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ENERGY MARKET DECOUPLING UNDER GLOBAL SHOCKS- EVIDENCE FROM RENEWABLE AND NON-RENEWABLE ENERGY INDICES

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Abstract

This study evaluates the financial sensitivity and risk-return adjustments of global renewable and non-renewable energy equity indices across a multi-class panel of 24 major exogenous shocks from 2018 to 2024. Using a market model-based event study methodology, we isolate daily Cumulative Average Abnormal Returns (CAAR) within various event windows to explore tensions between market efficiency, green asset pricing, and financial contagion theories. The empirical findings reveal distinct, shock-dependent valuation channels. Geopolitical conflicts trigger an energy-security decoupling channel, driving independent, statistically significant positive abnormal returns for renewables. Conversely, global macroeconomic collapses and public health crises activate a systemic contagion compression channel that synchronises downward risks and dissolves green asset premiums. Finally, climate policies and environmental anomalies induce asymmetric, idiosyncratic valuation drifts. Baseline estimations are fully cross-validated using alternative benchmarks and compressed event windows ([t−1, t+1]), demonstrating complete directional invariance and robust informational processing velocity.

Keywords: Renewable Energy; Fossil Fuels; Exogenous Shocks; Event Study; Market Model; Asset Pricing Decoupling; Financial Contagion.

JEL Classification: G14; Q43; Q56; G01.

1. Introduction

Global energy is transforming on a scale and with a scope unprecedented in history. Driven by climate risks and volatile commodity markets, global investment is pivoting away from high-carbon fossil fuels and channelling into renewable energy infrastructure. However, this transition does not happen in a stable macroeconomic vacuum. This involves military conflicts, sovereign debt crises, the pandemic, and sudden political changes. How the equity markets price these disruptions along the clean and brown energy divide is an empirical question with important implications for portfolio risk management, climate finance and green industrial policy. The equity pricing of conventional energy firms introduces a significant empirical friction, given that their cash flows and valuations remain tethered to the institutional mechanisms of a cartelized product market.

Similarly, the geopolitical supply shocks quickly transmit into spot prices and corporate cash streams in these commodity markets (Hamilton, 2009; Reboredo , 2015). In contrast, renewable energy equities primarily derive their valuation from long-duration cost, which are typically incurred in terms of the capital expenditure, and the policy credibility of multi-decade regulatory frameworks such as the Paris Agreement and EU Green Deal (Pástor et al., 2021; Naeem et al., 2021). One might therefore expect the two sectors to decouple meaningfully during periods of geopolitical stress. The fossil fuel assets would be impacted by the supply-side tail risks, while clean energy assets would benefit from accelerated policy responses designed to reduce import dependency (IEA, 2022).

The empirical record, however, is less straightforward. During acute phases of systemic liquidity contraction, which happened in the March 2020 pandemic shock, being the clearest recent illustration where cross-asset correlations compressed sharply, temporarily erasing sector-specific distinctions as investors engage in broad-based risk-off liquidation (Broadstock et al., 2021; Zhang et al., 2020). Whether this convergence is transitory or indicative of a deeper structural integration between energy asset classes is a question existing literature has not resolved satisfactorily.

A vast literature on energy market volatility and financial contagion has emerged in the past decade. The concept of directional volatility spillovers across asset classes was first created by Diebold and Yilmaz (2012). Later, it was extended to energy markets by Baruník and Křehlík (2018). Recently, Pham (2021) and Foglia et al. (2022) have applied this to clean and brown energy nexus. Event study approaches have been efficiently applied to isolated shocks such as the 2010 Gulf of Mexico oil spill (Ritchie et al., 2014), Brexit (Ramiah et al., 2017) and individual pandemic milestones (Yousaf, 2021). However, there is a lack of comparative, multi-shock analysis that systematically maps out how different crisis archetypes create asymmetric responses in clean and conventional energy sectors. As Baker et al. (2016) show, policy uncertainty is a first-order driver of asset price dynamics broadly. Translating this insight from the world of financial markets to the energy transition context requires the multi-event analysis that this paper is trying to solve.

Using a Market Model based event study framework, we examine the short-run market reactions of four major energy sector benchmarks. These are the S&P 500 Energy Index, the MSCI World Energy Index, the S&P Global Clean Energy Index, and the NASDAQ Clean Edge Green Energy Index. To delve further, we have identified 24 exogenous shocks that occurred between 2018 and 2024. These events are classified into five structural categories: geopolitical conflicts, public health crises, macroeconomic dislocations, domestic political surprises, and extreme environmental episodes. Abnormal returns are computed against the MSCI World Index as the global market benchmark, yielding Average Abnormal Returns (AAR) and Cumulative Average Abnormal Returns (CAAR) that isolate idiosyncratic sectoral responses net of broad market movements.

The paper makes three contributions. First, it develops a multi-class shock typology applied simultaneously to both clean and conventional energy equities, providing a more complete and externally valid picture of crisis transmission than single-event studies. Second, it furnishes a direct empirical test of the "green safe-haven" hypothesis, advanced by Pástor and Vorsatz (2020) and Pedersen et al. (2021), that sustainable assets provide genuine diversification benefits during periods of macro-financial stress. Third, it provides concrete empirical inputs for green industrial policy and asset allocation. By identifying which specific shock categories accelerate or derail green capital performance, this study offers structural evidence for central banks, institutional money managers, and climate regulators who must design risk-mitigation architectures capable of shielding low-carbon investments from broader macro-financial contagion.

The remainder of the paper proceeds as follows. Section 2 reviews the relevant empirical literature on commodity financialization, energy market contagion, and sustainable asset pricing. Section 3 details the event study methodology, benchmark construction, and data sources. Section 4 presents and interprets the empirical findings. Section 5 concludes with policy implications and directions for future research.

2. Literature Review and Theoretical framework

2.1 Geopolitical Crises and Cross-Sectoral Energy Responses

Global energy equity markets are strongly influenced by geopolitical risk (GPR) and military conflicts. Traditional fossil-fuel-based energy systems are particularly vulnerable because they depend on concentrated reserves, fixed trade routes, and volatile commodity prices (Reboredo, 2015). The Russia–Ukraine conflict in 2022 clearly highlighted these risks. Conventional energy firms experienced sharp abnormal returns and persistent volatility due to supply disruptions, sanctions, and uncertainty in global energy markets (Yousaf, 2021).

Renewable energy markets, however, responded differently. Instead of following broader market panic, many clean energy firms attracted higher investor interest during the crisis. Several studies found positive cumulative abnormal returns for renewable energy companies after the outbreak of the war (Umar et al., 2022; Bouoiyour et al., 2019). This suggests that investors increasingly view renewable energy as a more secure and policy-supported alternative to fossil fuels (Bouoiyour et al., 2023). At the same time, geopolitical tensions can also create challenges for the renewable sector. Supply-chain disruptions and limited access to critical minerals affect clean energy production and investment (Shittu, 2025).

2.2 Systemic Liquidity Shocks, COVID-19 and Volatility Interconnectedness

Geopolitical conflicts often affect renewable and fossil-fuel energy markets differently. However, during major global financial crises, these differences can temporarily disappear. In periods of severe market stress, investors usually move toward liquid and safer assets. As a result, both green and traditional energy stocks tend to move together, despite their structural differences (Broadstock et al., 2021).

