breaks, they model each series as an EGARCH process in order to capture any leverage effects in the volatility of returns. Empirical results suggest crude oil prices as measured by Brent benchmark have significant effects on stock market returns in Turkey. These results suggest that government policies must take into account risk spillover effects between markets and that investors are better off monitoring crude oil markets in portfolio allocation decisions.

Gürsoy and Kılıç (2021) investigated the impact of the economic and political uncertainty in global markets on financial markets in Turkey. Baker et al. (2016) and the global economic political uncertainty index prepared by Davis (2016) and Turkey's 5-year CDS premiums and BIST banking index variables were selected. Among the variables, the DCC-GARCH model was run using monthly data between March 2010 and October 2020. As a result of the study, it was found that there was a strong two-way volatility interaction between the global economic political uncertainty index and the CDS premium, BIST banking index. Alptürk et al. (2021), the aim of this study is to explore the relationship between the geopolitical risk index developed by Caldara and Iacoviello (2018) and CDS premiums for Turkey. In this research, monthly data of Turkey's geopolitical risk index and 5-year CDS premiums between March 2010 and October 2020 were used. In order to determine the relationships between GPR and CDS variables, the stationarity of the series was first tested using Lee-Strazicich unit root tests, taking into account structural breaks. Using the Hatemi-J causality test, it was determined whether there was a causal relationship between the variables and, if there was a causal relationship, what the direction of the relationships was. According to the research, it was seen that the increase and decrease in geopolitical risk in Turkey had an impact on 5-year CDS premiums.

Additionally, it has been determined that the increase or decrease in CDS premiums does not have any causal effect on geopolitical risk in Turkey.

Yang et al. (2021) investigated the effects of geopolitical risks on five renewable energy stock markets from a multi-scale dynamic risk contagion perspective. The empirical findings indicate notable transmissions of risk from geopolitical factors to renewable energy markets. These risk transmissions do not demonstrate a distinct positive or negative trend. Cheng et al. (2022) investigated the asymmetric impacts of geopolitical risks on the gold-oil relationship using monthly data from January 1990 to February 2021, including Brent crude oil prices, gold prices, and geopolitical risks. The results obtained for the entire sample and subsamples indicate a nonlinear transmission from geopolitical risk to the gold-oil relationship in the long run.

Wang et al. (2022) examined returns and volatility spillovers among various commodities in response to increasing geopolitical risks associated with the Russia-Ukraine conflict using a spillover analysis based on the TVP-VAR model. Return and volatility spillover relationships can vary across commodities. The findings indicate that crude oil is a net return transmitter, while wheat and soybeans act as net spillover receivers. Silver, gold, copper, platinum, aluminum, and sugar are identified as net volatility transmitters. It is concluded that during periods of heightened geopolitical risks, the returns and volatility spillovers between variables also increase. Jin et al. (2023) examined spillover effects between geopolitical risk, climate risk, and energy markets using GARCH models based on data from 13 countries spanning from 2002 to 2022. The main findings demonstrate a strong linkage between energy, geopolitical risk, and climate risk. The results reveals that the relationship between the variables varies across the frequency, with a more significant effect observed at higher frequencies. Oad Rajput et al. (2023) included geopolitical risks as an exogenous variable while testing volatility transmission among selected Islamic stock markets. They utilized GARCH models to examine both symmetric and asymmetric risk spillover and identified the presence of spillover effects from Turkey to Saudi Arabia, from Indonesia to Malaysia, and from Saudi Arabia and Malaysia to Indonesia. However, they found that only Malaysia and Indonesia exhibited volatility spillovers from the geopolitical risk index to their Islamic stock markets.

Sweidan (2023), delved into the dynamics of international geopolitical risk, focusing on a selected group of countries, including the US, Germany, China, and Ukraine, and explored its potential spillover impact on Russia. The study employed the Autoregressive Distributed Lag model (ARDL) to investigate whether the geopolitical tension between these countries is cointegrated. Covering the period from January 1993 to May 2022, the empirical model revealed that Russia's international geopolitical risk is indeed cointegrated with the selected quartet. The results underscored that the international geopolitical risk emanating from Ukraine, Germany, the US, and China influences Russia, leading to an increase in its own international geopolitical risk. Zheng et al. (2023) employed the TVP-VAR model to investigate risk spillover effects within the Geopolitical Risk (GPR) and the broader global financial market network. The findings suggest a robust risk network relationship between geopolitical risk and global financial markets, particularly with a pronounced impact on the global crude oil market. Feng et al. (2023) delved into the influence of geopolitical risk on volatility spillovers between G7 and BRICS stock markets, utilizing the impulse responses analysis based on the VAR model. The dynamic impact of geopolitical risk on the spread series revealed a nuanced pattern, with a negative effect in the early and late periods and a more substantial positive effect in the middle period. Zang et al. (2023) conducted a generalized VAR analysis to explore the asymmetric spillover between geopolitical risk and oil price volatility across six major global regions. The results indicated that developed countries primarily function as net risk transmitters, while developing countries tend to be relatively net receivers of geopolitical risk. Yıldırım and Özgür (2023), aims to determine the effects of geopolitical risks and control of corruption on foreign direct investments in Turkey, which is located in the geography where geopolitical risk is high. In the analysis conducted for the period 2003.Q1-2020.Q4, the Geopolitical Risk

Index created by Caldara and Iacoviello (2019) and the control of corruption index, which is a country-specific institutional risk indicator, were used. According to the findings obtained by using the ARDL method, it is observed that while the control of corruption and real gross domestic product affect foreign direct investment inflows positively, geopolitical risk and inflation have a reducing effect on foreign investments.

