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Comparing the Return and Volatility Performance of Renewable Energy Companies. Empirical Evidence from COVID-19 Pandemic and the 2015 Paris Agreement

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Abstract

This paper investigates the impact of the COVID-19 Pandemic and the 2015 Paris Agreement on the returns and volatility of renewable energy companies. The COVID-19 Pandemic led to a marked decline in volatility for TSLA, while volatility increased for NEE, FSLR, and the NDAQ index. In contrast, the 2015 Paris Agreement was linked to a significant reduction in volatility across all examined companies as well as the NDAQ. These results indicate that global policy agreements, such as the 2015 Paris Agreement, may help stabilise renewable energy markets, whereas the COVID-19 pandemic has affected volatility in a company-specific manner, reflecting differences in characteristics among NDAQ, TSLA, FSLR, and NEE.

Keywords

COVID-19, Paris Agreement, Renewable Energy

1. Introduction

Greenhouse gases are warming the planet at a faster rate than at any time in the past two thousand years. The Earth's average temperature is now approximately 1.55˚C warmer than it was in the 1800s, and even warmer than at any point in the past 100,000 years. The last decade was the hottest on record, and global temperatures continue to rise. This is one of the most urgent problems facing the world today, leading to rising sea levels, extreme heat, droughts, flooding, and other threats to humanity. The renewable energy sector is a key solution to minimizing these risks. Renewable energy is not only abundant, being derived from natural sources such as the sun, water, waste, and geothermal heat, but it also produces little to no greenhouse gas emissions or pollutants.

Studying the volatility of renewable energy stocks is vital information for financial markets. This is because investors, asset managers, and policymakers, understanding how renewable energy stocks behave in different market conditions helps in planning risk return trade-offs, developing hedging strategies, and deciding appropriate portfolio weights. Moreover, this sector is highly sensitive to shifting government incentives, evolving technologies, and changes in competing energy prices like oil and natural gas. Evaluating volatility aids financial markets to understand how sensitive the sector is to these drivers, which may differ significantly from traditional energy stocks. Volatility is also vital to study as it can enhance market efficiency as if the sources of volatility, such as speculation, macroeconomic shocks, or policy changes, are understood, then investors can price renewable energy assets more accurately. Furthermore, as the renewable energy sector is a high growth but comparatively a younger industry, understanding volatility will aid institutional investors and governments to determine whether the sector can attract stable, long-term capital or if it requires mechanisms to mitigate risk, which is critical for funding large-scale green infrastructure.

Given this strong link between market stability and the renewable energy transition, it is essential to examine how major global events shape volatility and returns in this sector. In recent years, two important events have changed the direction of the sector; these events are COVID-19 and the 2015 Paris Agreement. The 2015 Paris Agreement was a historic global climate agreement that showed long term commitment to reducing green gas emissions to well below 2˚C, preferably 1.5˚C. The COVID-19 Pandemic was an unexpected global health crisis that harmed economies, supply chains, and investors. It is clear that both of these events have significant implications for renewable energy companies. For instance, the 2015 Paris Agreement significantly decreased the volatility of NEE, ENPH, FLSR, TSLA, and NDAQ compared to before this event. Comparatively, the COVID-19 Pandemic significantly increased the volatility of NDAQ, FSLR, NEE, and ENPH however it decreased the volatility of TSLA. Regarding the return, the Paris Agreement does not change the return of renewable energy companies. Similarly the COVID-19 Pandemic also does not significantly impact the return of renewable energy companies. As such, the Paris Agreement is likely to boost investment in renewable energy and also make the market less uncertain by keeping policies stable. On the other hand, the COVID-19 Pandemic is a systemic shock that might make the market more volatile.

This paper aims to investigate how the volatility and return of renewable energy companies are affected by both the COVID-19 Pandemic and 2015 Paris Agreement. By using regression analysis, the paper emphasizes that global energy policy agreements likely stabilized renewable energy markets, whereas global pandemic shifts a company's volatility based on its characteristics, suggesting heterogeneous company level responses to systemic shocks. This paper contributes by analyzing renewable energy market reactions to both long-term climate policies and global crises, using firm-level regressions to build a robust sector index. Unlike prior studies that focus on single events or firms, it compares against broader indexes and uniquely integrates both the COVID-19 Pandemic and the 2015 Paris Agreement. One of the research gaps our paper addresses is the joint analysis of the COVID-19 pandemic and the Paris Agreement in relation to renewable energy stock volatility. This paper proceeds as follows: Section 2 analyzes the literature review of current papers. Section 3 analyses the empirical findings. Section 4 concludes the paper.

2. Literature Review

Various methodologies have been used and employed to investigate the effects of Covid-19 Pandemics and 2015 Paris Agreement on the volatility and return performance of renewable energy companies such as Diebold Yilmaz Approach (Liu et al., 2022; Umar et al., 2022), Wavelet Analysis (Hanif et al., 2023; Li et al., 2024), event study (Kuang et al., 2021), market model (Monasterolo & Angelis, 2020), VAR model (Qiu et al., 2023; Tiwari et al., 2022; Pham et al., 2023), ARIMA model (Ghosh & Jana, 2024), machine learning models (Ghallabi et al., 2025), TOPSIS (Gong et al., 2024), regression model (Li et al., 2024; Fahmy, 2022), Panal regression (Wan et al., 2021), causality test (Hammoudeh et al., 2021).

The variables used in literature write with different indicators such as stock market index (Liu et al., 2022), spillover index (Umar et al., 2022), carbon price (Tiwari et al., 2022; Qiu et al., 2023), idiosyncratic returns (Kuang et al., 2021), systematic risk (Monasterolo & Angelis, 2020), green stock (Pham et al., 2023), Brent crude oil (Slatinaa et al., 2023; Ghosh & Jana, 2024), EGS index (Ghallabi et al., 2025), liquidity (Gong et al., 2024), sustainability index (Li et al., 2024), natural gas returns (Ghabri et al., 2021; Umar et al., 2022), fuel oil (Umar et al. 2022), and oil price (Hammoudeh et al., 2021; Ghosh & Jana, 2024; Fahmy, 2022).