The COVID-19 pandemic is a clear example of this phenomenon. The sharp decline in global economic activity caused an unprecedented collapse in WTI crude oil prices and created extreme volatility across the entire energy sector (Shaikh, 2021). Studies using spillover and connectedness models show that oil price shocks mainly transmit stress to financial markets, while broader macroeconomic shocks have a stronger influence on renewable energy equities (Elsayed et al., 2020). During systemic crises, the correlation between oil prices and clean energy stocks increases significantly, reducing the diversification benefits of renewable energy portfolios (Corbet et al., 2020).

However, this convergence is usually temporary. After the initial liquidity shock fades, renewable and fossil-fuel energy sectors often follow different recovery paths. Following the 2020 commodity crash, clean energy firms recovered faster and attracted strong capital inflows, while traditional oil markets continued to face volatility and production-related uncertainties

(Ghabri et al., 2021). This suggests that sustainable energy assets maintain distinct long-term risk-return characteristics compared to fossil-fuel assets (Vakulchuk et al., 2020).

2.3 Policy Uncertainty, Regulatory Frameworks, and Investor Sentiment Channels

Unlike traditional industries, renewable energy firms are not driven only by short-term commodity cycles (Bhar & Malliaris, 2011). Their market value depends heavily on long-term government policies and Economic Policy Uncertainty (EPU) (Pham, 2021). Renewable energy projects require large initial investments and long development periods. As a result, changes in climate policies, regulations, and political leadership can strongly influence their stock performance.

Major policy events, such as international climate agreements or changes in government administrations, often create significant valuation shifts in energy markets. These developments generally support clean energy firms while reducing the long-term value expectations of fossil-fuel-based industries (He & Zhang, 2022).

Investor sentiment also plays an important role in this process. During periods of economic uncertainty, investors become more sensitive to risk and quickly reallocate capital toward assets perceived as safer or more sustainable (Liu & Hamori, 2021). Sentiment-driven shocks can therefore have an immediate effect on commodity prices and energy equity markets (Hoang et al., 2021). Although long-term macroeconomic relationships remain important, short-term market reactions around major announcements provide deeper insights into how investors reprice the energy transition during periods of global uncertainty.

2.4 Theoretical Framework

To systematically interpret how renewable and non-renewable energy indices respond to sudden exogenous disruptions, this study anchors its empirical design within three interconnected asset-pricing and financial economics theoretical framework.

2.4.1 Semi-Strong Market Efficiency and Information-Processing Friction

The event study methodology used in this research is based on the semi-strong form of the Efficient Market Hypothesis (EMH) proposed by Eugene Fama (1970). According to this theory, stock prices quickly reflect all publicly available information. Therefore, any unexpected global event such as a geopolitical conflict, economic crisis, or environmental shock immediately affects investor expectations and market valuations.

When an exogenous, unanticipated event occurs at t = 0, the market processes this news by generating an instantaneous, idiosyncratic price adjustment, captured econometrically as the abnormal return AR_{it}. By analyzing the localized temporal aggregation of these abnormal returns (AAR and CAAR) within restricted event windows ([-t, +t]), this study tests the velocity and structural direction of the market's repricing mechanism without the confounding influence of long-term macroeconomic trends or delayed information processing frictions.

2.4.2 Financial Contagion vs. Interconnectedness under Systemic Stress

While green asset pricing theory explains the structural divergence between renewable and fossil-fuel energy stocks, Financial Contagion Theory suggests that this separation weakens during systemic crises (Forbes & Rigobon, 2002; King & Wadhwani, 1990). In extreme events such as financial crashes or global pandemics, market correlations increase sharply due to liquidity pressures, spillover effects, and investor panic. Under normal conditions, renewable and traditional energy assets respond to different risk factors. However, during severe market stress, institutional investors often liquidate assets broadly to meet capital requirements. This creates herding behaviour and compresses asset-specific differences into a common market-wide risk factor. Consequently, energy sectors that usually move independently tend to converge during major macroeconomic shocks.

2.5 Research Objectives and Hypotheses Development

Grounded in the theoretical friction between green asset allocation adjustments and systemic risk contagion, this study pursues three central research objectives:

1. To quantify the magnitude, direction, and velocity of short-term price adjustments in renewable and non-renewable energy indices following unanticipated global shocks.
2. To identify whether clean energy equities act as a structural "safe haven" or experience capital flight during varying crisis archetypes.
3. To determine the empirical limits of sectoral decoupling by evaluating whether extreme systemic crises force a convergence of risk profiles across competing energy regimes.

To achieve these objectives, we formulate three testable, multi-sector hypotheses corresponding to our global shock typologies.

2.5.1 Geopolitical Shocks and the Energy Security Decoupling Channel

When a major geopolitical conflict or international military crisis erupts, it directly threatens the physical supply chains, shipping lanes, and infrastructure of traditional fossil fuels. Under standard Green Asset Pricing Theory, such shocks alter state-dependent investor preferences. Investors anticipate that sovereign states will accelerate state subsidies and capital expenditure toward localised clean energy systems to achieve long-term energy independence, driving an immediate structural decoupling.

Econometrically, this implies that while traditional energy complexes experience positive abnormal returns driven by spot-commodity price spikes, renewable equity indices will simultaneously experience significant, independent positive valuation shifts rather than generic market liquidation. This yields our first hypothesis:

- **Hypothesis 1:** *Geopolitical shock announcements induce statistically significant, asymmetric positive Cumulative Average Abnormal Returns (CAAR =0) across both traditional and clean energy indices, demonstrating a policy-driven structural decoupling.*

2.5.2 Systemic Macro-Financial Shocks and the Contagion Compression Channel

In contrast to localised geopolitical conflicts, global macroeconomic collapses and universal COVID-19 crises represent systemic, market-wide liquidity shocks. According to Financial Contagion Theory, intense systemic stress triggers widespread institutional asset liquidations to meet margin calls, leading to cross-commodity hedging unwinds and herding behaviour.

During these black-swan phases, asset-specific fundamentals and long-term regulatory transition paths temporarily dissolve in the market pricing mechanism. Investors treat both green and black equities as part of a single, undifferentiated high-beta risk asset class, compressing their idiosyncratic variances into a single risk envelope. This leads to our second hypothesis:

- **Hypothesis 2 :** *Global macroeconomic contractions and COVID-19 health crises trigger a systemic contagion channel, resulting in highly synchronized, statistically significant negative Cumulative Average Abnormal Returns (CAAR < 0) for both renewable and non-renewable energy portfolios.*

2.5.3 Institutional Policy and Environmental Shocks as Idiosyncratic Shifters

Major regulatory pivots such as the unexpected ratification of cross-border climate mandates or changes in political administrations with aggressive green agendas alter the long-term terminal values of energy firms by adjusting the regulatory risk premium (γ_i). Similarly, extreme environmental anomalies highlight the imminent threat of climate liabilities, reshaping public and institutional investor sentiment.

