

Navigating contemporary crisis risk spillover dynamics and growth of the S&P ESG exchange-traded funds

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Abstract

Purpose – This study investigates the volatility spillovers between S&P Environmental Social and Governance, Exchange-Traded Funds and growth during contemporary crises (the Russia–Ukraine and the Israel–Palestine conflicts).

Design/methodology/approach – This paper uses a connectedness index-based TVP-VAR model for daily data from April 16, 2021, to September 30, 2024.

Findings – The findings reveal that the SPDR S&P 500 ESG ETF (EFIV), Xtrackers S&P 500 ESG ETF (SNPE) and Xtrackers S&P MidCap 400 ESG ETF emerged as notable transmitters, whereas the Northern Global Sustainability Index Fund (NSRIX) was a major recipient of risk spillover during both the contemporary crisis. Furthermore, the Xtrackers S&P 500 Growth ESG ETF (SNPG) exhibits a dynamic response to crises, shifting its behavior accordingly: it acts as a risk spillover transmitter during the Israel–Palestine conflict, while it becomes a risk receiver during the Russia–Ukraine conflict, reflecting its adaptive approach to geopolitical events.

Originality/value – Our findings highlight the risks of ESG market contagion during crises and demonstrate how green markets can mitigate climate change while creating new opportunities for investors and businesses.

Keywords Sustainability, S&P ESG ETF, Geopolitical crisis, Spillover and connectedness approach

Paper type Research article

1. Introduction

Sustainability has evolved from a peripheral concern to a central pillar shaping business strategies and decision-making processes (Bajra *et al.*, 2025). This shift escalates sustainability challenges, compounded by global geopolitical uncertainties, which have become critical concerns for stakeholders (Bajra *et al.*, 2025; Zhu *et al.*, 2025). Current geopolitical crisis has contributed to substantial economic disruptions, including supply chain disturbances, surging logistics costs, inflated commodity prices, financial sanctions and increasing unemployment rates. In addition, these conflicts have intensified volatility across global financial markets, creating what many describe as “black swan-like” conditions characterized by extreme unpredictability and widespread economic repercussions (Rehman and Karimullah, 2024). These crises have pushed commodity prices to their highest levels in a decade, thereby exacerbating global food security challenges (Shah *et al.*, 2025).

Stakeholders are increasingly integrating Environmental, Social, and Governance (ESG) and the growing significance of ESG factors has prompted governments and investors to reshape corporate reporting standards, and investment strategies (Gao *et al.*, 2024). However, despite the rapid growth of ESG-focused investment products, and increasing recognition as distinct asset classes, understanding their interaction with broader equity markets is critical, especially during geopolitical uncertainty. Further many financial instruments such as green

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bonds and ESG exchange-traded funds (ETFs) have become increasingly important in stabilizing financial markets and financing eco-friendly investments during periods of turmoil. ESG ETFs expand this approach by providing diversified exposure to socially responsible assets while delivering returns equivalent to those of conventional bonds (Bajra *et al.*, 2025). Numerous studies have investigated the impact of geopolitical uncertainties on stock market returns (Pandey *et al.*, 2024; Boubaker *et al.*, 2022; Jebabli *et al.*, 2014).

Statistically the advent of “black swan” events has further influenced financial market behavior, reshaping investor preferences and risk perceptions (Rehman and Karimullah, 2024). Although ESG factors are increasingly becoming essential component of corporate strategy rather than voluntary considerations (Shalhoob and Hussainey, 2022). Moreover, the intersection of ETFs and financial markets plays a critical role in understanding how these instruments respond to evolving market conditions, especially given the shared risk exposures and asset allocation strategies of stakeholders (Pisani and Russo, 2021). Investors typically diversify portfolios by holding multiple sector-based ETFs and hedging risks through derivatives, thereby linking their risk exposures closely with the connectedness of sectoral ETFs. While the global financial sector has generally reacted negatively to recent geopolitical conflicts (Boubaker *et al.*, 2022) certain sectors, notably the defense industry, have identified emerging opportunities amid the crisis.

This paper makes several contributions are flows. First, this study adds a novel empirical investigation into the performance of S&P ESG ETFs during major geopolitical threats, such as the recent Israel–Palestine and the Ukraine–Russia wars, both of which have introduced heightened market volatility and uncertainty. The study evaluates their capacity to balance financial risk management with sustainability principles. Given the growing prominence of sustainable finance, understanding ESG ETF behavior during extreme conditions is crucial for investors and policymakers alike.

Second, the study investigates the long-term stability of S&P ESG ETFs during prolonged geopolitical crises rather than short-term market shocks. This approach provides deeper insights into the capacity of ESG investments to withstand persistent volatility and uncertainty, thereby highlighting their long-term risk management potential. While previous studies have commonly employed methods such as quantile regression (Luo and Sun, 2024), and hierarchical linear regression (Figueiredo *et al.*, 2022) to examine these effects. Third, the paper provides a comparative analysis of ESG ETFs performance across different types of geopolitical crises and underscores the diversification benefits of ESG investments in crisis and highlighting their potential as resilient instruments in navigating multiple forms of geopolitical turbulence.

Our study show that TCI reached to 56.53% during the Israel–Palestine war compared to the Russia–Ukraine conflict marked by 47.29%. During the Russia–Ukraine conflict, EFIV-ETF, SNPE-ETF and MIDE-ETF emerged as notable transmitters, while NSRIX was a major recipient of risk. Similar pattern was observed during the Israel–Palestine war, with EFIV-ETF and SNPE-ETF again acting as risk transmitters. By highlighting the performance and risk dynamics of S&P ESG ETFs during conflicts, the research offers valuable insights for institutional investors, asset managers and policymakers seeking resilient investment portfolios in the face of global instability.

The rest of the study is organized as follows: Section 2 discuss literature; Section 3 describes the data and methods; Section 4 documents findings and robustness; finally, Section 5 offers conclusion and implications.

2. Literature review

The current challenges and geopolitical crisis have emphasized the importance of integrating ESG factors into investment strategies. The implementation of ESG factors enhances a firm’s risk management and decision-making capacity. For instance, by analyzing daily data spanning the period from 2018 to 2022, Ali *et al.* (2024a) reveal that total connectedness intensifies at the extreme quantiles in crises. NFTs function primarily as shock transmitters,

while BRICS markets absorb these shocks in crisis. Similarly, [Shalhoob and Hussainey \(2022\)](#) investigate the effect of ESG disclosure practice on the sustainability performance of SMEs (Small and medium enterprises) in Saudi Arabia. The authors reveal a lack of awareness of ESG disclosure for investors and assist SMEs in implementing ESG practices.