Many studies have focused on many countries and regions such as Europe (Liu et al., 2022; Qiu et al., 2023), United States (Pham et al., 2023; Ghosh & Jana, 2024), global (Burleson, 2016; Ghallabi et al., 2025), China (Wan et al., 2021).

This paper makes several contributions to literature. First, we provide market reactions to long term climate policies and unexpected global crises within the renewable energy sector. We estimate many different regression analyses for all individual companies to present a more robust and aggregate index. While we have analyzed dozens of papers that discuss these events, the majority of them don't focus on these events in regards to their effects on renewable energy companies. Moreover, this paper doesn't simply focus on individual companies but also compares them to market indexes such as NDAQ. Furthermore, while analyzing the literature review, we found that most papers focus on only one event, either the COVID-19 Pandemic or 2015 Paris Agreement, whereas this paper has a combined focus on both events.

An extensive summary of literature is presented in Table 1 below.

Table 1. Literature review.

Literature Review						
Authors	Year	Country/Region	Key Variable	Key Findings	Method	Time Period
Liu et al.	2022	USA, Europe	Renewable Energy Stock index, economic uncertainty index	Covid 19 increases volatility of renewable energy stocks.	Diebold-Yilmaz	2004-2020
Hanif et al.	2023	USA	Spillover index	High spillovers during Covid 19 reduced diversification benefits	Wavelet, Spillovers Index	2018-2020
Tiwari et al.	2022	Europe	Green bond, carbon price, renewable energy stocks	Green bonds absorb shocks. Clean energy derives spillovers.	Var, Mvp	2015-2020
Kuang et al.	2021	United States	clean energy stocks, riskiness, returns	Stock prices fell when the Paris Agreement took into effect.	Events, Data, Event Study	2015-2016
Monasterolo and Angelis	2020	Europe, US, Global	carbon-intensive indices, systematic risk, (log-)return	After the Paris Agreement low-carbon stock indices became less risky leading to higher portfolio weights.	Five-Factor Model, Chow Test	Around 2015
Qiu et al.	2023	European Union, US	carbon, stock and renewable energy markets	Carbon prices hurt stocks but aid renewables, stock booms hinder renewablesCOVID-19 increased spillovers	TVP-VAR, Jarque-Bera Test	2014-2021
Pham et al.	2023	US	Green stock, climate energy	pro-climate policies boost green stock returns	VAR	2014-2022
Slatinaa	2023	Europe	Brent crude oil futures prices	positive link between Brent oil futures and the ERIX renewable energy index	VAR	2015-2022
Burleson	2016	Global,	Greenhouse gas emissions, Climate governance mechanism	Paris Agreement promotes bottom-up climate action	Qualitative Legal and Policy Analysis	2015

Continued

Ghosh and Jana	2024	United States	clean energy sectoral stock, crude oil prices	U.S. clean energy sector indices can be forecasted with high accuracy.	Time-Series Forecasting, ARFIMA	2017-2021
Ghallabi et al.	2025	Global	ESG stock market indices	ESG markets strongly predict clean energy stock prices	Machine Learning Models, Shapley Additive Explanations	2014-2023
Gong et al. Pirabi	2024	US	profitability, liquidity, market performance, TOPSIS	Renewables gain before and after Paris Agreement entry	TOPSIS, Shannon Entropy Weighting for Financial Ratios	2013-2021
Li et al. Norena-Chavez	2024	Global	S&P 500, Renewable Energy	Green finance and green technology both help achieve Paris Agreement goals	Wavelet-Based Quantile-On-Quantile Regression	2016-2023
Fahmy	2022	United States	Clean Energy Indices	Before the Paris Agreement, clean energy prices were driven by oil prices; after, technology stock prices drove it	Exogenous Smooth Transition Regression, Structural Break Analysis	2009-2019
Ghabri et al. Guesmi	2021	Global	Crude oil, Clean energy indices	During Covid-19, clean energy stocks surged after the oil price crash but fell after OPEC+ cuts	Time-Varying Parameter Vector Autoregression	2020-2020
Chai et al. (2022)	2022	Global	SPGB, SPCE, MSCI ACWI Index	COVID-19 increased the positive links between green bonds, clean energy, and stock prices	TVP-VAR, Impulse Response Analysis	2011-2021
Wan et al. Shan	2021	China	clean energy firms, return, volatility	COVID-19 negatively affected both clean energy and fossil fuel firms	Panel Regressions and Instrumental Variable (2SLS) Regression	2019-2020

Continued

Umar et al. Naeem	2022	Global	S&P Global Clean Energy Index, crude oil, natural gas	During COVID-19, spillovers intensify in the short term, but natural gas remains the least connected	Diebold & Yilmaz (2012) Barunik & Krehlik (2018)	2004-2020
Hammoudeh et al. Ajmi	2021	Global	Crude oil prices, NASDAQ, renewable energy stock	Before Covid-19, oil prices and renewable energy stocks were linked. During Covid-19, this connection vanished	Nonparametric Causality-In-Quantiles Test, Unit Root-In-Quantiles Test	2010-2020

3. Empirical Findings

Data

We obtained the most updated available data from Google Finance for selected individual renewable energy companies and an aggregate market index as NextEra Energy Inc (ticker symbol: NEE), First Solar Inc (ticker symbol: FSLR), Enphase Energy Inc (ticker symbol: ENPH), Tesla (ticker symbol: TSLA), and Nasdaq (ticker symbol: NDAQ), covering daily closing price for selected period from 1999 to 2025. We identified the starting period of COVID-19 as 11 March 2020 and the starting period of the Paris Agreement as 12 December 2015.