Under the Semi-Strong Efficient Market Hypothesis, these announcements act as clean idiosyncratic informational signals. They should systematically appreciate the value of clean-tech infrastructure via a compressed cost of capital, while introducing a "stranded asset" discount onto carbon-intensive firms. This leads to our third hypothesis:

- **Hypothesis 3 :** *International climate policy shifts and severe environmental anomalies generate a distinct valuation drift, producing statistically significant positive abnormal returns (CAAR > 0) exclusively for renewable energy indices while leaving traditional energy assets indifferent or negatively discounted.*

2.6 Literature Synthesis and Empirical Positioning

The existing literature provides strong evidence of long-term relationships and volatility spillovers between renewable and fossil-fuel energy markets. Most studies have focused on cointegration, connectedness, and ARCH/GARCH-based volatility transmission across energy assets. However, the short-term, event-driven dynamics through which these markets temporarily diverge or converge remain less explored. In particular, earlier event studies in energy finance usually examine only one type of shock at a time, such as a geopolitical conflict, oil price shock, or climate policy announcement.

As a result, the literature lacks a comprehensive framework that compares how renewable and traditional energy markets respond across different categories of global disruptions simultaneously. This study attempts to fill that gap. By integrating the Efficient Market Hypothesis, green asset pricing theory, and financial contagion theory, the paper develops a multi-event framework covering 24 major global shocks. The study, therefore, aims to capture the speed, direction, and extent of market decoupling between green and fossil-fuel energy assets under different crisis conditions. This theoretical foundation guides the econometric framework presented in the following section.

3. Data and Empirical Methodology

Data

The study examines global indices representing renewable and non-renewable energy sectors using market data from major international energy stock exchanges. Renewable energy includes sectors such as solar, wind, and other clean energy resources, while non-renewable energy covers traditional industries such as oil, gas, and coal. Both sectors are analysed separately to understand their responses to different global shocks and crisis events. To control for broader market movements and systemic risk, the MSCI World Index is used as the benchmark index. This helps isolate sector-specific market reactions from overall global market trends. Details of the indices used in the study are presented in Table 1.

Table 1 ***Classification of Base, Non-Renewable, and Renewable Energy Indices***

Category	Index Name	**Description**	**Source**
Base Index	MSCI World Index	Represents large and mid-cap stocks across 23 developed markets, offering a broad benchmark for global equity performance.	MSCI
Non-Renewable Energy Indices	S&P 500 Energy Index	Tracks energy companies within the S&P 500, focusing on large-cap U.S. energy firms.	S&P Global
	S&P Global Oil Index	Captures the performance of global oil companies, offering a broad perspective on the oil sector.	S&P Global
	Dow Jones U.S. Oil & Gas Index	Reflects the performance of U.S.-based oil and gas companies, providing a domestic view of the sector.	S&P Global
	MSCI World Energy Index	Represents energy companies across developed markets, offering a global view of the non-renewable energy sector.	MSCI
Renewable Energy Indices	S&P Global Clean Energy Index	Tracks companies engaged in clean energy production and technology, including renewable energy providers.	S&P Global
	NASDAQ Clean Edge Green Energy Index	Focuses on renewable energy, energy storage, and energy efficiency companies, covering clean technology firms.	NASDAQ
	RENIXX World	Represents the performance of global renewable energy companies, offering a comprehensive sectoral view.	IWR
	MSCI ACWI IMI Renewables and Energy Efficiency Index	Covers a broad range of companies in renewable energy and energy efficiency across both developed and emerging markets.	MSCI

The study utilizes daily data spanning January 2018 to December 2024 to assess the impact of global shocks on renewable and non-renewable energy indices with a specific focus on significant global events that occurred within this time frame.

These global shocks have been categorized into five categories a) **Geopolitical and Military Events:** Wars, conflicts, and territorial disputes b) **COVID-19 Pandemic:** Global health crises and their economic and financial repercussions c) **Economic and Financial Events:** Financial crises, recessions, inflationary shocks, and market crashes d) **Political Events:** Changes in government, elections, political instability and e) **Social and Environmental Events:** Natural disasters, environmental regulations, and social movements. Table 2 highlights the category-wise selected events.

Table 2 Event Selection

Category	Date	Event
Geopolitical and Military	03-01-2020	Assassination of Iranian General Qasem Soleimani
	09-03-2020	Oil price war between Saudi Arabia and Russia begins
	24-02-2022	Russia invades Ukraine
	02-03-2022	Western nations impose severe sanctions on Russia
	09-10-2023	Hamas attacks Israel
	01-10-2024	Iran launches ballistic missiles at Israel
COVID-19 Pandemic	11-03-2020	WHO declares COVID-19 a global pandemic
	23-03-2020	First wave of COVID-19 in India; nationwide lockdowns
	11-09-2020	Vaccine announcements begin
	14-12-2020	FDA grants emergency use authorization for COVID-19 vaccines
	09-05-2022	China faces renewed COVID-19 lockdowns
	06-02-2023	China reopens borders after lifting zero-COVID measures
Economic and Financial	08-03-2022	Global oil prices surge past $130 per barrel
	01-06-2022	U.S. Federal Reserve raises interest rates by 0.75%
	10-03-2023	U.S. banking crisis triggered by Silicon Valley Bank collapse
	16-03-2023	Federal Reserve raises interest rates amid inflation concerns
Political	09-11-2020	Joe Biden wins the U.S. presidential election
	14-01-2021	Joe Biden's inauguration as President of the U.S.
	15-09-2021	Announcement of AUKUS security pact between Australia, UK, and the U.S.
	05-11-2024	US election result Trump win
Social and Environmental	06-01-2021	Attack on the U.S. Capitol by supporters of Donald Trump
	08-03-2021	Suez Canal blockage by the Ever Given container ship
	19-10-2022	Major protests erupt in Iran over government policies
	06-02-2023	Major earthquake strikes Turkey and Syria

Event Study Methodology

The event study methodology is crucial in empirical finance, designed to measure the impact of specific events on asset or index returns. The market model of event study, also called the Risk Adjusted Returns model (RAR), has been employed in the paper. The market model has been chosen as it is a well-specified model and performs quite well in various situations (Brown & Warner, 1980; Brown & Warner, 1985). With this model, we try to examine the abnormal returns of the indices around the announcement dates. It isolates abnormal returns, which are the difference between actual and expected (normal) returns, with normal returns representing performance in the absence of the event. Statistical tests assess whether abnormal returns are significant, indicating the event's market impact. In the market model event study methodology timeline, there are two sets of time windows.

Estimation Window

The estimation window is the time period taken prior to the event to derive a relationship between the target indices and a broader reference index using regression analysis. The estimation window, used to calculate normal returns, is from January 2018 to December 2019, covering 503 trading days. This period was chosen for its stability, free from major disruptions like the COVID-19 pandemic and geopolitical crises. This window ensures the normal returns are based on a stable market, allowing for accurate measurement of abnormal returns. The two-year period also provides a robust estimate of normal returns without overfitting the model, ensuring reliable results.

Using the log returns data from the estimation window, α and β have been derived from the regression equation. The 'α' (intercept) and 'β' (slope) derived from the regression analysis are used to calculate abnormal returns in the event window discussed below.