3. Econometric Framework

The time-varying spillover analysis suggested by Antonakakis et al. (2020) is based on the TVP-VAR model where the time-varying variance-covariance matrix can be calculated using the Kalman filter suggested by Koop and Korobilis (2014). It is important to highlight that the TVP-VAR spillover approach is an enhanced version of the Diebold and Yilmaz (2012) connectedness approach, and it offers several advantages compared to the it. As Antonakakis et al. (2020) have pointed out, the TVP-VAR model relies on a stochastic volatility assumption rather than a rolling-window approach to determine time-varying connectedness among variables. This eliminates the biases associated with choosing a rolling window and prevents the loss of crucial observations. Consequently, the connectedness approach based on the TVP-VAR model can be effectively applied to low-frequency data and limited time series data.The TVP-VAR model is formulated as follows:

$$y_t = \beta_t z_{t-1} + \epsilon_t \qquad \epsilon_t \mid F_{t-1} \sim N(0, S_t) \tag{1}$$

$$vec(\beta_t) = vec(\beta_{t-1}) + v_t \qquad v_t \mid F_{t-1} \sim N(0, R_t) \tag{2}$$

here, we have the vectors y_t and $z_{t-1} = [y_{t-1}, \dots, y_{t-p}]'$, which have dimensions $N \times 1$ and $Np \times 1$, respectively. β_t represents a time-varying coefficient matrix of dimensions $N \times Np$, and ϵ_t is a error disturbance vector with dimensions $N \times 1$ and a time-varying variance-covariance matrix, S_t, of size $N \times N$. The vectors $vec(\beta_t)$, $vec(\beta_{t-1})$ and v_t have dimensions $Np^2 \times 1$, while R_t is an $N^2p \times N^2p$ dimensional matrix.

For computing the Generalized Impulse Response Functions (GIRF) and the Generalized Forecast Error Variance Decomposition (GEFVD) as recommended by Koop et al. (1996) and Pesaran and Shin (1998), we convert the VAR into its vector moving average (VMA) representation:

$$y_t = \sum_{j=0}^{\infty} L' W_t^j L \epsilon_{t-j} \tag{3}$$

$$y_t = \sum_{j=0}^{\infty} A_{it} \epsilon_{t-j} \tag{4}$$

In Equation (3), L, a matrix of dimensions $Np \times N$, is defined as $L = [I_N, \dots, 0_p]'$. The matrix W, with dimensions $Np \times Np$, is expressed as $W = [\beta_t; I_{N(p-1)}, 0_{N(p-1)\times p}]$. Additionally, A_{it} represents an $N \times N$ dimensional matrix. The Generalized Impulse Response Functions (GIRFs) depict how all variables react to a shock in variable *i*. As we lack a structural model, we calculate the difference between two *J*-step ahead forecasts: one with a shock to variable *i* and one without. This difference can be attributed to the shock in variable *i* and can be calculated by:

$$GIRF_t(J, \delta_{j,t}, F_{t-1}) = E(Y_{t+J} \mid \epsilon_{j,t} = \delta_{j,t}, F_{t-1}) - E(Y_{t+J} \mid F_{t-1}) \tag{5}$$

$$\psi_{j,t}^g(J) = \frac{A_{J,t} S_t \epsilon_{j,t}}{\sqrt{S_{jj,t}}} \frac{\delta_{j,t}}{\sqrt{S_{jj,t}}} \qquad \delta_{j,t} = \sqrt{S_{jj,t}} \tag{6}$$

$$\psi_{j,t}^g(J) = S_{jj,t}^{-\frac{1}{2}} A_{J,t} S_t \epsilon_{j,t} \tag{7}$$

where $\psi_{j,t}^g(J)$ represents the GIRFs of variable *j* and *J* represents the forecast horizon, $\delta_{j,t}$ the selection vector with one on the *j*th position and zero otherwise and F_{t-1} the information set until *t*-1. The GFEVD is calculated as the variance share one variable has on others as follows:

$$\tilde{\phi}_{ij,t}^g(J) = \frac{\sum_{t=1}^{J-1} \psi_{ij,t}^{2,g}}{\sum_{j=1}^{N} \sum_{t=1}^{J-1} \psi_{ij,t}^{2,g}} \tag{8}$$

with $\sum_{j=1}^{N} \tilde{\phi}_{ij,t}^g(J) = 1$ and $\sum_{i,j=1}^{N} \tilde{\phi}_{ij,t}^N(J) = N$. Using the GFEVD, the total spillover index (TSI) is calculated as follows:

$$C_t^g(J) = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\phi}_{ij,t}^g(J)}{\sum_{i,j=1}^{N} \tilde{\phi}_{ij,t}^g(J)} \times 100 = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\phi}_{ij,t}^g(J)}{N} \times 100 \tag{9}$$