According to stakeholder theory, the investors play a crucial role in a business's success, profitability, stability, growth and risk-taking on financial performance ([Dao and Phan, 2023](#)). Companies that maintain strong relationships with their stakeholders tend to enhance their financial performance ([Freeman, 1984](#)). Moreover, the signaling theory highlights that firms may use sustainability disclosure to demonstrate their commitment and attention to social matters ([López-Santamaría et al., 2021](#)). While employees can improve a company's financial and managerial performance ([Alnafrh, 2024](#); [Kilic et al., 2022](#); [Shah et al., 2025](#); [Luo and Sun, 2024](#)).

Regarding portfolio performance, [Dumitrescu et al. \(2023\)](#) reported that equally weighted Socially Responsible Investment (SRI) ETFs underperformed compared to their benchmarks over the long term, while this trend has recently changed. [Lei et al. \(2023\)](#) showed that palladium emerged as a preferable short-term safe haven for developed ESG markets in North America, Europe and the Asia-Pacific, whereas gold confirmed limited protective benefits throughout most of the examined period. [Liu et al. \(2024\)](#) documented a valuable perspective on the resilience of ESG investments during severe climate uncertainties, finding reduced transmission of shock spillovers between conventional and ESG assets and thereby suggesting possible diversification advantages.

These geopolitical crises have not only disrupted international markets but also emphasized on maintaining portfolio resilience. [Zhu et al. \(2025\)](#) argue that geopolitical uncertainties significantly exacerbate price volatility, disrupting supply chains and changing policy priorities. By examining a sample of 94 countries, [Boungou and Yatié \(2022\)](#) demonstrated that the geopolitical crisis has a negative impact on countries condemning the war and those that share borders with Russia and Ukraine. ESG ETFs during turbulent times, providing valuable insights into their role in stabilizing the spillover volatility among markets ([Xu et al., 2024](#); [Shalhoob and Hussainey, 2022](#); [Luo and Sun, 2024](#)). [Xu et al. \(2024\)](#) reveal that European ETFs dominate the global ESG system, not only due to their size and market maturity, but also because of their ability to significantly reduce portfolio volatility.

Recent empirical studies ([Pisani and Russo, 2021](#); [Ullah et al., 2024](#); [Pandey et al., 2024](#); [Zhu et al., 2025](#); [Ghallabi et al., 2025](#); [Ali et al., 2024b](#)) have further investigated the interconnection and spillover effects among climate-related assets, clean and dirty energy markets and broader cross-markets dynamics during crisis periods. [Kilic et al. \(2022\)](#) demonstrate notable co-movement patterns between ESG performance and stock markets returns across different frequencies, particularly during times of financial crises.

During the Russia-Ukraine conflict, [Ghallabi et al. \(2025\)](#) identified a substantial linkage between clean energy stock returns and ESG market indices. Their analysis revealed that ESG markets in India and the USA exhibit robust predictive capabilities for clean energy stocks, whereas the influence of ESG markets in Australia and South Africa is comparatively weaker. During the COVID-19 pandemic, S&P ESG ETFs demonstrated notable resilience, as firms with strong ESG practices were better positioned to adapt to energy market disruptions and regulatory changes ([Pandey et al., 2024](#); [Ali et al., 2024b](#)). [Alnafrh \(2024\)](#) highlight a remarkable negative impact of geopolitical crisis on non-ESG companies. According to [Ali et al. \(2024b\)](#), the application of the DCC-GARCH model shows that including renewable energy tokens in BRICS-based portfolios enhances diversification benefits and risk reduction, particularly under normal market conditions.

However, [Bajra et al. \(2025\)](#) found that geopolitical tensions predominantly influence Green Bond ETFs, which provide a degree of stability during uncertain periods of market volatility. Though, equities – especially Global and ESG Equity ETFs – exhibit differing levels of sensitivity to geopolitical risks and market fluctuations. The authors also found that cryptocurrencies display a sharp sensitivity to the VIX, with some assets showing moderate

responses to geopolitical risk premium (GPR). [Han \(2024\)](#) explores the transmission of risk between ETFs in geopolitical crisis. The ETFs experiences a moderate increase following these conflicts, suggesting heightened interdependence during geopolitical uncertainty. [Dumitrescu et al. \(2023\)](#) outline that SRI ETFs do not consistently underperform compared to their non-SRI counterparts. Their results show a significant growth in the SRI sector; the performance of SRI ETFs was statistically comparable to that of the benchmark ETFs during COVID-19.

While previous studies ([El Khoury et al., 2023](#); [Gabr and ElBannan, 2024](#)) have examined ESG investments and ETFs during crises, most have focused on limited regions, asset classes or single crisis events. Little attention has been paid to the dynamic risk transmission and interconnectedness of sustainable ETFs across multiple, overlapping crises such as the Russia–Ukraine and Israel–Palestine conflicts. Moreover, although studies such as ([Ghallabi et al., 2025](#)) and ([Bajra et al., 2025](#)) highlight ESG resilience, few studies have explored detailed spillover effects between ESG ETFs and energy markets during extreme shocks. This study addresses these gaps by analyzing the dynamics of growth and crisis-related risk associated with sustainable climate ETFs under recent global crises.

3. Research methodology and data sources

3.1 Data and basic analysis

Sustainable investment can have different meanings for various investors and policy makers. Some concepts still need more clarity, such as sustainable investment, socially responsible investment, social investment. However, the incorporation of ESG criteria remains the key concept to sustainable investment. Accordingly, we have selected six of the S&P ESG ETF indices due to their standardized screening methodology, global relevance, transparency and consistent daily data availability. In addition, we included the Northern Global Sustainability Index (NSRIX), a passively managed sustainability index fund that applies ESG screening techniques comparable to those used in ETF-based methodology. Including NSRIX enables us to benchmark ETF-based ESG spillover behavior against a widely followed ESG index fund. The current study covers the entire sample period from April 16, 2021, to September 30, 2024, divided into two crisis-specific sub-samples: the Russia–Ukraine conflict (February 1, 2022, to September 30, 2023) and the Israel–Palestine war (IP-war) (October 1, 2023, to September 30, 2024). Notably, data for the S&P ESG TEFs sustainability index (SNPG-ETF) are available from November 2022 onward. The datasets employed in this study were collected from [investing.com](#). [Table 1](#) provides detailed insights into the sustainability characteristics of the selected S&P ESG ETFs indices.