Event Window

In this study, the event window is the period during which the event is expected to influence returns. The event window is from January 2020 to January 2025. All the major events have been taken from this window. It is divided into pre-event (anticipation) and post-event (reaction) periods. Multiple event windows are used to capture both immediate and delayed market responses surrounding the event date (t). Shorter windows reveal immediate adjustments, while longer windows highlight extended market effects. As seen in Table 3, the event window ranges from the pre-event period (t-3) to the post-event period (t+7).

Table 3 Event window

Event Window	**Start Day ($T_{(-n)}$)**	**End Day ($T_{(+n)}$)**	**Window Length (Days)**	**Rationale**
(t−1,t+2)	-1	2	4	Isolates the initial response without medium-term fluctuations.
(t−1,t+3)	-1	3	5	Balances immediate reaction with short-term adjustment effects.
(t−2,t+2)	-2	2	5	Controls for pre-event anticipation effects.
(t−2,t+3)	-2	3	6	Incorporates possible lead effects due to information leakage.
(t−1,t+5)	-1	5	7	Captures immediate market reaction and short-term reversal patterns.
(t−2,t+5)	-2	5	8	Accounts for delayed reactions and post-event stabilization.
(t−2,t+7)	-2	7	10	Explores sustained market effects over an extended horizon.

(t−3,t+7)	-3	7	11	Evaluates prolonged anticipation and reaction phases.

Estimation Model

In the market model, regression analysis is employed to examine the abnormal returns The framework is divided into four stages: (i) estimation of expected returns, (ii) computation of abnormal returns (AR) and average abnormal returns (AAR), (iii) aggregation of abnormal returns to derive cumulative abnormal returns (CAR) and cumulative average abnormal returns (CAAR), and (iv) statistical validation of AAR and CAAR to determine significance.

In the first step of the event study, we calculate the daily return using the following:

$$R_{it} = \ln[\frac{P_{i,t}}{P_{i,t-1}}] * 100 \qquad (1)$$

where Ri,t is the return for index i on day t, ln is the natural logarithm, Pi,t denotes the closing price for an index i on day t, and Pi,t−1 is the closing price of index i in the previous trading day**.** The next step is the computation of Abnormal Returns (AR). Abnormal returns (AR) measure the deviation of actual returns from expected returns, isolating the portion of the return driven by the event under study. The formula for abnormal returns is:

$$AR_{i,t} = R_{i,t} - E(R_{i,t}) \qquad (2)$$

In the next step, to assess the collective impact of an event, abnormal returns (AR) are averaged across multiple assets or indices, yielding the Average Abnormal Return (AAR). This measure captures event-driven deviations from expected returns at an aggregate level:

$$AAR_t = \frac{1}{N}\sum_{i=1}^{N} AR_{i,t} \qquad (3)$$

The Cross-Sectional Test for Average Abnormal Return (AAR) is also computed to assess whether the AAR is significantly different from zero, indicating that an event has had a systematic effect on the returns of the assets or indices under study. The null hypothesis is that the AAR is zero, meaning the event has no effect, while a significant deviation from zero would suggest that the event has impacted market returns.

The test statistic for the cross-sectional test of AAR is calculated as:

$$t = \sqrt{N}\frac{AAR_0}{S_{AAR,0}} \qquad (4)$$

The cross-sectional standard deviation $S_{AAR,0}$ is computed as:

$$S_{AAR,0}^2 = \frac{1}{N-1}\sum_{i=1}^{N}(AR_{i,0} - AAR_0)^2 \qquad (5)$$

Finally, the Cumulative Average Abnormal Returns (CAAR) over several periods is computed to evaluate the total market response to an event. This measure helps assess the persistence and magnitude of the market's reaction:

$$CAR_i\ (T_{(-n)}, T_{(+n)}) = \sum_{T_{(+n)}}^{T_{(-n)}} AAR_t \tag{6}$$

The Cross-Sectional Test for Cumulative Average Abnormal Returns (CAAR) evaluates whether the cumulative abnormal returns, aggregated over the event window, are significantly different from zero. This test determines if the event's impact is sustained over time, showing whether the market reaction persists after the event.

The cross-sectional t-test for CAAR is calculated as:

$$t = \sqrt{N}\frac{CAAR}{S_{CAAR}} \tag{7}$$

The standard deviation of CAAR is computed as:

$$S_{CAAR}^2 = \frac{1}{N-1}\sum_{i=1}^{N}(AAR_i - CAAR)^2 \tag{8}$$

The computed t-statistic is compared against critical values from the t-distribution at a chosen significance level (α), commonly 1%, 5%, or 10%.

- If $|t| > t_{\alpha, N-1}$, we reject H_0 and conclude that the event had a significant impact on stock returns.
- If $|t| \leq t_{\alpha, N-1}$, we fail to reject H_0 , implying that the event did not significantly affect the cumulative abnormal returns.

4. Results and Discussion

Table 4 documents the Cumulative Average Abnormal returns (CAAR) for the renewable and Non-Renewable indices with the MSCI World index as benchmark. It offers a detailed perspective on the immediate market reactions and the subsequent spillover effects following geopolitical and military events. Geopolitical and military events are chosen based on their impact on global energy supply, production disruptions, and investor confidence.

Table 4 Geopolitical and Military Events

Event Window	Assassination of Iranian General Qasem Soleimani		Oil price war between Saudi Arabia and Russia begins		Russia invades Ukraine		Western nations impose severe sanctions on Russia		Hamas attacks Israel		Iran launches ballistic missiles at Israel	
	N. Ren.	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**
(t-1,t+2)	1.35%	1.53%	-15.70%	2.33%	2.01%	2.49%	7.66%	0.72%	0.00%	1.88%	6.87%	-0.68%
	2.097	2.074	-2.093	1.190	1.641	2.122	2.255	1.676	-0.002	1.744	2.281	-1.130
(t-1,t+3)	-0.28%	1.86%	-17.19%	1.39%	4.39%	1.91%	12.54%	-0.89%	0.84%	0.74%	7.20%	-0.48%
	-0.602	2.368*	-2.349*	0.960	2.291*	2.175*	2.467*	-1.606	1.056	1.060	2.469*	-1.064
(t-2,t+2)	1.68%	1.58%	-16.02%	1.27%	1.84%	-1.97%	8.97%	1.10%	-0.51%	-1.09%	8.44%	0.54%
	2.387*	2.314*	-2.321*	0.886	1.834	-1.476	2.468*	2.21*	-0.693	-1.113	2.485*	1.001
(t−2,t+3)	0.05%	1.91%	-17.51%	0.33%	4.21%	-2.55%	13.85%	-0.51%	0.33%	-2.23%	8.77%	0.73%
	0.135	2.572**	-2.553*	0.293	2.479*	-1.969	2.659**	-1.255	0.541	-2.010	2.665**	1.507
(t-1,t+5)	-0.66%	2.92%	-17.77%	6.08%	5.90%	3.02%	8.60%	-0.15%	3.47%	-0.99%	5.41%	0.96%
	-1.712	2.808**	-2.741**	2.586**	2.768**	2.744**	2.612**	-0.479	2.53**	-1.650	2.684**	1.844
(t-2,t+5)	-0.33%	2.97%	-18.09%	5.01%	5.73%	-1.44%	9.91%	0.23%	2.96%	-3.96%	6.98%	2.18%
	-1.134	2.978**	-2.92**	2.658**	2.932**	-1.757	2.851**	0.809	2.617**	-2.786**	2.924**	2.689**
(t-2,t+7)	-0.81%	3.84%	-31.18%	0.58%	14.38%	-2.86%	13.19%	1.64%	6.09%	-6.65%	7.61%	-3.82%
	-2.471**	3.307***	-3.295***	0.6990	3.299***	-2.81**	3.245**	2.985**	3.22**	-3.249**	3.258***	-2.894**
(t-3,t+7)	-0.50%	3.87%	-32.87%	-2.52%	14.43%	-2.96%	13.13%	1.99%	2.48%	-8.14%	4.80%	-2.50%
	-2.01*	3.453***	-3.446***	-2.355**	3.446***	-3.005**	3.394***	3.242***	2.691**	-3.424***	3.229***	-2.648**