The total directional spillovers to others (spillover transmission from variable *i* to all other variables *j*) is calculated as follows:

$$C_{i\rightarrow j,t}^g(J) = \frac{\sum_{j=1, i\neq j}^{N} \tilde{\phi}_{ji,t}^g(J)}{\sum_{j=1}^{N} \tilde{\phi}_{ji,t}^g(J)} \times 100 \tag{10}$$

The total directional spillover from others (the variable *i* receives spillover from variables *j*) is calculated as following:

$$C^g_{i\leftarrow j,t}(J) = \frac{\sum_{j=1,i\neq j}^{N}\tilde{\phi}^g_{ji,t}(J)}{\sum_{j=1}^{N}\tilde{\phi}^g_{ji,t}(J)} \times 100 \quad (11)$$

The net total directional spillover is represented as following:

$$C^g_{i,t}(J) = C^g_{i\rightarrow j,t}(J) - C^g_{i\leftarrow j,t}(J) \quad (12)$$

The net pairwise directional spillover (NPDS) is represented as following:

$$NPDS_{ij}(J) = \frac{\tilde{\phi}^g_{ji,t}(J) - \tilde{\phi}^g_{ij,t}(J)}{T} \times 100 \quad (13)$$

4. Data and Empirical Results

In the study, the relationships between geopolitical risks among G20 countries are investigated using a spillover analysis rely on the TVP-VAR model. The monthly geopolitical risk indices calculated by Caldara and Iacoviello (2022) for the period from January 1985 to May 2023 were utilized in the analysis. According to the descriptive statistics in Table 1, the highest average monthly geopolitical risk index is observed for the United States, while the lowest average geopolitical risk index is calculated for Argentina. In terms of standard deviation, the highest volatility is obtained from Russia. This result is consistent with expectations as geopolitical risks in Russia have significantly increased due to the Russia-Ukraine war. The Jarque-Bera statistics provides evidence in favor of nonnormal distribution, and the skewness and kurtosis statistics imply that the distribution of series is leptokurtic. The integration levels of the series are analyzed using ADF and PP unit root tests, and the results show that all series are stationary at the levels.

Table 1: Descriptive Statistics

	ARG	AUS	BRA	CAN	CHN	DEU	FRA	GBR	IDN	IND
Mean	0.031	0.087	0.048	0.226	0.426	0.397	0.526	0.952	0.045	0.210
Median	0.020	0.070	0.040	0.190	0.340	0.330	0.460	0.820	0.030	0.180
Max	0.260	0.530	0.230	1.720	2.570	2.750	2.800	5.990	0.510	1.130
Min	0.000	0.000	0.000	0.060	0.070	0.080	0.140	0.230	0.000	0.040
Std. Dev.	0.028	0.070	0.034	0.160	0.295	0.281	0.317	0.625	0.052	0.133
Skew.	2.885	2.318	2.052	4.168	2.065	3.625	2.942	4.138	4.389	2.914
Kurt.	16.732	10.662	8.918	31.083	10.244	24.180	15.456	28.448	32.215	15.430
J-B	4261.675	1540.447	996.384	16483.760	1335.591	9626.512	3645.253	13754.99	17875.02	3620.395
ADF	-7.779***	-9.456***	-13.867***	-10.067***	-11.203***	-8.997***	-10.970***	-7.114***	-7.894***	-11.633***
PP	-13.909***	-13.918***	-15.25***	-10.019***	-12.299***	-8.881***	-11.270***	-8.938***	-15.23***	-12.233***
	ITA	**JPN**	**KOR**	**MEX**	**RUS**	**SAU**	**TUR**	**USA**	**ZAF**	
Mean	0.156	0.234	0.248	0.093	0.839	0.217	0.206	2.333	0.085	
Median	0.120	0.190	0.180	0.080	0.690	0.130	0.150	2.100	0.060	
Max	1.440	1.240	1.820	0.460	8.980	3.570	1.200	13.230	0.620	
Min	0.030	0.050	0.040	0.020	0.200	0.020	0.020	0.750	0.000	
Std. Dev.	0.133	0.163	0.224	0.058	0.688	0.343	0.179	1.255	0.082	
Skew.	4.341	2.549	2.928	2.458	5.429	6.744	2.146	4.425	3.314	
Kurt.	33.237	11.765	14.944	12.074	52.226	59.533	9.379	32.139	18.045	
J-B	19009.140	1974.790	3398.890	2045.568	48811.290	64883.180	1135.434	17814.36	5191.903	
ADF	-12.329***	-11.263***	-5.868***	-9.438***	-7.030***	-6.185***	-7.409***	-6.928***	-2.610***	
PP	-13.764***	-12.096***	-10.100***	-14.920***	-6.799***	-10.018***	-13.776***	-8.448***	-9.058***	

Notes: ARG: Argentina, AUS: Australia, BRA: Brazil, Can: Canada, CHN: China, DEU: Germany, FRA: France, GBR: the UK, IDN: Indonesia, IND: India, ITA: Italy, JPN: Japan, KOR: South Korea, MEX: Mexico, RUS: Russia, SAU: Saudi Arabia, TUR: Turkiye, ZAF: South Africa. *** indicates stationarity at 1% significance level.