[Table 2](#) summarizes the descriptive statistics for full sample. The SNPG-ETF exhibited the lowest mean return (−0.31276), indicating modest returns, whereas E200-ETF had the highest mean return (−0.01535), reflecting a weak performance. This implies that these ETFs have struggled over the entire period, possibly due to persistent market volatility. The maximum values reveal significant variability, particularly for NSRIX (4.469), whereas the negative minimum values underscore noteworthy downturns. In addition, according to the standard

Table 1. Sustainability S&P ESG ETFs indices details

Ticker symbol	Index details
EFIV-ETF	SPDR S&P 500 ESG ETF (EFIV)
SNPE-ETF	Xtrackers S&P 500 ESG ETF (SNPE)
SNPG-ETF	Xtrackers S&P 500 Growth ESG ETF - SNPG - ETF
MIDE-ETF	Xtrackers S&P MidCap 400 ESG ETF
E200-ETF	SPDR S&P/ASX 200 ESG ETF (E200.ASX)
SYGESGJ-ETF	Sygnia Itrix S&P Global 1200 ESG ETF (SYGESGJ)
NSRIX	Northern Global Sustainability Index Fund Class I

Table 2. Descriptive statistics

	EFIV- ETF	SNPE- ETF	SNPG- ETF	MIDE- ETF	E200- ETF	SYGESGJ- ETF	NSRIX
Mean	-0.08597	-0.08615	-0.31276	-0.04443	-0.01535	-0.06829	-0.07633
Median	-0.06946	-0.09563	-0.06299	-0.10135	-0.08127	-0.08026	-0.05741
Maximum	3.252033	3.281447	4.0088	3.030303	3.743316	4.42976	4.469607
Minimum	-5.25066	-5.31617	-100	-5.5381	-1.8378	-7.01925	-5.40223
Std. dev.	0.891135	0.904341	4.692426	1.113807	0.76328	1.011352	0.89673
Skewness	-0.21952	-0.19814	-20.2414	-0.10667	0.687647	-0.50074	-0.08367
Kurtosis	5.387471	5.356389	430.6401	4.254013	4.384407	7.865973	6.589696
Jarque-Bera	116.6278	113.0028	3,651,858	32.02414	75.36701	488.4717	255.588
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Note(s): This table presents the mean, median, standard deviation, minimum and maximum values of the selected variables

Source(s): Author created using R

deviations (Std. Dev), SNPG-ETF was the riskiest ETFs, followed by MIDE-ETF and SYGESGJ-ETF. The Jarque-Bera test results, all with probability values at zero, strongly indicate non-normal distributions across the data. [Figure 1](#) presents the time series trend of the selected market over the sample period.

3.2 Econometric TVP-VAR approach

Previous studies on connectedness have relied on time-series techniques but often ignore frequency-based variations. To overcome this, we use the TVP-VAR framework, which avoids arbitrary rolling windows and captures dynamic interconnections ([Antonakakis and Gabauer, 2017](#)). Its parameters follow a first-order random walk, allowing both temporary and permanent changes ([Nakajima, 2011](#)). Recent studies frequently employ this method to evaluate interconnectedness in time series data ([Shah et al., 2025](#); [Jebabli et al., 2014](#)). We

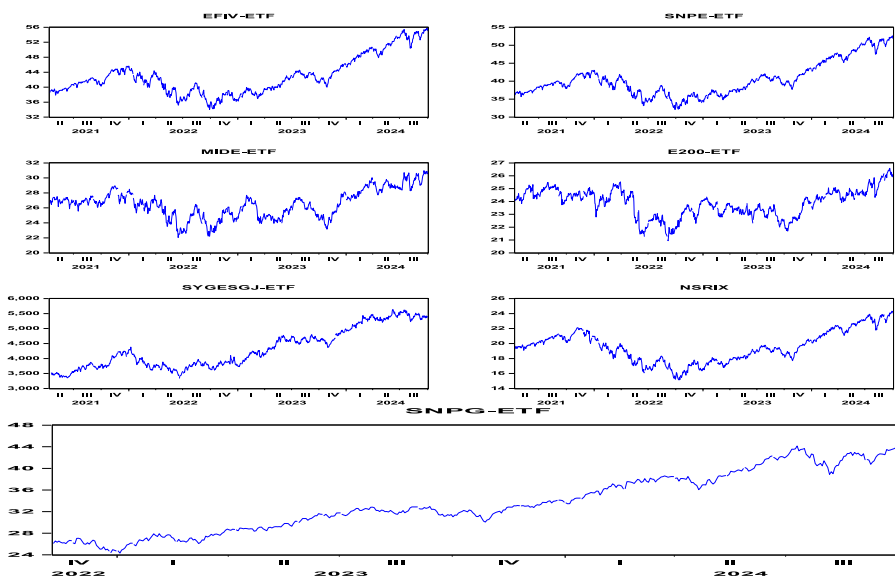


Figure 1. Time series graph of the selected indices. Source: Author created using R

combine it with the [Diebold and Yilmaz \(2009, 2012\)](#) framework and [Antonakakis et al. \(2020\)](#) to analyze risk spillovers and connectedness in S&P ESG ETFs.