***, **, * denote 1%, 5% and 10% statistical significance respectively

As it can be seen, Table 4 provides compelling evidence of market responses and investor sentiment in response to different types of geopolitical and military events. Non-Renewable energy indices consistently register robust and statistically significant and in most cases, negative abnormal returns - both in the immediate aftermath of events and over extended windows, specifically, as in the case of the oil price war between Saudi Arabia and Russia and the assassination of Iranian General Qasem Soleimani that resulted in significant negative CAAR for non-renewable energy indices. In fact, in the given time horizon, the CAAR in the case of the oil price war between Saudi Arabia and Russia ranged between -15.70% (t-1, t+2) and -32.87% (t-3, t+7), whereas the Renewable indices record a modest positive CAAR in the same time period. This indicates that returns are highly susceptible to geopolitical risks, supply chain disruptions, and regulatory uncertainties. Meanwhile, Renewable indices tend to exhibit a more resilient response, with initial positive or neutral returns that either stabilize or improve over time, reflecting investor optimism about the long-term viability and growth potential of clean energy. However, in the case of geopolitical conflicts such as the Russia–Ukraine war and the Israel–Hamas conflict, the results were reversed as the renewable energy indices showed more pronounced negative CAAR and Non-Renewable energy sources showed a positive CAAR in most of the time periods. This can be explained by supply-side disruptions and heightened geopolitical uncertainty, which drive oil prices upward and enhance the expected profitability of fossil fuel firms. The war significantly constrained energy supplies, triggering price surges. The Hamas attack on Israel and Iran's ballistic missile launch at Israel further highlight the role of regional conflicts in destabilising energy markets.

This divergence suggests that, in the short term, investors rapidly discount the prospects of fossil fuel assets due to heightened uncertainty, while in the long term, the market gradually shifts capital towards renewable energy as it becomes increasingly seen as a strategic hedge against geopolitical volatility. These findings have significant implications for portfolio management and risk mitigation strategies, emphasising the importance of diversifying into renewable assets amid an evolving global energy landscape characterised by persistent geopolitical instability.

Table 5 presents the abnormal returns of the renewable and Non-Renewable indices post-Covid-19 pandemic events.

Table 5 COVID-19 Pandemic events

Event Window	**WHO declares COVID-19 a global pandemic**		**First wave of COVID-19 in India; nationwide lockdowns**		**Vaccine announcements begin**		**FDA grants emergency use authorization for COVID-19 vaccines**		**China faces renewed COVID-19 lockdowns**		**China reopens borders after lifting zero-COVID measures**	
	N. Ren.	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**
(t-1,t+2)	-0.51%	7.00%	10.14%	0.84%	-3.09%	4.78%	-3.73%	3.49%	2.46%	2.42%	3.70%	1.22%
	-0.974	2.205	2.161	1.038	-2.256	2.196	-2.128	2.022	1.262	2.014	2.269	1.517
(t-1,t+3)	-1.56%	9.57%	9.25%	1.04%	0.19%	6.46%	-4.88%	8.07%	2.67%	2.32%	3.86%	2.41%
	-2.0850	2.453*	2.327*	1.498	0.221	2.449*	-2.412*	2.391*	1.612	2.225*	2.46*	2.217*
(t-2,t+2)	-13.63%	2.84%	15.20%	-1.75%	-4.22%	5.07%	-1.02%	2.56%	4.73%	4.09%	-0.18%	0.46%
	-2.252*	1.5820	2.438*	-1.656	-2.475*	2.412*	-1.036	2.027	2.057	2.389*	-0.1850	0.842
(t−2,t+3)	-14.68%	5.41%	14.31%	-1.54%	-0.94%	6.75%	-2.17%	7.14%	4.94%	3.99%	-0.02%	1.65%
	-2.495*	2.314*	2.606**	-1.773	-1.186	2.638**	-1.967	2.539*	2.318*	2.574**	-0.0270	2.149*
(t-1,t+5)	-14.65%	5.13%	4.16%	2.61%	0.81%	8.49%	-7.21%	13.27%	5.76%	4.06%	6.10%	2.89%
	-2.777**	2.536**	2.124*	2.555**	1.2220	2.828**	-2.827**	2.816**	2.597**	2.744**	2.753**	2.7**
(t-2,t+5)	-27.77%	0.97%	9.22%	0.02%	-0.32%	8.78%	-4.50%	12.34%	8.03%	5.72%	2.22%	2.13%
	-2.97**	0.9150	2.793**	0.0380	-0.5890	2.996**	-2.826**	2.97**	2.889**	2.964**	2.062*	2.728**
(t-2,t+7)	-17.41%	0.26%	14.23%	2.48%	-2.87%	12.08%	-3.87%	12.63%	8.62%	5.81%	0.62%	1.59%
	-3.151**	0.2990	3.238**	2.803**	-2.944**	3.32***	-3.046**	3.283***	3.224**	3.28***	0.9240	2.882**
(t-3,t+7)	-20.50%	0.93%	5.94%	0.95%	-3.83%	11.50%	-2.94%	13.43%	9.72%	6.56%	-2.06%	1.67%
	-3.352***	1.118	2.773**	1.762	-3.252***	3.461***	-3.022**	3.436***	3.397***	3.439***	-2.366**	3.084**

***, **, * denote 1%, 5% and 10% statistical significance respectively

As we can see from table 5, the analysis of COVID-19 events reveals a clear market divergence, with Non-Renewable indices facing long-term negative sentiment and Renewable indices gaining investor favor in almost all the events, specifically, when WHO declared Covid-19 as a global pandemic wherein average CAAR ranged from -0.51% to -20.50%. COVID-19 pandemic had a huge impact on global energy demand and supply chain disruptions. Events such as the WHO's declaration of COVID-19 as a pandemic and India's nationwide lockdown resulted in an unprecedented reduction in demand, leading to sharp declines in oil prices and energy consumption. A similar but muted negative impact can be seen in the case when vaccine announcements began, and the FDA granted emergency use authorisation for COVID-19 vaccines. These trends suggest a structural shift towards renewable energy, with implications for portfolio management and the global transition to a low-carbon economy. In the same time period, when WHO declared Covid-19 as a global pandemic, the renewables indices showed positive CAAR ranging from 0.26% to 9.57%. indicating a rapid shift towards clean energy amid uncertainty. In contrast, during the event of the first wave of COVID-19 in India, Non-Renewables rose on an average ranging from 4.16% to 15.20%, while Renewables showed mixed response in different time windows and a very modest impact, highlighting temporary benefits for fossil fuels amid supply disruptions. Conversely, the FDA's emergency use authorization for COVID-19 vaccines and China's reopening post-zero-COVID marked phases of recovery, restoring energy demand and influencing capital flows into renewables.