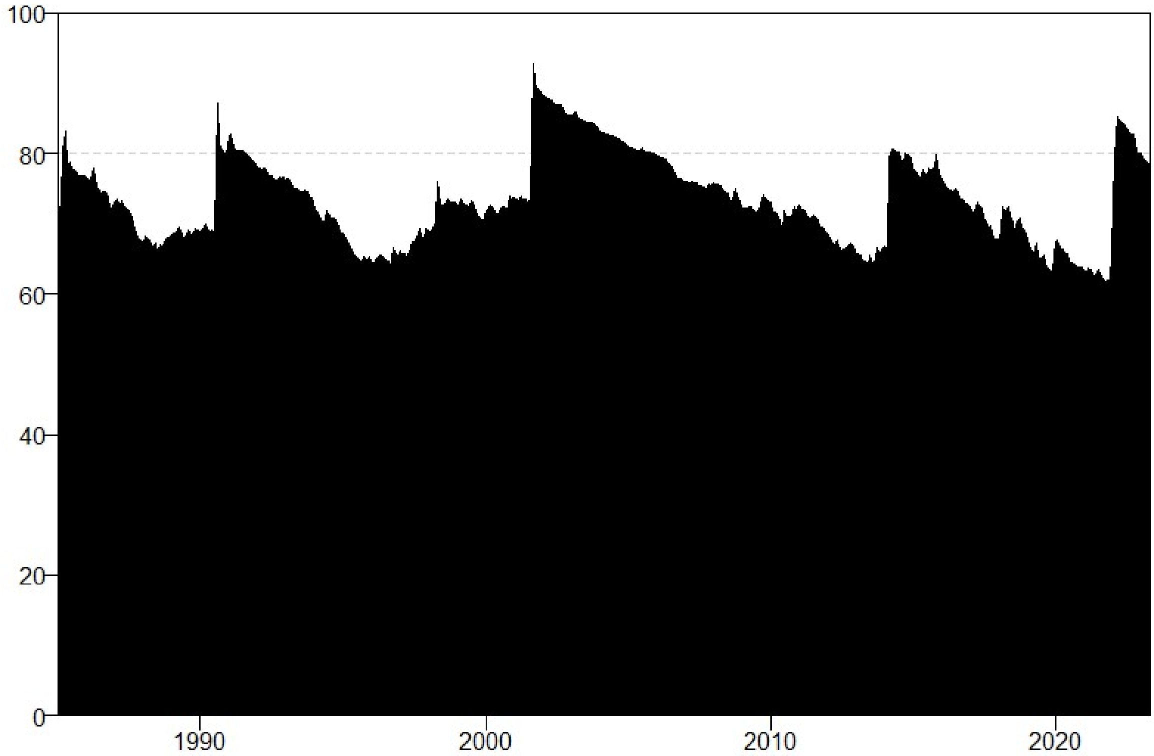
In the empirical analysis, we first estimate the VAR model and determine the optimal lag order based on model information criteria that suggest one lag is sufficient to render the residuals white noise. Subsequently, the TVP-VAR model is estimated, and the forecasting horizon is set to 12 to calculate the GIRF and GEFVD. The outcomes of the spillover approach are displayed in Table 2. According to the results in Table 2, the US, the UK, Germany, Russia, France, Canada, China, and Japan are identified as net geopolitical risk transmitters, while Turkey, South Korea, Italy, Brazil, Australia, India, South Africa, Mexico, Argentina, and Indonesia are determined as net geopolitical risk receivers. More specifically, based on the net spillover analysis results, the three most significant countries transmitting geopolitical risk to other countries are the US, the UK, and Germany, in that order. The US transmits the most geopolitical risk to the UK and Canada, and it is a net risk transmitter against all other countries. Among the countries receiving the highest net risk spillover, Indonesia is in the first place, receiving the most geopolitical risk spillover from Canada, the UK, and the US. Examining the results for Turkiye, it is a net receiver of geopolitical risk, receiving the highest spillover from the UK, France, the US, and Germany. In contrast, Turkey serves as a net transmitter of geopolitical risk against Argentina, Brazil, Indonesia, India, Japan, and Mexico. In the bottom right corner of Table 2, the total spillover index value is provided, which indicates that 77.5% of the total forecast error can be explained by the variables in question.