One way to characterize the TVP-VAR approach is:

$$y_t = \beta_t z_{t-1} + \epsilon_t; \epsilon_t | F_{t-1} \sim N(0, S_t) \quad (1)$$

$$\text{vec}(\beta_t) = \text{vec}(\beta_{t-1}) + v_t; v_t | F_{t-1} \sim N(0, R_t) \quad (2)$$

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where y_t and $z_t = [y_{t-1}, \dots, y_{t-p}]'$ denote $N \times 1$ and $P \times 1$ dimensional vectors, respectively. β_t is an $N \times N_p$ dimensional time-varying coefficient matrix and ϵ_t is an $N \times 1$ dimensional error disturbance vector with an $N \times N$ time-varying variance-covariance matrix S_t , $\text{vec}(\beta_t)$ and v_t are $N_p^2 \times 1$ dimensional vectors and R_t is an $N_p^2 \times N_p^2$ dimensional matrix. The generalized forecast error variance decomposition (GFEVD) and generalized impulse response functions (GIRF) are then calculated using the vector moving average (VMA) model of the VAR system ([Koop et al., 1996](#)) as follows:

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

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

where $L = [I_N, \dots, 0_p]'$ is an $N_p \times N$ dimensional matrix, $W = [\beta_t; I_{N(p-1)}, 0_{N(p-1) \times N}]$ is an $N_p \times N_p$ dimensional matrix and A_{it} is an $N \times N$ -dimensional matrix. Variable i 's GIRFs show the reaction of each variable to a shock.

$$\text{GIRF}_t(K, \delta_{j,t} F_{t-1}) = E(y_{t+K} | \epsilon_{j,t} = \delta_{j,t} F_{t-1}) - E(y_{t+K} | F_{t-1}) \quad (5)$$

$$\psi_{j,t}^g(K) = \frac{A_{K,t} S_t \epsilon_{j,t}}{\sqrt{S_{j,j,t}}} \frac{\delta_{j,t}}{\sqrt{S_{j,j,t}}} \delta_{j,t} = \sqrt{S_{j,j,t}} \quad (6)$$

$$\psi_{j,t}^g(K) = \frac{A_{K,t} S_t \epsilon_{j,t}}{\sqrt{S_{j,j,t}}} \quad (7)$$

where $\psi_{j,t}^g$ show the GIRFs of variable j th and k th predicted horizon, $\delta_{j,t}$ the selected vector with one in the j th place and zeros otherwise and F_{t-1} the data set until $t-1$. Afterwards, the GFEVD, which denotes the percentage of variation attributed to one variable by another, can be calculated using the following procedure:

$$\tilde{\Phi}_{ij,t}^g(K) = \frac{\sum_{t=1}^{K-1} \psi_{j,t}^{2,g}}{\sum_{j=1}^N \sum_{t=1}^{K-1} \psi_{j,t}^{2,g}}; \sum_{j=1}^N \tilde{\Phi}_{ij,t}^g(K) = 1 \text{ and } \sum_{j=1}^N N_{ij,t}^g(K) = N \quad (8)$$

The impact of one variable on other variables can be investigated using the total connectedness index (TCI), as details in [Equation \(7\)](#).

$$C_t^g(K) = \frac{\sum_{i,j=1, i \neq j}^N \tilde{\Phi}_{ij,t}^g(K)}{N} * 100 \quad (9)$$

There are three methods used to determine directional connectedness: Firstly, the following is the definition of total directed interconnection with others:

$$C_{i \rightarrow j,t}^g(K) = \frac{\sum_{i,j=1}^N \sum_{i \neq j} \tilde{\Phi}_{ij,t}^g(K)}{\sum_{i,j=1}^N \tilde{\Phi}_{ij,t}^g(K)} * 100 \quad (10)$$

Second, total directional interconnection differs from others in the following ways:

$$C_{i \leftarrow j,t}^g(K) = \frac{\sum_{i,j=1}^N \sum_{i \neq j} \tilde{\Phi}_{ij,t}^g(K)}{\sum_{j=1}^N \tilde{\Phi}_{ij,t}^g(K)} * 100 \quad (11)$$

Nevertheless, the net total directional interconnectedness is calculated by deducting [equation \(11\)](#) from [equation \(10\)](#).

$$C_{i,t}^g(K) = C_{i \rightarrow j,t}^g(K) - C_{i \leftarrow j,t}^g(K) \quad (12)$$

[Equation \(12\)](#) illustrates the impact of stock prices on the analysis network. To compute the net pair-wise directional connectedness (NPDC), however, additional investigation into the bidirectional linkages yields the following formula:

$$NPDC_{i,j}(K) = \tilde{\Phi}_{ij,t}^g(K) - \tilde{\Phi}_{ji,t}^g(K) \quad (13)$$

[Equation \(13\)](#), a positive NPDC value implies that variable j th dominates variables i th, while a negative NPDC value suggests the opposite.

4. Findings and discussion

4.1 Dynamic total connectedness index

We first compute ([Table 3](#)) that during the entire sample period, the TCI stands at 47.26% (see [Figure 2a](#)), indicating a moderate to high degree of interconnected tail risks among the analyzed markets. The NET values provide insight into whether a market acts as a transmitter or receiver of volatility spillovers. Some markets such as EFIV-ETF (48.05%) and SNPE-ETF (48.68%) exhibit positive NET values, indicating they acted as net transmitters of risk and volatility spillovers during times of geopolitical threat. These insights align well with findings of previous studies ([D'Ecclesia et al., 2024](#); [Jebabli et al., 2014](#)). Moreover, [Ji et al. \(2024\)](#) demonstrate that different types of ETFs become increasingly interconnected during times of crisis. Similarly, [Esmailpour Moghadam \(2023\)](#) examines the role of ETFs in shaping interdependent stock market returns in emerging markets. In contrast, markets such as SNPG-ETF (−6.97%), MIDE-ETF (−4.85%), E200-ETF (−3.36%), SYGESGJ-ETF (−4.17%), NSRIX (−77.40%) show negative NET values, identifying them as net receivers of shocks. These markets absorbed more risk and shock from external sources than transmitted, highlighting their vulnerability to spillovers during the geopolitical threat period.