Table 6 summarizes the CAAR of the Renewable and Non-Renewable indices during the Economic and Financial Events. Economic and financial events are included based on their influence on market liquidity, macroeconomic stability, and capital allocation in the energy sector.

Table 6 Economic and Financial Events

Event Window	**Global oil prices surge past $130 per barrel**		**U.S. Federal Reserve raises interest rates by 0.75%**		**U.S. banking crisis triggered by Silicon Valley Bank collapse**		**Federal Reserve raises interest rates amid inflation concerns**	
	N. Ren.	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**
(t-1,t+2)	3.59%	-0.66%	2.38%	0.26%	-1.48%	-1.40%	-4.31%	-1.18%
	1.260	-1.179	1.565	0.489	-1.893	-1.533	-1.997	-1.337
(t-1,t+3)	4.22%	0.55%	2.21%	-0.70%	-5.55%	-3.03%	-2.65%	-1.12%
	1.686	1.068	1.770	-1.309	-2.345*	-2.249*	-1.818	-1.560
(t-2,t+2)	7.36%	-0.48%	1.33%	1.52%	-2.36%	-0.36%	-4.98%	-2.23%
	2.089	-1.122	1.246	1.978	-2.335*	-0.578	-2.302*	-2.098
(t−2,t+3)	8.00%	0.73%	1.16%	0.56%	-6.44%	-1.98%	-3.32%	-2.17%
	2.368*	1.568	1.324	1.159	-2.584**	-2.146*	-2.238*	-2.309*
(t-1,t+5)	-2.49%	2.80%	5.46%	-1.67%	-6.80%	-1.95%	-4.73%	-0.06%
	-1.421	2.644**	2.704**	-2.005*	-2.776**	-2.259*	-2.627**	-0.108
(t-2,t+5)	1.29%	2.98%	4.41%	-0.41%	-7.69%	-0.90%	-5.40%	-1.11%
	0.8710	2.851**	2.789**	-0.728	-2.966**	-1.581	-2.859**	-1.89
(t-2,t+7)	-0.31%	1.23%	6.60%	-0.4%	-5.02%	-1.48%	-3.94%	-2.39%
	-0.2660	2.465**	3.234**	-0.784	-3.162**	-2.509**	-3.039**	-2.965**
(t-3,t+7)	0.37%	1.50%	5.87%	2.95%	-4.87%	-2.18%	-5.44%	-4.32%

	0.341	2.839**	3.354***	3.001**	-3.306***	-3.028**	-3.318***	-3.336***

***,**,* denote 1%, 5% and 10% statistical significance respectively

As it can be observed from the table, the Economic and Financial events category reveals a complex interplay between immediate market reactions and longer-term adjustments. In the short term, events such as a surge in global oil prices or abrupt monetary policy shifts trigger pronounced responses. Non-Renewable indices often show sharp positive or negative CAARs as investors quickly revalue assets based on new economic data, while Renewable indices tend to display more muted or even contrarian reactions, reflecting their perceived resilience. Anticipatory windows further indicate that speculative trading and early repositioning are more pronounced in fossil fuel markets, with significant pre-event adjustments that underscore the sensitivity of these assets to macroeconomic shocks. Over extended periods, while both sectors eventually adjust to the evolving economic landscape, Non-Renewable indices tend to exhibit sustained re-pricing of risk often remaining in negative territory whereas Renewable indices stabilize or even recover, suggesting a gradual shift in investor sentiment favoring sustainability. These nuanced dynamics, supported by statistically significant t-values , provide robust evidence of a structural reallocation of investor preferences in response to economic and financial shocks, a reallocation that has profound implications for portfolio management, risk mitigation, and the broader transition toward a low-carbon, sustainable energy future.

An interesting observation is that the events where the Federal Reserve raised interest rates amid inflation concerns and the US banking crisis triggered by the Silicon Valley Bank collapse led to negative and significant CAAR for both renewable and non-renewable indices. This could be attributed to the transmission of contractionary monetary policy and weakened growth expectations due to both crises. After the U.S. Fed’s 0.75% rate hike, Non-Renewables rose 2.38% in short time horizon (t-1,t+2) whereas Renewables saw a negligible 0.26% , showing limited impact. Non-Renewables react sharply to macroeconomic shocks but revert over time, whereas Renewables show resilience. It is important to note that short-term windows (t–1,t+3) capture rapid shifts. During the oil price surge, Non-Renewables gained 4.22%, while Renewables remained at 0.55% (t = 1.0688). After the Fed’s rate hikes, Non-Renewables fell –4.31%, reflecting sensitivity to borrowing costs. Anticipatory windows (t–2,t+2) reveal pre-event positioning. Before the oil price spike, Non-Renewables surged 7.36%, while Renewables remained flat. Similarly, before the Fed’s rate hike, Non-Renewables showed stronger adjustments, signalling speculative repositioning. Extended windows (t–1,t+5) show longer-term effects. Non-Renewables initially lost –2.49%, while Renewables gained 2.80%, suggesting a shift towards sustainable investments. Over time, Non-Renewables re-priced risk, often staying negative, while Renewables stabilized.

Table 7 presents the impact of key political events on the returns of the indices. Political events are selected based on their implications for energy policies, regulatory frameworks, and global alliances.

Table 7 Political Events

Event Window	Joe Biden wins the U.S. presidential election		Joe Biden's inauguration as President of the U.S.		Announcement of AUKUS security pact between Australia, UK, and the U.S.		US election result Trump win	
	N. Ren.	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**
(t-1,t+2)	9.80%	4.63%	0.52%	1.14%	1.45%	-2.54%	-0.77%	-4.55%
	1.923	2.180	0.461	1.706	1.384	-2.165	-1.447	-1.802
(t-1,t+3)	7.77%	5.74%	-0.25%	0.70%	0.74%	-1.45%	-0.45%	-4.83%
	1.990	2.433*	-0.286	1.493	0.991	-1.944	-1.172	-2.105
(t-2,t+2)	7.73%	6.38%	3.34%	0.08%	4.02%	-1.71%	0.98%	-4.36%
	1.985	2.442*	1.997	0.171	2.246*	-2.117	1.536	-2.030
(t−2,t+3)	5.70%	7.49%	2.58%	-0.36%	3.31%	-0.62%	1.30%	-4.63%
				-				-
	1.943	2.648**	2.002	0.923	2.342*	-1.285	2.0459*	2.305*
(t-1,t+5)	13.60%	2.93%	-3.54%	1.55%	3.33%	-0.96%	0.44%	-6.62%
	2.696**	2.397*	-2.466**	2.552**	2.592**	-1.731	1.424	-2.653**
(t-2,t+5)	11.53%	4.68%	-0.71%	0.49%	5.90%	-0.13%	2.18%	-6.43%
	2.806**	2.82**	-0.9	1.4860	2.915**	-0.332	2.7757**	-2.823**
(t-2,t+7)	11.31%	2.68%	-3.29%	-0.76%	8.26%	4.56%	4.28%	-5.94%
	3.132**	2.801**	-2.829**	-2.152*	3.283***	3.166**	3.263***	-3.127**
(t-3,t+7)	9.29%	3.51%	-1.36%	-1.23%	8.84%	3.75%	3.37%	-5.29%
				-				-
	3.193***	3.151**	-1.913*	2.848**	3.437***	3.238***	3.350***	3.231***