4. Descriptive Statistics

Table 2. Descriptive statistics.

Descriptive Statistics					
Variables	Obs	Mean	Std. Dev.	Min	Max
Return NEE	6639	0.0003	0.0151	−0.1442	0.1303
Return NDAQ	5747	0.0005	0.0235	−0.1625	0.2327
Return ENPH	3310	0.0005	0.0502	−0.4679	0.3538
Return FSLR	4660	0.0004	0.0371	−0.2921	0.3752
Return TSLA	3753	0.0014	0.0364	−0.2365	0.2188
Volatility 30 NEE	6610	0.0133	0.0072	0.0042	0.065
Volatility 30 NDAQ	5718	0.0198	0.0125	0.0053	0.0808
Volatility ENPH	3281	0.0475	0.0163	0.017	0.1214
Volatility FSLR	4631	0.0342	0.0144	0.0129	0.1066
Volatility TSLA	3724	0.034	0.0123	0.0116	0.0886

Table 2 provides descriptive statistics of return and volatility variables for NEE, NDAQ, FSLR, TSLA, ENPH. The return NEE has 6639 observations with a mean of 0.0003 and a standard deviation of 0.0151, ranging from a minimum of −0.1442 to a maximum of 0.1303. The return of NDAQ has 5747 observations with a mean of 0.0005 and a standard deviation of 0.0235, ranging from minimum of −0.1625 to a maximum of 0.2327. The return of ENPH has 3310 observations with a mean of 0.0005 and a standard deviation of 0.0502, ranging from a minimum of −0.4679 to a maximum of 0.3538. The return of FSLR has 4660 observations with a mean of 0.004 and a standard deviation of 0.0371, ranging from a minimum of −0.2921 to a maximum of 0.3752. The return of TSLA has 3753 observations with a mean of 0.0014 and a standard deviation of 0.0364, ranging from a minimum of −0.2365 and a maximum of 0.2188.

The volatility of NEE has 6610 observations with a mean of 0.0133 and a standard deviation of 0.0072, ranging from a minimum of 0.0042 to a maximum of 0.065. The volatility of NDAQ has 5718 observations with a mean of 0.0198 and a standard deviation of 0.0125, ranging from a minimum of 0.0053 to a maximum of 0.0808. The volatility of ENPH has 3281 observations with a mean of 0.0475 and a standard deviation of 0.0163, ranging from a minimum of 0.017 to a maximum of 0.1214. The volatility of FSLR has 4631 observations with a mean of 0.0342 and a standard deviation of 0.0144, ranging from a minimum of 0.0129 to a maximum of 0.1066. The volatility of TSLA has 3724 observations with a mean of 0.034 and a standard deviation of 0.0123, ranging from a minimum of 0.0116 to a maximum of 0.0886.

5. Findings

Figure 1 illustrates the historical performance of NEE in terms of price, return, and volatility. With two key events such as the 2015 Paris Agreement (black dash line) and the COVID-19 Pandemic (red dash line). As seen through the top-most graph of the price series, it illustrates a steady upward trend after 2015, suggesting that the period following the 2015 Paris Agreement benefited NEE. Furthermore, there is a dramatic decrease after COVID-19 Pandemic. The middle panel, signifying the return of NEE, illustrates that the return fluctuates throughout, but we can see a significant spike after 2019. The bottom panel shows the volatility of NEE. After the 2015 Paris Agreement, the volatility decreased, consistent with a stabilizing effect. Comparatively, the volatility dramatically increased at the starting point of COVID-19. It is clear that the 2015 Paris Agreement emphasizes market stability while COVID-19 Pandemic illustrates market uncertainty.

Figure 2 illustrates the historical performance of ENPH in terms of price, return, and volatility. With the COVID-19 Pandemic (red dash line). As seen through the top-most graph of the price series, it illustrates no change after 2015, suggesting that the period following the 2015 Paris Agreement did not strongly affect ENPH. Furthermore, there is a sharp decline after COVID-19 Pandemic. The middle panel, signifying the return of ENPH, illustrates that the return fluctuates throughout, but we can see a significant spike after 2015 and a contraction after the COVID-19 Pandemic. The bottom panel shows the volatility of ENPH,