During the Russia–Ukraine conflict period, we observe that TCI represents 56.53%, demonstrating a moderate to high degree of interconnected tail risk among the analyzed markets. This suggests a significant level of risk transmission and volatility spillover during this period of geopolitical risks, aligning with prior studies ([Angelini et al., 2022](#); [Adeosun et al., 2024](#)). EFIV-ETF (44.35%), SNPE-ETF (44.78%) and MIDE-ETF (17.77%) act as main net transmitters of risk, meaning they contribute more volatility to the system than they absorbed. Conversely, E200-ETF (−9.20), SYGESGJ-ETF (−15.42) and NSRIX (−85.10) exhibited negative NET values, identifying them as net recipients of risk. Notably, NSRIX emerged as a significant absorber of systemic shocks during this period. Markets such as

Table 3. Dynamics connectedness analysis

	EFIV-ETF	SNPE-ETF	SNPG-ETF	MIDE-ETF	E200-ETF	SYGESGJ-ETF	NSRIX	FORM
<i>Israel–Palestine (IP-war)</i>								
EFIV ETF	29.08	28.80	25.47	14.11	1.20	0.09	1.24	70.92
SNPE ETF	28.94	29.17	25.36	14.23	1.07	0.10	1.13	70.83
SNPG ETF	28.65	28.33	32.62	8.69	0.83	0.09	0.79	67.38
MIDE ETF	20.97	20.99	11.80	40.78	2.83	0.55	2.08	59.22
E200 ETF	3.69	3.23	2.59	5.37	83.23	0.60	1.29	16.77
SYGESGJ ETF	3.81	3.94	3.41	3.30	0.70	82.93	1.91	17.07
NSRIX	26.62	26.63	22.71	16.42	0.94	0.23	6.46	93.54
TO	112.68	111.93	91.34	62.12	7.57	1.65	8.44	395.73
Inc.Own	141.76	141.10	123.96	102.90	90.80	84.58	14.90	cTCI/TCI
NET	41.76	41.10	23.96	2.90	−9.20	−15.42	−85.10	65.69/56.53
NPT	6.00	5.00	4.00	3.00	1.00	0.00	2.00	
<i>RU-war Sample</i>								
EFIV ETF	35.24	35.07	6.60	22.56	0.22	0.19	0.13	64.76
SNPE ETF	35.03	35.21	6.64	22.59	0.23	0.18	0.12	64.79
SNPG ETF	9.93	10.06	72.45	6.84	0.25	0.34	0.13	27.55
MIDE ETF	26.78	26.88	5.17	39.85	0.43	0.27	0.63	60.15
E200 ETF	1.71	1.74	0.73	1.64	91.72	2.07	0.38	8.28
SYGESGJ ETF	1.58	1.59	0.73	1.44	1.43	92.84	0.40	7.16
NSRIX	34.09	34.24	6.77	22.84	0.27	0.15	1.64	98.36
TO	109.12	109.57	26.63	77.92	2.84	3.20	1.78	331.05
Inc.Own	144.35	144.78	99.08	117.77	94.56	96.04	3.42	cTCI/TCI
NET	44.35	44.78	−0.92	17.77	−5.44	−3.96	−96.58	NET 55.18/47.29
NPT	5.00	6.00	3.00	4.00	0.00	1.00	2.00	NPT
<i>Full Sample</i>								
EFIV ETF	37.95	37.64	9.81	13.38	0.35	0.20	0.66	62.05
SNPE ETF	37.56	37.91	9.80	13.50	0.34	0.19	0.71	62.09
SNPG ETF	16.31	16.82	56.16	7.33	0.85	0.51	2.02	43.84
MIDE ETF	23.69	23.79	6.13	39.35	0.80	0.51	5.73	60.65
E200 ETF	1.23	1.17	0.93	1.96	92.75	1.23	0.72	7.25
SYGESGJ ETF	1.55	1.56	0.99	1.25	1.14	92.90	0.62	7.10
NSRIX	29.77	29.80	9.20	18.38	0.41	0.30	12.14	87.86
TO	110.11	110.77	36.87	55.80	3.89	2.94	10.47	330.85
Inc.Own	148.05	148.68	93.03	95.15	96.64	95.83	22.60	cTCI/TCI
NET	48.05	48.68	−6.97	−4.85	−3.36	−4.17	−77.40	55.14/47.26
NPT	5.00	6.00	3.00	4.00	0.00	1.00	2.00	
Note(s): This table illustrates the TCI capturing systemic risk dynamics across assets								
Source(s): Author created using R								

SNPG-ETF (−0.92%), E200-ETF (−5.44%), SYGESGJ-ETF(−3.96%) and NSRIX (−96.5%) exhibit negative NET values, indicating that they function as net recipients of volatility spillovers absorbing more shock than they influencing them and are consistent with previous literature (Alnafrah, 2024; Ullah et al., 2024; Xu et al., 2024).

During the Israel–Palestine conflict sample period, TCI is 56.53%, reflecting a higher degree of risk interconnectedness. We observe that EFIV-ETF (41.76), SNPE-ETF (41.10), SNPG-ETF (23.96) and MIDE-ETF (2.90) are found to be net transmitters of volatility to all other variables, while E200-ETF (−9.20), SYGESGJ-ETF (−15.42) and NSRIX (−85.10) are continued to act as major net recipients of volatility from all the other variables during

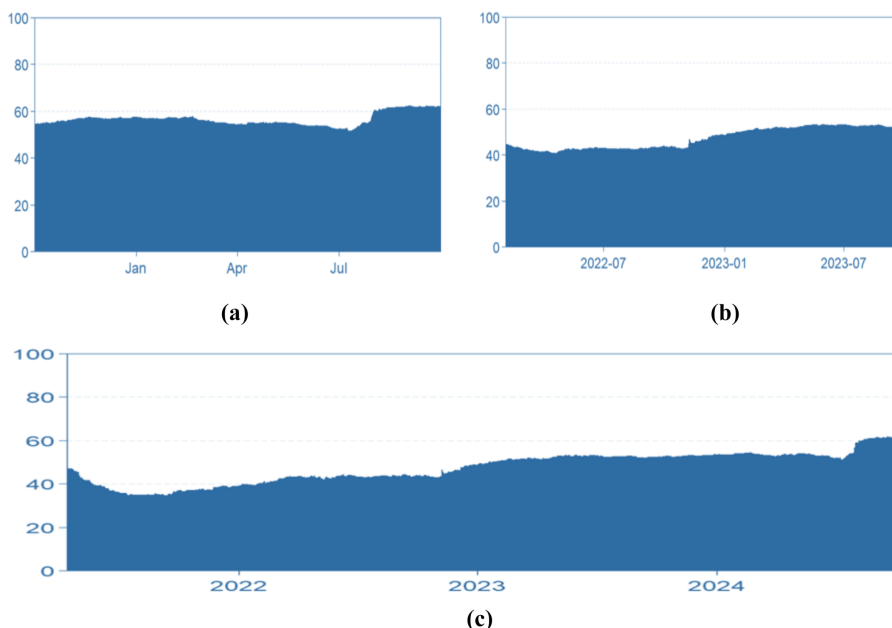


Figure 2. (2a, 2b, 2c): Total connectedness index. Note: This figure plots the dynamic evolution of the Total Connectedness Index over time. Source: Author created using R

IP-conflict. This pattern is consistent with prior research (Lin and Swain, 2024) in crisis (Sharma and Talan, 2020) and in context of policy uncertainty (Banerjee *et al.*, 2024). Raza *et al.* (2024) discover that climate policy uncertainty increases the volatility of the S&P Global Clean Energy Index, the S&P Green Bond Index and the Dow Jones Sustainability Index.