Table 2: Spillover Analysis Results

	ARG	AUS	BRA	CAN	CHN	DEU	FRA	GBR	IDN	IND	ITA	JPN	KOR	MEX	RUS	SAU	TUR	USA	ZAF	FROM
ARG	40.87	1.15	4.79	4.89	2.88	5.72	4.00	2.79	1.77	1.52	2.51	3.95	2.38	2.13	5.40	2.36	2.26	4.76	3.86	59.13
AUS	0.92	25.75	1.89	6.46	6.29	5.71	4.18	8.67	4.00	3.53	3.06	4.12	3.19	1.98	6.56	2.67	2.10	7.88	1.05	74.25
BRA	3.32	1.87	32.03	4.81	4.31	5.98	3.90	4.76	2.51	2.60	3.11	4.33	2.07	3.34	5.59	3.05	3.64	6.65	2.12	67.97
CAN	2.45	3.92	2.59	17.84	2.38	8.81	6.32	7.76	2.25	2.70	5.59	6.51	1.43	2.70	7.16	3.92	3.01	10.58	2.07	82.16
CHN	1.21	4.73	2.40	2.70	25.03	6.58	3.97	7.41	1.46	2.94	2.31	5.46	10.60	2.03	7.02	1.71	3.48	5.93	3.03	74.97
DEU	1.51	2.80	2.60	6.63	4.26	18.54	9.15	7.75	1.31	1.05	5.45	5.05	1.60	1.59	11.04	3.74	4.82	9.61	1.51	81.46
FRA	1.06	2.60	1.98	6.27	3.56	9.65	18.05	10.42	1.30	1.66	4.80	5.79	2.29	1.57	7.94	4.48	5.64	10.02	0.91	81.95
GBR	0.92	4.69	2.19	7.18	4.58	7.37	9.33	17.54	2.06	2.61	4.60	5.16	3.17	2.21	5.58	4.41	4.03	11.60	0.77	82.46
IDN	1.95	7.47	2.92	5.63	4.01	2.85	3.13	5.66	38.69	2.45	1.82	4.13	2.68	2.85	2.06	2.32	2.68	4.32	2.35	61.31
IND	1.15	4.45	2.81	6.78	5.46	3.56	3.60	6.55	1.83	32.27	3.34	5.00	2.36	2.10	4.26	2.69	1.50	8.09	2.19	67.73
ITA	1.26	2.42	2.47	8.01	2.54	9.15	8.04	7.79	0.98	1.85	23.94	4.80	1.32	1.54	6.57	4.00	3.39	8.33	1.62	76.06
JPN	1.45	3.05	2.69	6.99	6.27	7.36	6.42	6.06	1.96	2.39	3.42	17.55	7.89	2.31	6.01	4.16	3.52	9.20	1.31	82.45
KOR	1.01	3.85	2.10	2.46	13.90	3.23	3.72	4.60	1.19	2.12	1.17	12.49	29.58	3.08	4.26	1.32	2.55	5.46	1.90	70.42
MEX	2.13	2.74	4.02	6.05	3.49	4.08	3.21	4.21	2.25	2.99	1.95	4.50	4.61	37.43	3.43	1.83	2.60	6.37	2.12	62.57
RUS	1.35	2.87	2.08	5.37	5.15	12.73	7.12	6.47	1.02	1.42	4.54	3.99	2.05	0.94	22.02	3.83	5.20	9.66	2.18	77.98
SAU	1.32	2.37	1.89	5.15	2.68	6.44	7.28	8.03	1.49	1.48	3.85	5.08	1.47	1.29	5.30	27.04	5.99	10.80	1.05	72.96
TUR	0.86	3.14	2.34	3.62	4.83	7.13	8.33	8.87	1.53	1.11	3.39	3.15	2.27	1.76	7.29	5.65	25.37	7.58	1.79	74.63
USA	1.51	2.91	2.74	8.46	3.10	9.25	8.12	9.83	1.64	2.18	4.53	6.39	2.05	2.50	8.18	5.76	3.93	15.84	1.09	84.16
ZAF	2.38	2.15	2.42	4.92	5.76	5.24	2.55	3.09	2.14	3.70	2.66	2.82	4.57	1.80	5.19	2.23	3.34	3.56	39.48	60.52
TO	27.76	59.19	46.91	102.38	85.45	120.84	102.39	120.71	32.71	40.28	62.11	92.74	58.02	37.73	108.82	60.13	63.68	140.40	32.92	
NET	-31.37	-15.06	-21.06	20.22	10.49	39.38	20.44	38.25	-28.61	-27.45	-13.96	10.28	-12.40	-24.85	30.84	-12.83	-10.95	56.24	-27.60	**TSI: 77.51**
NPT	1	7	7	13	12	16	14	17	0	4	7	10	7	2	15	8	10	18	3	

The time-varying total spillover index is shown in Figure 1. Based on the results in Figure 1, four distinct periods stand out where the index significantly increased. The first period corresponds to the start of the First Gulf War in 1990 with Iraq's invasion of Kuwait. The second period coincides with the year 2001, which also marks the historical peak of the index. During this period, the 9/11 attacks occurred, followed by the start of the Second Gulf War. It is concluded that geopolitical risks increased in 2014 and 2015 due to Russia's annexation of Crimea and terrorist attacks in Paris. The last period is related to the Russia-Ukarine war. The results in Figure 1 show that the spillover analysis successfully captures periods of heightened global geopolitical risks.