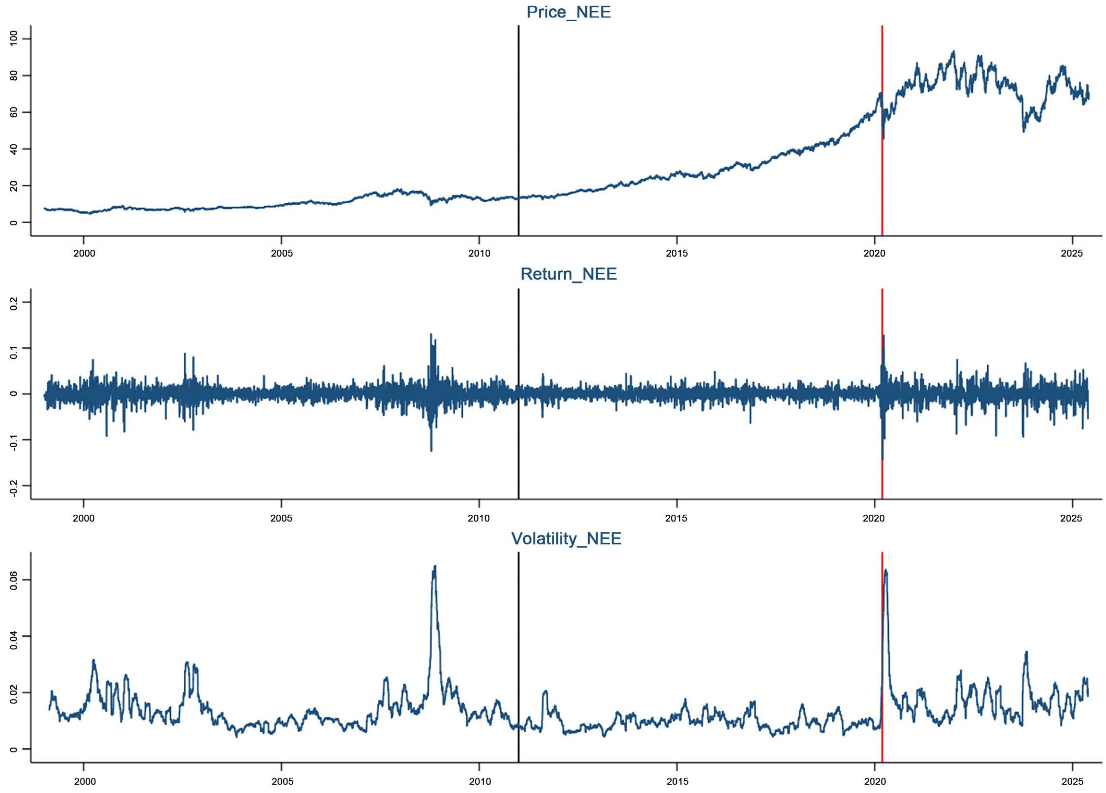

Figure 1. Price, return, and volatility of NEE.

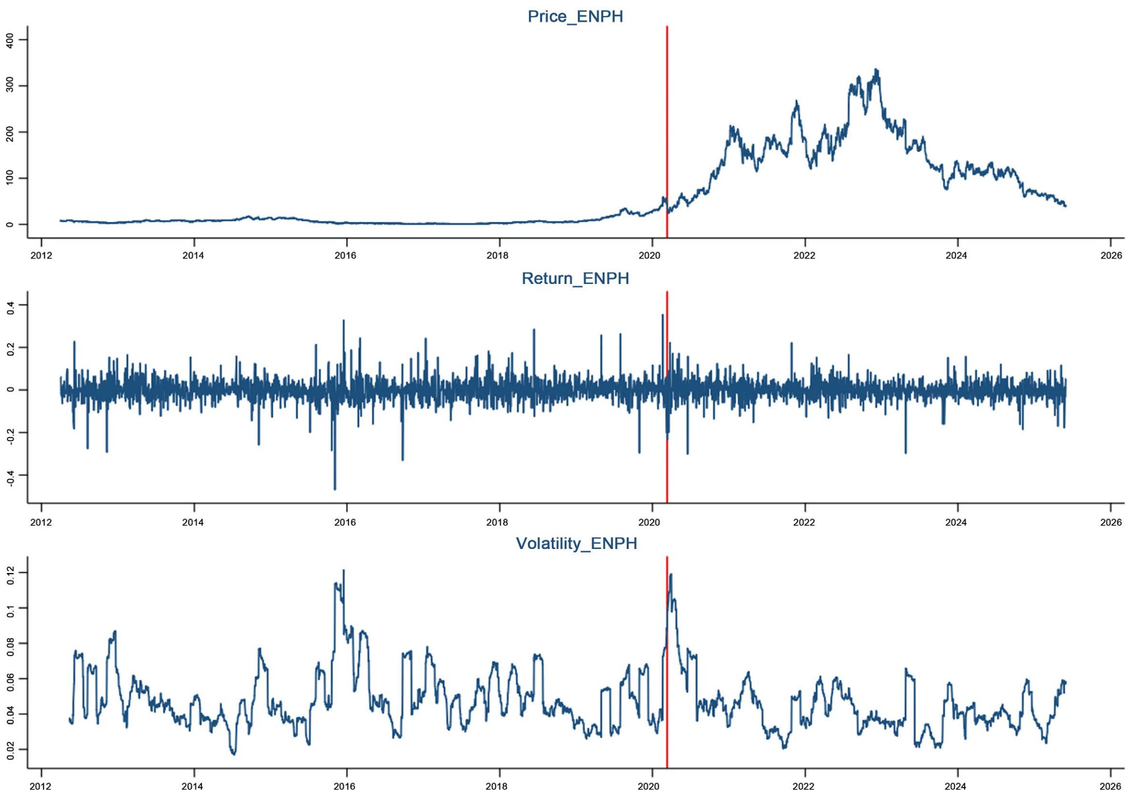

Figure 2. Price, return, and volatility of ENPH.

it is very clear that after the 2015 Paris Agreement, the volatility significantly decreased, consistent with a stabilising effect. In contrast the volatility dramatically increased at the starting point of COVID-19. It is clear that the 2015 Paris Agreement emphasizes market stability while the COVD-19 Pandemic illustrates market instability.