Figure 2a shows that dynamic total connectedness during the Israel–Palestine war ranges from 45% to 64%, remaining relatively stable but rising around July, reflecting stronger market interdependence and reactions to conflict escalations. In contrast, Figure 2b indicates lower connectedness during the Russia–Ukraine conflict (43%–55%), with a modest increase in early 2023 followed by a decline, suggesting that markets gradually adapted and had largely priced in the conflict risk. Figure 2c, covering the full sample (April 2021–September 2024), reveals persistently high connectedness (45%–62%), with the strongest spike linked to Middle East tensions. These findings highlight that geopolitical crises significantly increase interconnectedness among ESG ETFs and financial markets, reducing diversification benefits. The sharp rise in the TCI during periods of geopolitical stress suggests that ESG investors should actively adjust portfolios to manage risk and exploit opportunities arising from stronger cross-market linkages, consistent with (Gao *et al.*, 2024; Xu *et al.*, 2024).

4.2 Net and pairwise connectedness

Figure 3a presents the dynamic pairwise connectedness among ETFs, with values ranging from 20 to 80, indicating varying degrees of spillover effects and market interdependence. Connectedness generally increases from 2022 to 2024, particularly for pairs such as EFIV-ETF, SNPG-ETF and SNPE-ETF-NSRIX, reflecting the influence of changing macroeconomic conditions, geopolitical uncertainty and growing interest in sustainable investments. While some ETF pairs exhibit persistently high connectedness, suggesting strong co-movement and shared risk exposure, others, such as SYGESGJ-ETF and E200-ETF,

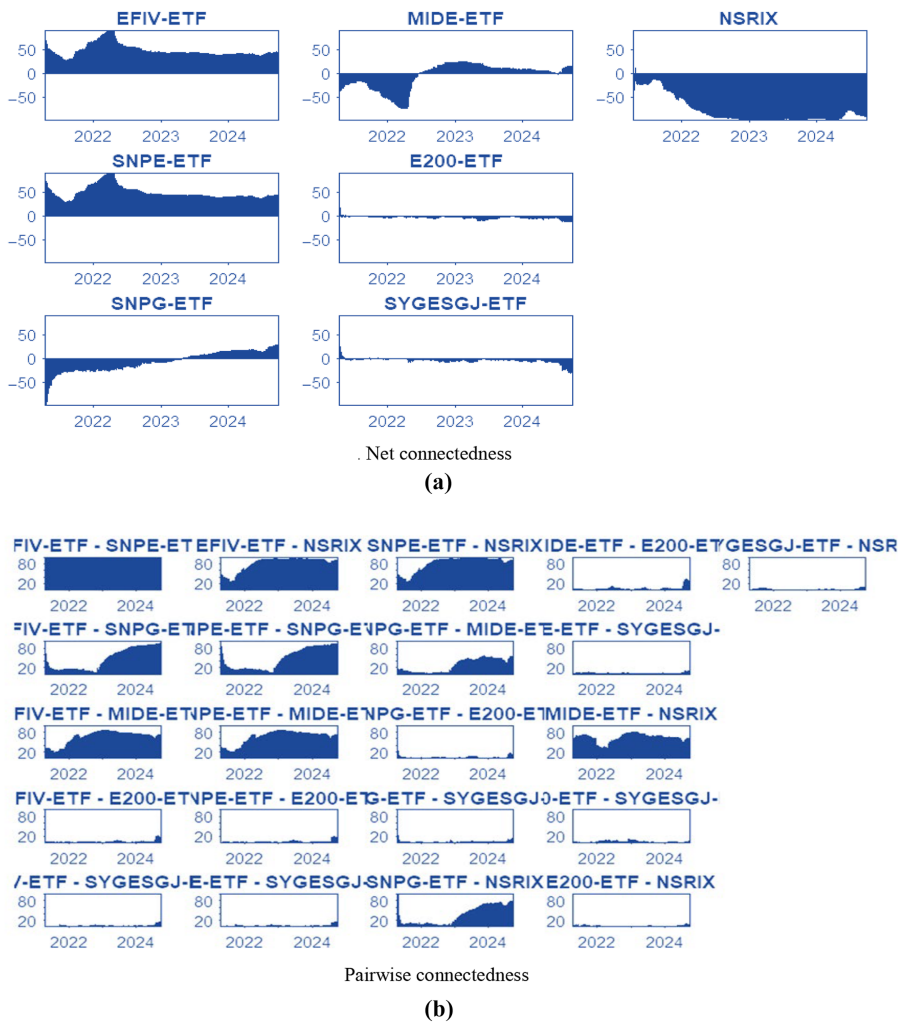


Figure 3. Net and Pairwise connectedness of full samples. Note: This figure displays the net directional and pair wise connectedness across assets. Source: Author created using R

maintain lower and more stable levels, offering greater diversification potential. The increase in connectedness is especially evident around major geopolitical events, notably the Israel–Palestine conflict and regulatory developments during 2023–2024. Overall, the results indicate a growing integration between ESG ETFs and broader financial markets. Higher connectedness may increase systemic risk, whereas lower-connected assets can provide diversification benefits, underscoring the importance of active risk management and portfolio adjustment in sustainable investing.

Figure 3b illustrates pairwise connectedness such as EFIV-ETF, SNPG-ETF and SNPE-ETF-NSRIX, signifying that market connections have intensified from 2022 to 2024. While some ETF pairs reveal persistently high levels of connectedness, indicating strong co-movements and shared risk factors, others, like SYGESGJ-ETF & E200-ETF, reveal more stable and lower interconnectedness that could offer enhanced diversification opportunities.