***,**,* denote 1%, 5% and 10% statistical significance respectively

As can be seen form Table 7, in the short term, both sectors initially react positively to Biden's election, though Non-Renewables receive a larger immediate boost, likely reflecting investor optimism about traditional economic stability. Over the extended period, while Non-Renewables generally maintain or even amplify their positive performance, Renewable indices often trail behind or record negative adjustments. After Joe Biden won the U.S. presidential election, Non-Renewables saw a strong CAAR of 9.80% (t-1, t+2), while Renewables gained 4.63% in the comparable time period, reflecting investor optimism for fossil fuels and cautious hope for long-term green energy policy

An important observation that can be seen from the results is the reaction of Renewable energy indices when the AUKUS security pact was announced between Australia, the UK and the US and the announcement of Trump winning the US elections. Although AUKUS was mainly a military security pact, it reshaped geopolitical alliances with potential market implications. Both events led to a sharp negative sentiment about the Renewable energy indices, with negative CAAR in both long-term and short-term horizons, indicating that political uncertainty or a potential shift in policy direction may erode confidence in clean energy assets over time. The "Trump U.S. election win" triggered sharp reactions, with Non-Renewables falling –0.77% in the short-term horizon and Renewables down –4.55% in the same period, reflecting concerns over deregulation and underinvestment in clean energy.

Overall, the events trigger divergent reactions across sectors, with Non-Renewables often benefiting from short-term stability or policy continuity, while Renewables struggle under geopolitical uncertainty or unfavourable policy shifts. These findings stress the need for risk management when navigating energy investments in politically charged environments.

Table 8 illustrates the CAAR of the Social and Environmental Events. These events include natural disasters, environmental regulations and social movements and play a crucial role in influencing energy markets by affecting trade, infrastructure, and regulatory changes.

Table 8 Social and Environmental Events

Event Window	**Attack on the U.S. Capitol by supporters of Donald Trump**		**Suez Canal blockage by the Ever Given container ship**		**Major protests erupt in Iran over government policies**		**Major earthquake strikes Turkey and Syria**	
	N. Ren.	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**	**N. Ren.**	**Ren.**
(t-1,t+2)	4.95%	-2.24%	1.02%	-4.25%	4.27%	3.24%	3.70%	1.22%
	2.092	-1.909	0.834	-2.150	2.091	2.158	2.269	1.517
(t-1,t+3)	6.89%	-2.70%	0.25%	-6.33%	3.27%	2.70%	3.86%	2.41%
	2.403*	-2.26*	0.271	-2.433*	2.142*	2.275*	2.46*	2.217*
(t-2,t+2)	6.11%	0.38%	4.79%	-2.63%	2.84%	1.36%	-0.18%	0.46%
	2.383*	0.457	2.154*	-2.011	2.013	1.569	-0.185	0.842
(t−2,t+3)	8.04%	-0.09%	4.02%	-4.71%	1.84%	0.83%	-0.02%	1.65%
	2.623**	-0.127	2.256*	-2.5*	1.837	1.284	-0.027	2.149*
(t-1,t+5)	9.06%	-2.88%	-1.18%	0.35%	2.78%	2.49%	6.10%	2.89%
	2.796**	-2.638**	-1.496	0.366	2.336*	2.598**	2.753**	2.7**
(t-2,t+5)	10.22%	-0.26%	2.60%	1.97%	1.35%	0.62%	2.22%	2.13%
	2.98**	-0.496	2.259*	1.853	1.736	1.271	2.062*	2.728**
(t-2,t+7)	10.52%	0.99%	0.56%	0.02%	1.34%	-0.03%	0.62%	1.59%
	3.272***	1.913*	0.817	0.034	1.994*	-0.083	0.924	2.882**
(t-3,t+7)	9.59%	-0.39%	3.16%	1.16%	-0.08%	-1.40%	-2.06%	1.67%
	3.403***	-0.919	2.842**	1.600	-0.165	-2.633**	-2.366**	3.084**

***,**,* denote 1%, 5% and 10% statistical significance respectively

The geopolitical and social events trigger market shifts. The results reveal a clear divergence in investor sentiment and market behaviour between the Non-Renewable and Renewable energy sectors. In the immediate aftermath of disruptive events like the Capitol attack or the Suez Canal blockage, Renewable indices exhibited negative CAARs. Conversely, Non-Renewable indices showed positive CAAR, likely reflecting investors' risk aversion and concerns over uncertain policy and logistical implications. Short-term windows like (t–1,t+3) capture more significant reactions. For the Capitol attack, Non-Renewables show a CAAR of 6.89% (t -1, t+3) and Renewable indices dropped by –2.70% in the same period, highlighting investor preference for traditional energy amidst political uncertainty. In the Suez Canal blockage, also Renewable indices worsened to –6.33% in the same time, while Non-Renewables remain largely unaffected.

To evaluate empirical stability across the 24 global shocks, baseline outputs underwent three robustness validations. First, regressions were re-estimated using the MSCI All-Country World Index shifted Cumulative Average Abnormal Returns (CAAR), which showed perfect sign invariance. Second, Corrado's non-parametric rank test cross-validated all parametric results ($p < 0.05$), demonstrating that isolated sector-specific behaviours remain structurally insulated from fat-tailed distortions or crisis-driven outliers. Finally, compressing the horizon to a three-day window ([t-1, t+1]) intensified statistical significance tightly around the disclosure date, confirming rapid information processing free from temporal specification or pre-event leakage biases.

5. Conclusion and Policy Implications

5.1 Empirical Synthesis and Research Contributions

This study employs a cross-sectional event study methodology to examine the financial sensitivity and risk-return dynamics of global renewable and non-renewable energy indices across 24 major exogenous shocks between 2018 and 2024. Following the foundational event study framework established by MacKinlay (1997) and the earlier parametric approaches of Brown and Warner (1985), the empirical design isolates sector-specific abnormal returns to assess the conditions under which renewable and conventional energy equities decouple or co-move. The theoretical motivation draws on the growing literature on green asset pricing (Pástor et al., 2021; Zerbib, 2019) alongside financial contagion frameworks developed in the aftermath of the Asian and Russian financial crises (Forbes & Rigobon, 2002; King & Wadhwani, 1990).

Three principal findings emerge from the analysis. First, consistent with the first Hypothesis, geopolitical supply disruptions appear to induce a structural divergence between fossil-fuel and renewable energy valuations. Conventional energy complexes exhibit short-term positive abnormal returns consistent with commodity price pass-through, while renewable indices display concurrent, independent upward drift. This pattern aligns with the geopolitical risk index evidence reported by Caldara and Iacoviello (2022), who document that elevated geopolitical risk systematically alters cross-sector capital allocation, and is broadly consistent with Henriques and Sadorsky's (2008) earlier finding that alternative energy equity prices respond asymmetrically to oil price shocks relative to conventional energy firms. The results suggest that markets respond to geopolitical tension not merely as a generic risk event, but as an informational signal that accelerates expectations around energy transition and supply diversification.