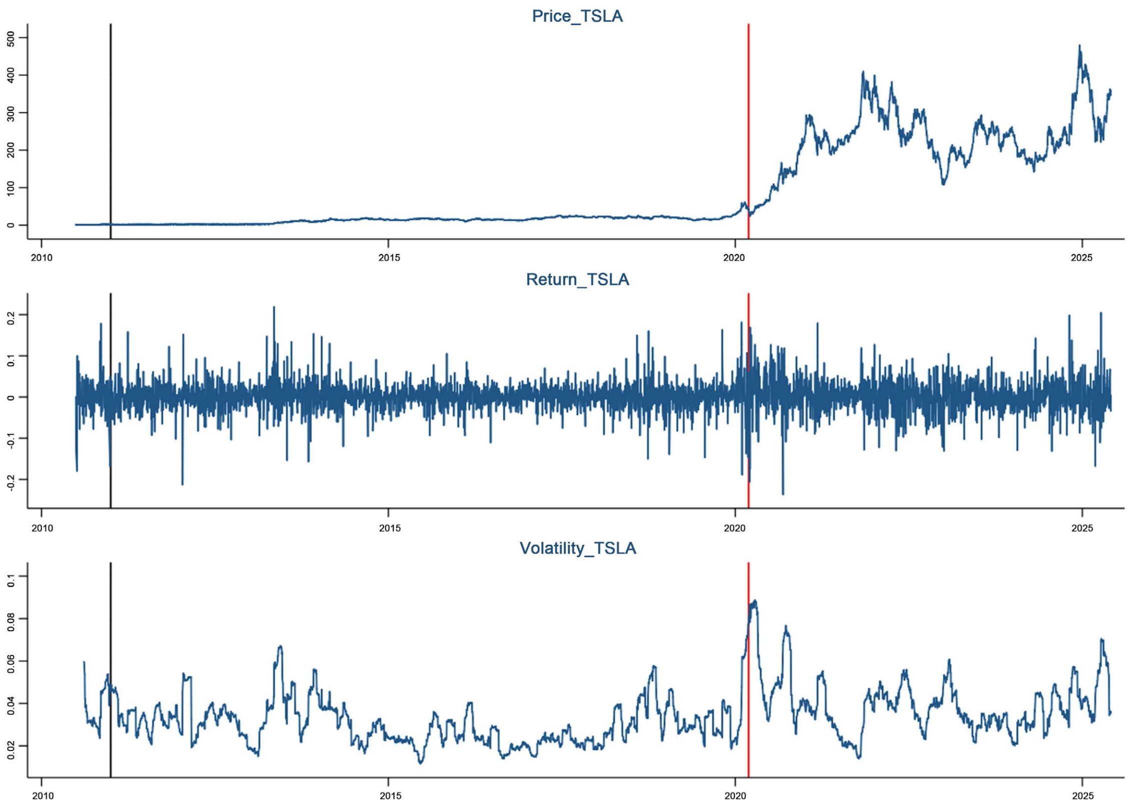

Figure 3. Price, return, and volatility of TSLA.

Figure 3 illustrates the historical performance of TSLA in terms of price, return, and volatility. With two key events such as the 2015 Paris Agreement (black dash line) and the COVID-19 Pandemic (red dash line). As seen through the top-most graph of the price series, there is no change in the price of TSLA after the 2015 Paris agreement was signed, suggesting that TSLA was not affected by the 2015 Agreement in regards to price. Furthermore, there is a dramatically sharp increase in price after COVID-19 Pandemic, suggesting that the COVID-19 Pandemic strongly benefited TSLA. This is unlike many other renewable energy stocks likely because TSLA announced a five-for-one stock split in August 2020, which enhanced affordability and liquidity, attracting substantial retail investor participation. Additionally, TSLA's inclusion in the S&P 500 index in December 2020 created a strong wave of institutional buying, as all index-tracking funds were required to acquire TSLA shares, thereby amplifying demand and price momentum. The middle panel, signifying the return of TSLA, illustrates that the return fluctuates throughout, but we can see a significant spike after 2019, suggesting that the

COVID-19 Pandemic was beneficial for TSLA. Comparatively, the return decreased after the 2015 Paris Agreement. The bottom panel shows the volatility of TSLA, it is very clear that after the 2015 Paris Agreement, the volatility decreased, consistent with a stabilising effect. Similarly, the volatility dramatically decreased at the starting point of COVID-19.

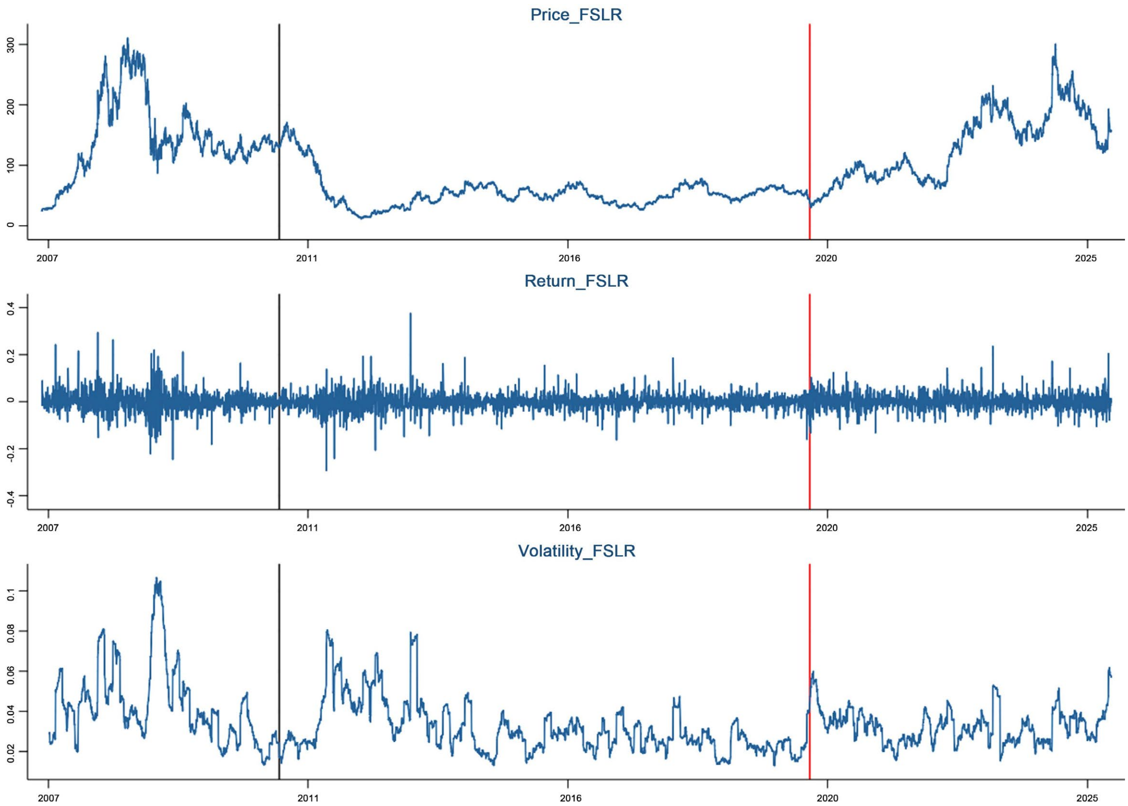

Figure 4. Price, return, and volatility of FSLR.