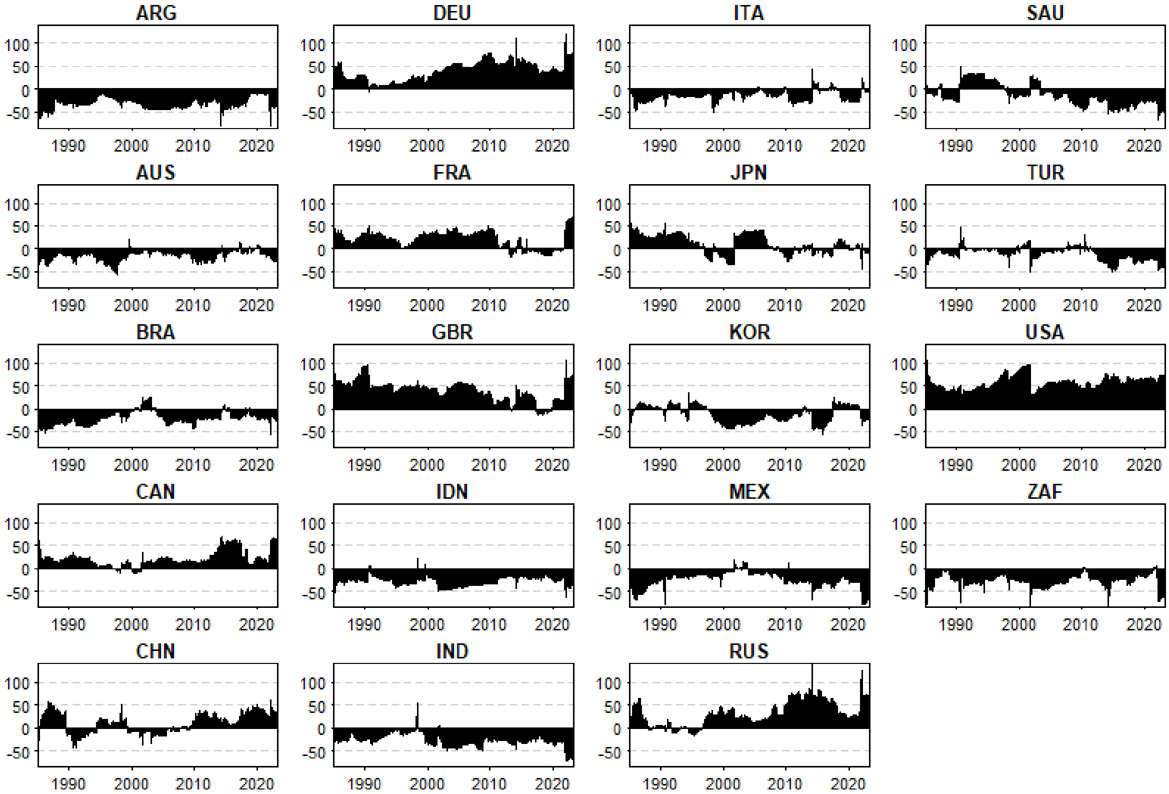
Figure 1: Total Spillover Index



In Figure 2, the results of the time-varying net directional spillover analysis are presented.[2] Positive values in the figure indicate that the country is a net risk transmitter during the respective period, while negative values indicate that the country is a net risk receiver. According to the results in Figure 2, Germany, the UK, the US, and Canada are net geopolitical risk transmitter during all sub-samples. On the other hand, Argentina, Italy, Australia, Turkey, Brazil, South Korea, Indonesia, Mexico, South Africa, and India are net geopolitical risk receivers throughout all sub-samples. Indeed, it should be noted that in particular after the 2010, France has become a net risk receiver country, while China and Russia have emerged as significant geopolitical risk transmitter. This finding indicates the dynamics of geopolitical risk transmission has been chnaged after 2010.