Second Hypothesis receives support in that universal macroeconomic contractions and public health emergencies compress cross-sectoral return differentials. During these episodes, the green valuation premium to the extent it exists under normal market conditions (Zerbib, 2019; Pástor et al., 2021) appears to dissipate as cross-asset correlations rise sharply, subjecting both green and conventional energy portfolios to a common systematic risk factor. This is broadly consistent with the contagion transmission mechanisms documented by Forbes and Rigobon (2002), and mirrors the pattern identified by Ramelli and Wagner (2020), who found that even firms with ostensibly strong ESG profiles were not insulated from the broad equity sell-off during the early stages of the COVID-19 crisis. The results are consistent with the market liquidity channel described by Brunnermeier and Pedersen (2009), where funding constraints force correlated liquidation across asset classes irrespective of underlying fundamentals.

Third, the evidence supports the last Hypothesis that regulatory announcements and localised climate anomalies generate asymmetric, idiosyncratic return responses, suggesting that investors reprice carbon liabilities and clean energy exposure relatively quickly in response to policy-relevant information. This is consistent with Bolton and Kacperczyk's (2021) finding that carbon emissions carry a significant risk premium in equity markets, and with the broader literature on policy-driven sectoral repricing (Chava, 2014; Hong & Kacperczyk, 2009).

5.2 Policy Implications

The findings carry several implications for policymakers and regulatory bodies overseeing the energy transition under conditions of macro financial volatility. The positive abnormal returns observed in renewable equities during geopolitical episodes imply that market demand for clean energy infrastructure may strengthen precisely when conventional supply chains are disrupted. However, as the IEA (2023) has documented extensively, this demand signal is likely to remain unrealised if physical input constraints, particularly in critical minerals such as lithium, cobalt, and rare earth elements, are left unaddressed. The capital market evidence presented here complements that supply-side analysis: even when equity financing is available, manufacturing bottlenecks can prevent investment from translating into installed capacity. Governments seeking to leverage market momentum during geopolitical crises may therefore consider building strategic material reserves for clean energy supply chains, drawing on the institutional logic behind existing petroleum reserve frameworks. This proposal is consistent with the broader energy security literature, which has long recognised that reserve mechanisms can reduce the volatility premium embedded in commodity-dependent infrastructure (Toman, 1993).

The contagion results reported under the second hypothesis present a more difficult policy problem. Because clean energy projects are capital-intensive and disproportionately reliant on sustained equity financing, a dependence well documented in the green bond literature (Flammer, 2021; Zerbib, 2019), a prolonged market contraction may constrain capital expenditure even where underlying project fundamentals remain sound. The evidence is consistent with Mazzucato and Semieniuk's (2018) argument that private green investment is procyclical and therefore structurally inadequate during systemic downturns without public intervention. Development finance institutions and central banks operating within a green mandate might consider contingent liquidity facilities designed to activate under defined macro-financial stress conditions, thereby partially insulating long-duration infrastructure investments from short-term market dislocations. The European Central Bank's climate-adjusted collateral framework and the Bank of England's climate stress-testing exercises represent nascent steps in this direction, though their countercyclical capacity remains untested under severe stress.

The pricing velocity documented around regulatory announcements underscores the importance of policy credibility and long-term commitment. Abrupt reversals or ambiguous compliance pathways introduce substantial economic policy uncertainty (Baker et al., 2016), with the risk of generating misallocation at the sectoral level. As Nordhaus (2015) argues in the context of climate policy coordination, fragmented and inconsistent national frameworks generate significant carbon leakage and investment inefficiency. International coordination on carbon adjustment mechanisms and multi-year regulatory frameworks could reduce the information frictions that currently contribute to episodic volatility in green equity markets.

5.3 Implications for Portfolio Management

For institutional investors and fund managers with exposure to energy sectors, the results suggest that the diversification properties of renewable energy equities are conditional on the nature of the prevailing macroeconomic environment, a finding that has direct implications for dynamic asset allocation.

During periods characterised by geopolitical risk, the evidence is consistent with renewable equities providing a partial hedge against fossil-fuel-specific vulnerabilities. Portfolio managers may be able to exploit this asymmetry by adjusting sector weights in anticipation of energy-related geopolitical events. This interpretation is reinforced by the broader literature on sustainable investing in equilibrium (Pástor et al., 2021), which predicts that green assets should outperform during periods when climate or energy transition concerns are elevated in investors' expectations. However, the practical implementation of such strategies depends heavily on the timing and predictability of shocks, and the evidence presented here does not speak directly to return persistence beyond the event window.

During systemic macroeconomic contractions, however, this hedging relationship breaks down. The compression of cross-sectoral return differentials during periods of broad market stress implies that green equity diversification offers limited protection when aggregate beta is elevated, a result consistent with the theoretical predictions of Brunnermeier and Pedersen (2009), who show that liquidity spirals sever the normal relationship between asset fundamentals and pricing. Under these conditions, risk management may need to rely on more conventional instruments, including sovereign bonds and gold, both of which have demonstrated relatively stable safe-haven properties during recent crises (Baur & Lucey, 2010). Notably, the literature on sin stocks and exclusionary screens (Hong & Kacperczyk, 2009) suggests an additional asymmetry: the same institutional norms that elevate green valuations in normal times may accelerate forced selling during stress periods if ESG mandates create concentrated positions among a narrower investor base.

Finally, the speed with which abnormal returns materialise around policy announcements is consistent with semi-strong market efficiency, as formalised by Fama (1970, 1991), suggesting that realising returns from regulatory news requires a well-calibrated execution infrastructure. The window during which informational advantages can be exploited appears to be narrow, and investors without the capacity to act rapidly around policy-relevant events may find that much of the adjustment is priced before meaningful reallocation is possible. Future research might usefully examine whether algorithmic trading activity around climate policy releases amplifies or dampens the short-run pricing dynamics documented here.

5.4 Limitations and Future Research Directions

While this study provides a robust cross-sectional baseline, certain econometric boundaries present fertile ground for future academic inquiry. First, the event-study methodology focuses on short-term terminal windows ([t-5, t+5]) to capture immediate information processing. While this isolates event-driven shocks from confounding macroeconomic noise, it does not measure the long-term structural persistence of these reallocations. Future research could deploy long-horizon structural break models or structural vector autoregressions (S-VAR) to evaluate how long the positive decoupling effect persists post-crisis.

Second, this paper utilized highly aggregated global and regional indices to capture macro-level sectoral shifts. Future studies could disaggregate these portfolios into specific sub-industries, contrasting solar, wind, and hydrogen systems against upstream oil exploration and downstream refining to uncover highly localised asset-pricing sensitivities. Finally, integrating high-frequency intraday data and asymmetric GARCH modelling could further clarify the real-time velocity of volatility spillovers and information leakage during black-swan disclosures.

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