Figure 4 illustrates the historical performance of FSLR in terms of price, return, and volatility, with the COVID-19 Pandemic (red dashed line) and the 2015 Paris Agreement (black dashed line). As seen through the top-most graph of the price series, the trend following the 2015 Paris Agreement suggests little immediate change, indicating that the agreement did not strongly affect FSLR's price trajectory in the short term. However, after the onset of the COVID-19 Pandemic, the price experienced heightened fluctuations but no sustained downward movement, reflecting resilience compared to broader market declines. The middle panel, signifying the return of FSLR, illustrates consistent fluctuations throughout the period, with no major structural shift after the Paris Agreement. In contrast, following the COVID-19 Pandemic, there is a clear pattern of intensified short-term contractions, showing the impact of systemic uncertainty on firm-level returns. FSLR may differ in regards to return and price due to its Q2 2020 exceeding analyst expectations, reinforcing investor confidence despite broader market uncertainty. Additionally, by April 2021, FSLR's stock had climbed over 75%, supported by strong financial performance and optimism around the Biden administration's clean energy agenda. The bottom panel, depicting volatility, provides the sharpest contrast. After the 2015 Paris Agreement, volatility visibly declined, aligning with the notion of market stabilization under long-term climate commitments. Conversely, at the onset of COVID-19, volatility spiked dramatically, underscoring the destabilizing influence of global crises. Overall, the figure reinforces that the Paris Agreement emphasized market stability for renewable energy firms such as FSLR, while the COVID-19 Pandemic introduced heightened uncertainty and firm-specific risk.

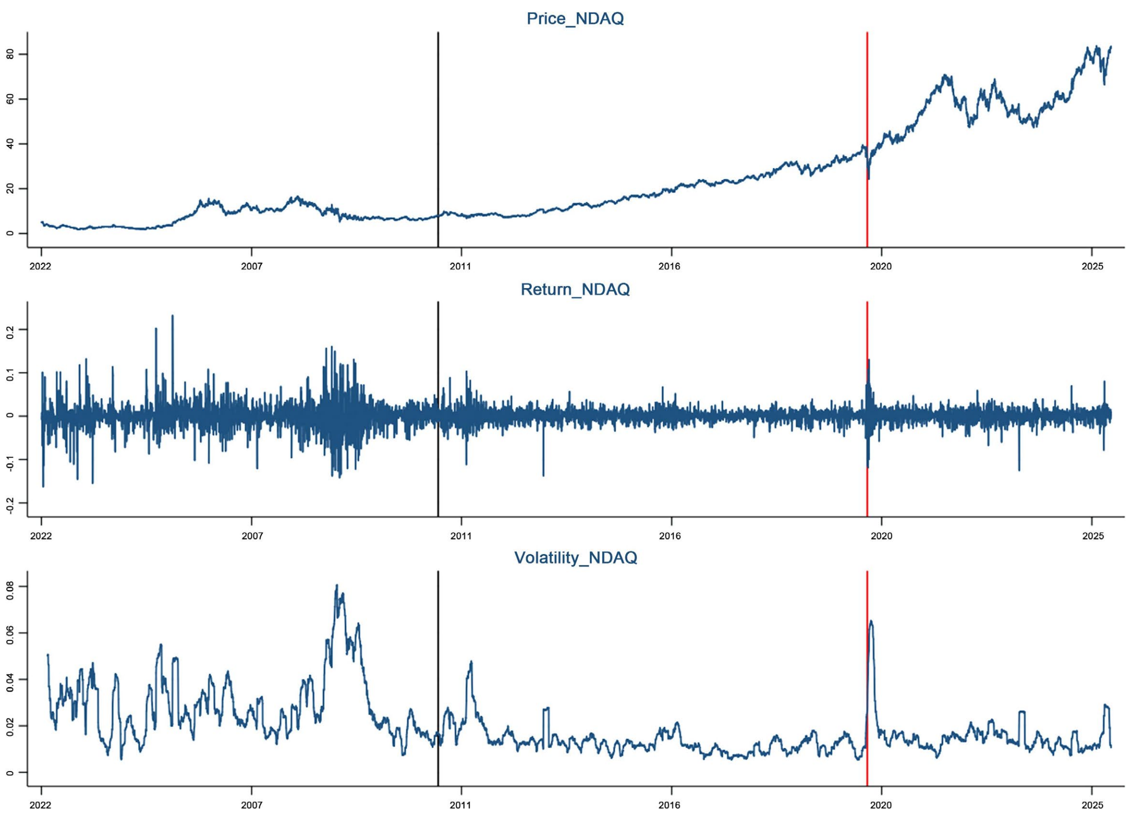

Figure 5. Price, return, and volatility of NDAQ.

Figure 5 illustrates the historical performance of NDAQ in terms of price, return, and volatility. With two key events such as the 2015 Paris Agreement (black dash line) and the COVID-19 Pandemic (red dash line). As seen through the topmost graph of the price series, it illustrates a slow upward trend after 2015, suggesting that the period following the 2015 Paris Agreement slightly benefited NDAQ. Comparatively, there is a dramatically sharp decrease after COVID-19 Pandemic. The middle panel, signifying the return of NDAQ, illustrates that the return fluctuates throughout pre-Paris Agreement, a steady return after this event. The return also dramatically spiked at the beginning of COVID-19. The bottom panel shows the volatility of NDAQ. After the 2015 Paris Agreement, the volatility has significantly lower rates than before, consistent with a stabilising effect. In contrast, it is very clear that the volatility significantly increased at the starting point of COVID-19. This demonstrates that while the Paris Agreement contributed to steady growth and reduced volatility for NDAQ, the COVID-19 Pandemic introduced sharp disruptions that amplified both return fluctuations and market instability.