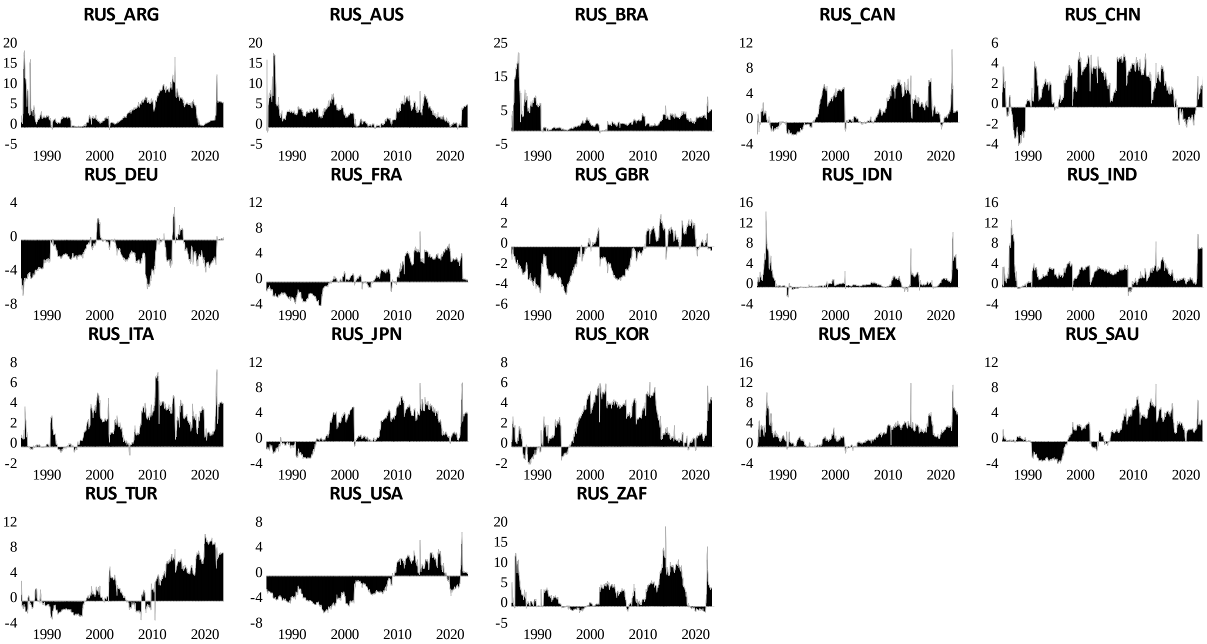
[2] We present results for time-varying directional spillovers "FROM" and "TO" in appendix in Figure A1 and A2.

Figure 2: Net Directional Spillover Results



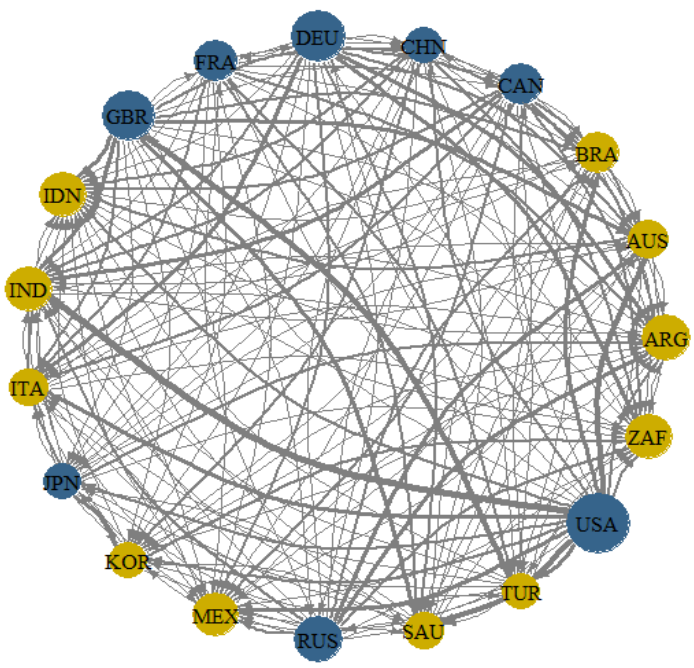
An important research question is how the increased geopolitical risks in Russia during the Russia-Ukraine war have spillovered to other countries. In other words, to investigate whether there has been geopolitical risk spillover from Russia to other countries due to the Russia-Ukraine war, the pairwise directional spillover analysis results for Russia have been calculated and shown in Figure 3. According to the results, it can be concluded that since 2021, Russia has been transmitting geopolitical risk to all countries in the sample except for Germany and France, thereby increasing geopolitical risks in those countries. The results highlight that during the early stages of the Russia-Ukraine conflict, Argentina, Canada, Indonesia, India, Mexico, Turkey, and South Africa experienced the most substantial transmission of geopolitical risk originating from Russia. This suggests that the Russia-Ukraine war had a more pronounced impact on emerging economies, contributing to heightened geopolitical risks within these nations.

Figure 3: Net Pairwise Directional Spillover Results for Russia



Finally, Figure 4 presents the results of bidirectional geopolitical risk spillovers network among countries. The results in Figure 4 are derived from the results in Table 2. The blue circle in the figure represents that the country is the net geopolitical risk transmitter, while the country in the yellow circle is the net geopolitical risk receiver. The arrow's direction signifies the direction of risk spillover, while the arrow's size reflects the magnitude of risk spillover, with larger arrows indicating higher intensity of risk spillover. As indicated above, the US, the UK and Germany come to the fore in terms of geopolitical risk transmitter. On the other hand, Argentina, South Africa, India and Indonesia are determined as the most important countries in terms of net geopolitical risk receiver.