The figure also reveals the impact of crises and market shocks, as the rise in pairwise connectedness correlates with major geopolitical events and regulatory shifts, thereby reinforcing the interconnectedness among ESG and financial assets.

4.3 Network connectedness

Figures 4a and 4b reveal notable changes in volatility spillover dynamics across geopolitical conflict periods. During the Israel–Palestine conflict, SNPG-ETF, EFIV-ETF, SNPE-ETF and MIDE-ETF act as net transmitters of volatility spillovers, whereas NSRIX emerges as the strongest recipient of shocks, indicating substantial risk transmission between climate-focused investments and ESG ETFs. During the Russia–Ukraine conflict, NSRIX remains the largest recipient of volatility spillovers, while SNPG-ETF shifts from being a net transmitter to a net recipient of shocks. In contrast, EFIV-ETF, SNPE-ETF and MIDE-ETF continue to transmit shocks to other markets. Over the full sample period (Figure 4c), NSRIX remains the primary shock receiver and maintains strong connections with other ETFs, particularly EFIV-ETF and SNPE-ETF, while MIDE-ETF is the dominant transmitter of shocks. Conversely, SNPE-ETF, SNPG-ETF and E200-ETF exhibit relatively weaker network linkages, suggesting lower exposure to systemic risk and a limited role in propagating volatility. These findings highlight the evolving nature of market reactions to geopolitical shocks and underscore the importance of understanding interconnectedness within ESG investment markets (Xu *et al.*, 2025).

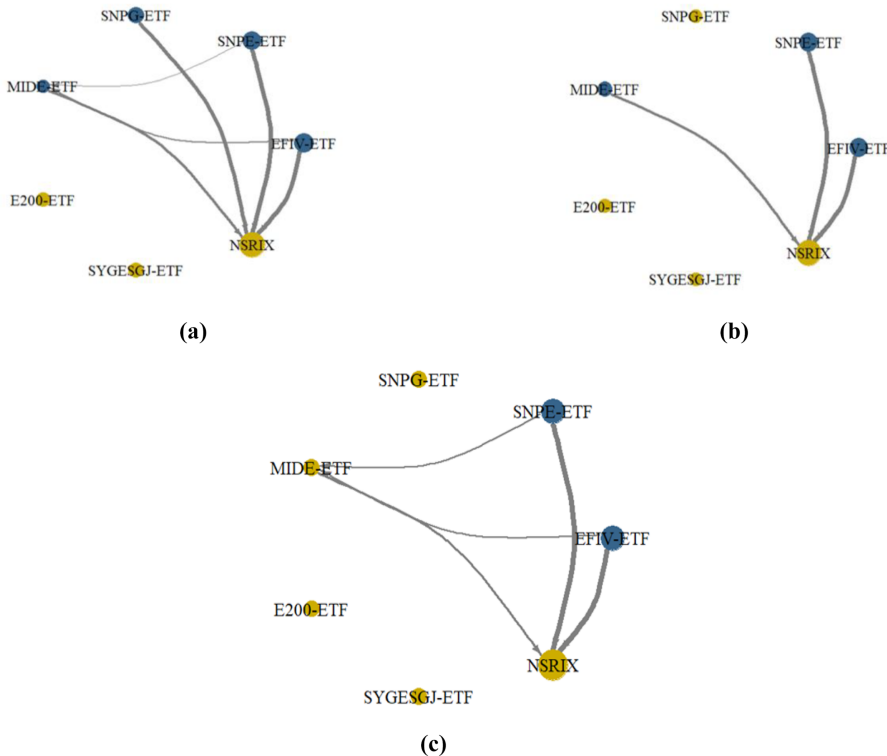
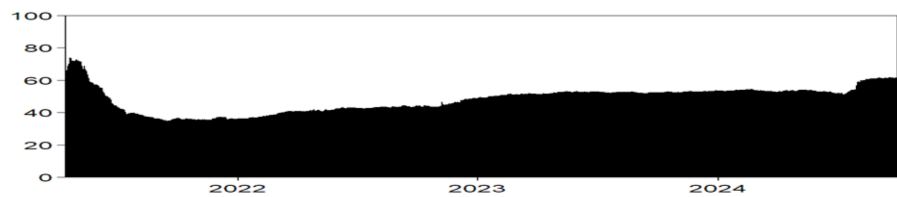


Figure 4. Network connectedness. Note: This figure visualizes the network nodes and arrows/colors interconnectedness structure among assets based on spillover intensity. Source: Author created using R

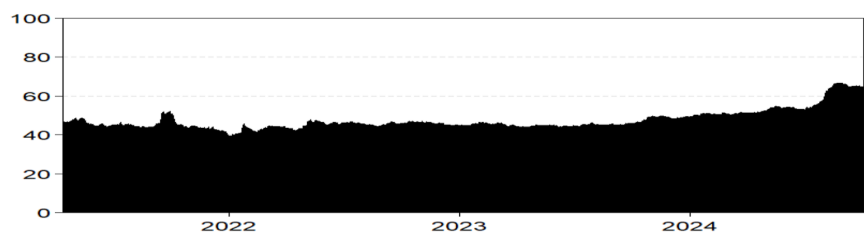
4.4 Robustness

Figure 5 illustrates the TCI over a window size of 20, highlighting the stability and resilience of the relationships between S&P ESG ETFs and the Northern Global Sustainability Index (NSRIX) throughout the entire sample period. In Figure 5, the TCI computed using an alternative lag length specification ($nlag = 2$) remains largely consistent with the baseline full-sample results, and TCI estimated under an extended forecast horizon ($nfore = 20$) shows comparable magnitude and pattern to the baseline TCI, indicating that the connectedness structure is stable across different forecast horizons and further validating the reliability of the results.