Table 3. Regression analysis of volatility for Paris agreement.

	Regression Analysis of Volatility for Paris Agreement			
	(1)	(3)	(4)	(5)
Variables	NEEv	FSLRv	TSLAv	NDAQv
Dum 1	−0.001***	−0.002***	0.006***	−0.011***
	0.000	0.000	(0.001)	0.000
Constant	0.014***	0.035***	0.033***	0.024***
	0.000	0.000	0.000	0.000
Observations	6610	4631	3724	5718
R-squared	0.005	0.004	0.020	0.174

Robust standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 3 presents the result of 4 different regression models, when the dependent variables are volatility of NEE, FSLAR, TSLA, and NDAQ respectively. Each column corresponds to a distinct model with explanatory Covid-19 dummy variables which takes 0 before the Covid-19 Pandemic and 1 otherwise. If the results are statistically significant, at 1 percentage level, we indicated by (***), the 5 percentage level (**), and the 10 percentage level (*). In model 1, Covid-19 dummy variable is negatively associated with volatility of NEE suggesting the higher level of volatility linked to before the Covid-19 Pandemic. It is clear that the Covid-19 Pandemic has a significant effect on the volatility of NEE. In model 2, Covid-19 dummy variable is negatively associated with volatility of FSLR suggesting the higher level of volatility linked to before the Covid-19 Pandemic. It is clear that the Covid-19 Pandemic has a significant effect on the volatility of FSLR. Interestingly, in Model 3, Covid-19 dummy variable is positively associated with volatility of TSLA, suggesting that the higher level of volatility is associated with after the Covid-19 Pandemic period. In model 4, Covid-19 dummy variable is negatively associated with volatility of NDAQ suggesting the higher level of volatility linked to before the Covid-19 Pandemic. It is clear that the Covid-19 Pandemic has a significant effect on the volatility of NDAQ. If we compare the size of coefficients, Covid-19 Pandemic has the biggest effect on the volatility of NDAQ, TSLA, FSLR, NEE respectively. It is obvious that the Covid-19 Pandemics has a negative effect on the volatility of the financial market except TSLA.

Table 4 presents the result of 5 different regression models, when the dependent variables are volatility of NEE, ENPHS, FSLAR, TSLA, and NDAQ respectively. Each column corresponds to a distinct model with explanatory Paris

Table 4. Regression analysis of volatility for Paris agreement.

	Regression Analysis of Volatility for Paris Agreement				
	(1)	(2)	(3)	(4)	(5)
Variables	NEEv	ENPHv	FSLRv	TSLAv	NDAQv
Dum 1	0.0011***	−0.0018***	−0.009	−0.002***	−0.011***
	(0.0001)	(0.0006)	(0.0004)	(0.0004)	0.000
Constant	0.012***	0.048***	0.0389	0.032*	0.024***
	(0.001)	(0.0005)	(0.0003)	0.000	0.000
Observations	6610	3281	4631	3724	5718
R-squared	0.005	0.026	0.1049	0.0086	0.111

Robust standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Agreement dummy variables which takes 0 before the Paris Agreement and 1 otherwise. If the results are statistically significant, at 1 percentage level, we indicated by (***), the 5 percentage level (**), and the 10 percentage level (*). From model 1 to model 5, the Paris Agreement dummy variable is negatively associated with volatility of NEE, ENPH, FLSR, TSLA, and NDAQ respectively, suggesting the higher level of volatility linked to before the Paris Agreement. It is clear that the Paris Agreement has a significant effect on the volatility of all individual renewable energy companies and aggregate market index which emphasizes the volatility of all individual renewable energy companies and aggregate market index dramatically decreased after the Paris Agreement period. It is obvious that the arrangement on climate risk has a positive effect on the volatility of the financial market.

Table 5. Regression analysis of return for COVID-19.

	Regression Analysis of Return for COVID-19			
	(1)	(3)	(4)	(5)
Variables	NEEr	FSLRr	TSLAr	NDAQr
Dum 1	0.000	0.001	−0.001	0.000
	0.000	(0.001)	(0.002)	(0.001)
Constant	0.000	0.000	0.002**	0.000
	0.000	(0.001)	(0.001)	0.000
Observations	6639	4660	3753	5747
R-squared	0.000	0.000	0.000	0.000

Robust standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5 presents the result of 4 different regression models, when the dependent variables are logarithmic return of NEE, FSLAR, TSLA, and NDAQ respectively. Each column corresponds to a distinct model with explanatory Covid-19 dummy variables which takes 0 before the Covid-19 Pandemic and 1 otherwise. If the results are statistically significant, at 1 percentage level, we indicated by (***), the 5 percentage level (**), and the 10 percentage level (*). According to 4 different models, we couldn't capture any significant relationship between Covid-19 dummy and the volatility of all individual companies and the aggregate market index. Table 3 suggests that the pandemic period did not have a statistically significant impact on the returns of NEE, FSLR, TSLA, or NDAQ.

Table 6. Regression analysis of return for Paris agreement.