Figure 4: Geopolitical Risk Spillover Networks



5. Conclusion

Indeed, the impact of geopolitical risks faced by a country is not limited to that particular country alone but can spillover to neighboring and even other countries. While the sources of geopolitical risks stem from political, geographical, and geopolitical factors, they can affect other countries due to tensions in international relations, security issues, trade wars, terrorism, military conflicts, natural disasters and political instability. For instance, increased geopolitical risks can disrupt trade between countries, reduce investments, and increase uncertainty about the future, thereby negatively affecting economic growth. Similarly, geopolitical risks increase future uncertainty, leading to heightened risk perception among investors, which can result in sudden drops in financial markets, exchange rates, and commodity prices. Consequently, geopolitical risks impact not only the country experiencing heightened risk but also a specific region and even the global economy in a negative way.

In this study, the spillover between the geopolitical risk indices of G20 countries is examined. The analysis results indicate the spillover of geopolitical risks from developed countries to developing countries. In particular, the US, the UK, and Germany are identified as the most important risk transmitter. Furthermore, the time-varying total spillover index captures hightened geopolitical risks episodes. Indonesia, Argentina, and Mexico stand out as the countries receiving the highest level of geopolitical risk spread. It was determined that Russia and China have been net geopolitical risk transmitters, particularly since 2010, and during the Russia-Ukraine war, Russia transmitted risks to all countries.

In summary, our empirical findings have important political implications. Firstly, they underscore the continued dominance of developed countries in shaping global geopolitical dynamics and emphasize their role in maintaining global political stability. This highlights the sensitivity of emerging nations to political developments elsewhere and raises questions about how foreign actions and policies impact the stability and future economic prospects of developing countries. Secondly, our results invite discussions about the goals and strategies of Russia and China as they actively influence geopolitical developments worldwide. These findings underscore the importance of risk assessment and mitigation strategies in international relations. Governments may need to develop more comprehensive plans to address and respond to geopolitical threats, especially if they are identified as sources of risk transmission. The consequences caused by geopolitical risks can lead to very different consequences that will challenge and trouble countries both nationally and globally. Governments may need to develop comprehensive plans that can prevent the deterioration of general stability, the shaking of the trust system, and the emergence of civil unrest problems.

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Appendix

Figure A1: Directional Spillovers from Each Countries to Others

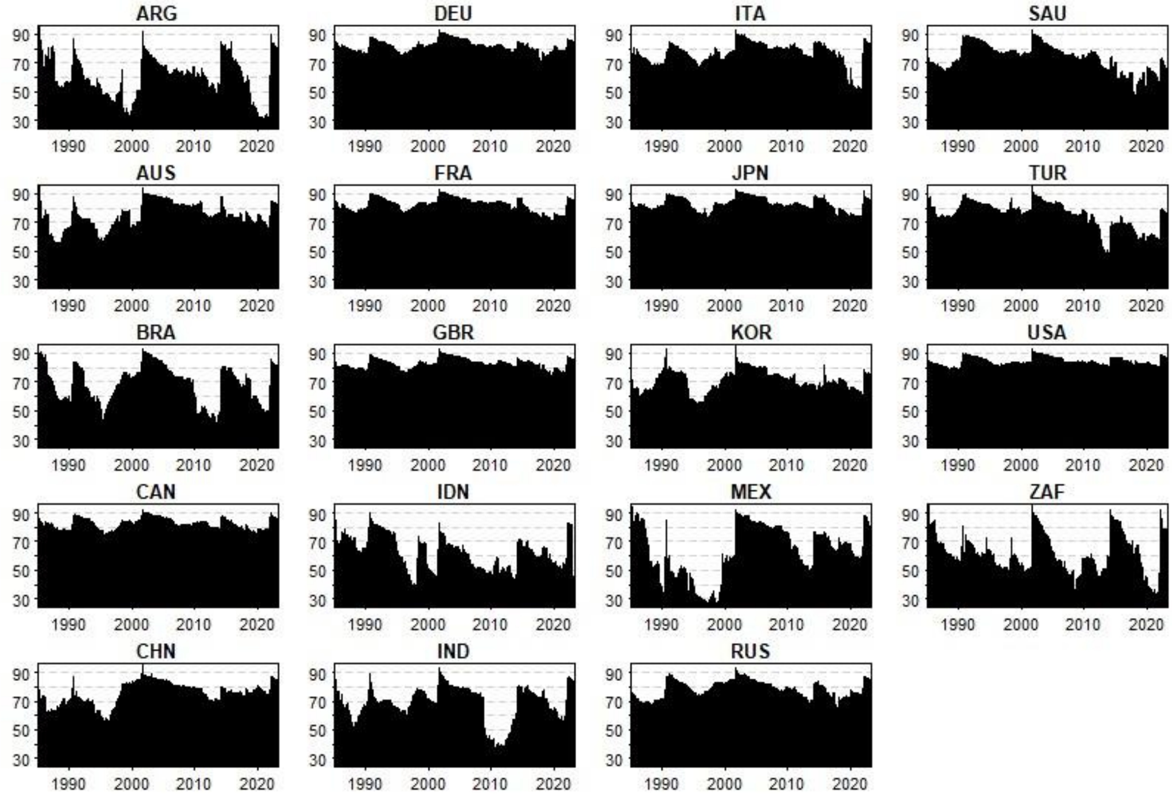

Figure A2: Directional Spillovers from the Others to Each Variables