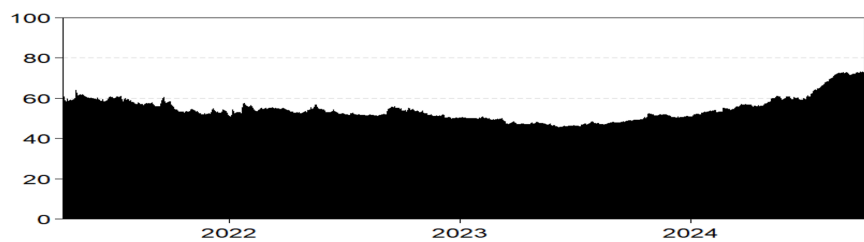
The static VAR connectedness results reported in Table 4 provide a strong robustness check for the full-sample dynamic connectedness analysis. Specifically, the overall TCI from the



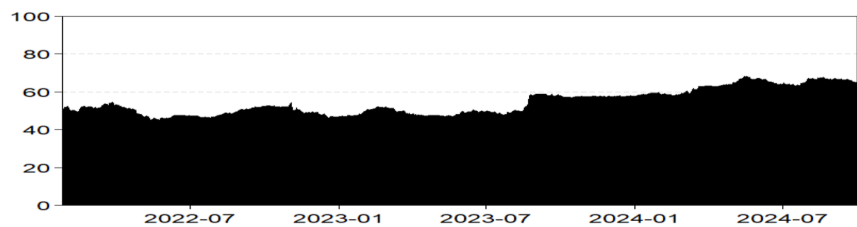
TCI at reduced window size



TCI at change for lag ($nleg=2$)



TCI at change for forecasted horizon ($nfore=20$)



TCI at STATIC-VAR

Figure 5. Total connectedness index full sample at reduced window size – Robustness test

Table 4. STATIC-VAR connectedness analysis

	EFIV-ETF	SNPE-ETF	SNPG-ETF	MIDE-ETF	E200-ETF	SYGESGJ-ETF	NSRIX	FROM
EFIV-ETF	35.55	35.49	11.84	13.1	2.76	0.65	0.61	64.45
SNPE-ETF	35.51	35.54	11.83	13.12	2.74	0.64	0.62	64.46
SNPG-ETF	14.8	14.73	59.24	3.65	4.24	1.12	2.21	40.76
MIDE-ETF	26.91	26.97	6.3	30.22	5.45	1.5	2.65	69.78
E200-ETF	2.35	2.37	2.21	1.56	89.14	1.35	1.02	10.86
SYGESGJ-ETF	11.01	10.79	8.95	4.3	2.45	60.87	1.62	39.13
NSRIX	30.22	30.36	11.75	14.07	2.76	2.61	8.24	91.76
TO	120.81	120.71	52.88	49.8	20.39	7.88	8.73	381.2
Inc.Own	156.36	156.25	112.12	80.02	109.53	68.75	16.97	cTCI/TCI
NET	56.36	56.25	12.12	-19.98	9.53	-31.25	-83.03	63.53/54.46
NPT	5	4	3	2	6	1	0	

Note(s): This table illustrates the static-VAR across assets

Source(s): Author created using R

static VAR framework (54.46%) is broadly comparable to the dynamic framework (47.26%), indicating a consistent level of spillover intensity across methodologies.

5. Conclusion and policy implications

This study investigates the static and dynamic volatility interconnectedness among ESG ETFs and the transmission of risk during recent geopolitical conflicts, specifically the Russia–Ukraine conflict and the Israel–Palestine war. Using the TVP-VAR approach, we analyzed daily returns of six selected S&P ESG ETF indices (EFIV-ETF, SNPE-ETF, SNPG-ETF, MIDE-ETF, E200-ETF and SYGESGJ-ETF) alongside the Northern Global Sustainability Index (NSRIX). The results provide novel evidence on the evolving risk dynamics and spillover behavior within sustainability-focused financial markets, revealing important implications for both investors and policymakers. The TCI index shows that the strong effects of crisis risk transmission between markets increase more intensely in conflict events. These frequent geopolitical tensions and fragmentations have profoundly affected the energy markets.

Notably, certain ESG-ETFs, such as EFIV-ETF and SNPE-ETF, emerged as consistent transmitters of volatility spillovers, contributing to heightened volatility across the market. While some others, such as NSRIX, acted predominantly as risk absorbers, reflecting their relative vulnerability and sensitivity to external shocks. These insights demonstrate that geopolitical tensions can aggravate interconnectedness among sustainability-focused financial instruments, thereby complicating investment strategies and risk management for ESG-focused investors. As connectivity increases among these sustainability ETFs, the effectiveness of traditional diversification strategies may be reduced, necessitating a reevaluation of portfolio compositions. Our dynamic analysis indicates that while some funds retain resilience, serve as potential safe havens, others are highly sensitive to market fluctuations induced by political events. These findings underscore the importance of integrating ESG strategies into investment choices, particularly within the evolving landscape of sustainable finance.

This study offers valuable insights for policymakers and regulators. From an investment perspective, these findings suggest several actionable strategies. First, investors and portfolio managers should adopt dynamic portfolio allocation strategies under turbulent conditions, reallocating capital toward ESG-ETFs that demonstrate resilience or safe-haven characteristics. Second, ESG-based hedging tactics, such as combining ESG-ETFs with lower-connected sustainability indices or complementary green assets, may help mitigate

heightened volatility spillovers. Third, fund managers should reassess ESG screening and weighting methodologies, particularly during geopolitical turmoil, to account not only for ESG scores but also for connectedness and spillover exposure. These adjustments can improve risk-adjusted returns and enhance portfolio robustness under extreme uncertainty.

For policymakers and regulators, the results underscore the importance of strengthening ESG market infrastructure. Policymakers should encourage deeper corporate ESG integration through targeted incentives, including tax benefits, preferential financing and sustainability-linked subsidies, thereby enhancing market stability during crises. Regulators are encouraged to update disclosure and assessment standards by incorporating ESG performance metrics alongside traditional financial indicators, ensuring better transparency and alignment between financial returns and social responsibility. For academics and researchers, explore the deeper interplay between ESG performance and geopolitical risk to guide future sustainable finance models.

At the corporate level, firms should strengthen ESG disclosures and embed sustainability practices into core business strategies to build resilience against geopolitical and sustainability-related financial shocks. Enhanced ESG transparency not only supports investor decision-making but also fosters stronger relationships with regulators and policymakers.

This study is limited to ESG and climate-focused ETFs and does not include a conventional ETF market, which may restrict direct comparison between ESG and non-ESG dynamics. Future research should extend this analysis by incorporating conventional (non-ESG) benchmark assets to enable direct comparison between ESG and broader market dynamics during crisis periods. Additionally, examining ESG ETFs across both developed and emerging markets would improve the generalizability of the findings.

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