	Regression Analysis of Return for Paris Agreement				
	(1)	(2)	(3)	(4)	(5)
Variables	NEEr	ENPHr	FSLRr	TSLAr	NDAQr
Dum 1	0.001	0.0025	−0.0009	−0.0003	0.002
	(0.003)	(0.002)	(0.001)	(0.001)	(0.003)
Constant	−0.002	−0.001	0.00035	0.002**	0.003
	(0.001)	(0.002)	(0.009)	(0.001)	(0.004)
Observations	6639	3310	4660	3753	5747
R-squared	0.000	0.001	0.001	0.001	0.001

Robust standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 6 presents the result of 5 different regression models, when the dependent variables are volatility of NEE, ENPHS, FSLAR, TSLA, and NDAQ respectively. Each column corresponds to a distinct model with explanatory Paris Agreement dummy variables which takes 0 before the Paris Agreement and 1 otherwise. If the results are statistically significant, at 1 percentage level, we indicated by (***), the 5 percentage level (**), and the 10 percentage level (*). From model 1 to model 5, the Paris Agreement dummy variable is not statistically significant on the logarithmic return variable for all individual renewable energy companies and the aggregate market index. Table 4 suggests that the Paris Agreement did not have a statistically significant impact on the volatility of NEE, FSLR, TSLA, or NDAQ.

The regression analysis in Table 3 suggests that the COVID-19 Pandemic did not affect industry level renewable energy firms in the same manner. NEE, FSLR, and NDAQ all experienced increased volatility during the pandemic period, while TSLA faced the opposite pattern, with significantly higher volatility. Despite the fact that all of the firms analysed in this study are from the renewable energy industry, each of them face numerous differing factors that alter their risk and profitability.

Despite the fact that NEE is considered a defensive stock as it operates as a utility and has long-term power contracts, after the COVID-19 Pandemic its volatility increased. For instance, commercial and industrial demand for power fell sharply in 2020 as more individuals worked at home, while residential demand rose, which created uncertainty in NEE's revenue for the following quarter. In addition, customer relief programs in Florida raised concerns about payment arrears, and the company faced uncertainty over completing large-scale projects like the Okeechobee Clean Energy Center on schedule. These pressures increased short-term uncertainty around operations, which explain why NEE's volatility rose despite its operations as a utility.

Even while FSLR provides predictable revenue streams due to its strong reliance on long-term power purchase agreements and contracts that last 15 to 20 years, after the COVID-19 Pandemic its volatility increased. This is primarily due to pressures caused by global supply chain disruptions. For instance, key inputs for the solar modules that FSLR provides such as tempered glass, cadmium telluride semiconductors, and aluminum frame faced shortages as factories in Asia and Europe shut down or reduced output. Due to its wide geographical reach, international shipping delays and rising freight rates added further uncertainty about whether FSLR could deliver modules on time and at stable costs. Furthermore, construction delays further amplified this risk as many of their projects in North America and Asia such as its Ohio Manufacturing Expansion and its Vietnam Production Facilities faced slowdowns and labor shortages due to the restrictions that the COVID-19 Pandemic required. As such, even if contracts secured revenues over the long term, uncertainty remained regarding their quarterly earnings and cash flow projections.

In contrast, TSLA's volatility decreased during COVID-19 Pandemic and several factors contributed as to why. For instance, TSLA raised over $12 billion in equity capital in 2020, significantly strengthening its financials. They also consistently beat delivery targets by delivering 499,550 vehicles in 2020 versus expectations of ~480,000 which strengthened investor expectations. Additionally, the U.S. and EU policies such as the EV tax credits and the EU's Green Deal reduced doubts about long-term demand for EVs. TSLA also received inclusion in the S&P 500 in December 2020 which required index-tracking funds to buy more than $80 billion worth of TSLA shares, thereby reducing measured volatility even as the share price rose sharply.

6. Model

$$Y_t = \beta_0 + \beta_1 X_t + \epsilon_t$$

where Y_t is the dependent variable for observation t, which refers to volatility and return. Volatility is measured as the 30-day rolling standard deviation of daily stock returns. β_0 is the constant term, representing the expected value of a dependent variable when the independent variable is 0. β_1 is the coefficient of the independent variables which includes Covid-19 dummy and Paris Agreement dummy. The dummy variables take 0 before the event period and 1 after the event period. The dummy variables show how much the dependent variable changes before and after the event periods. ϵ_t is the error term, which represents the error between the actual value and the predicted value of the model.

7. Conclusion

This study provides empirical evidence of how renewable energy companies and the aggregate market index responded to two major global events: the 2015 Paris Agreement and the COVID-19 Pandemic. The results emphasize that long-term climate policy commitments, such as the Paris Agreement, tend to reduce volatility without significantly affecting returns, stabilizing renewable energy markets. In contrast, systemic shocks like the COVID-19 Pandemic introduce heterogeneous firm level responses, with some companies experiencing decreased volatility while others became more volatile, though overall returns remained largely unaffected. The main findings highlight that global energy policy agreements such as the 2015 Paris Agreement can provide stability and predictability for renewable energy companies, while global crises generate such as the COVID-19 Pandemic uncertainty that amplifies company-specific risk profiles. This study provides empirical evidence of how renewable energy companies and aggregate market index responded to two major global events such as the 2019 Paris agreement and COVID-19. The COVID-19 epidemic decreased volatility for TSLA while increasing it for NEE, FSLR, ENPH and the NDAQ index. On the other hand, the 2015 Paris Agreement reduced volatility across all companies and the NDAQ. These findings suggest that global policy agreements like the Paris Accord may stabilize renewable energy markets, but the COVID-19 epidemic has affected volatility differently for NDAQ, TSLA, FSLR, ENPH and NEE due to their variations.

Future studies put the extent of this analysis by incorporating additional sectors beyond renewable energy, adopting longer time horizons, and applying alternative methodologies to capture a broader spectrum of market dynamics. Moreover, future research could expand the dataset to include more firms, regions, and renewable energy sub-sectors. These insights hold practical value for policymakers aiming to design effective climate policies, for investors seeking to allocate capital efficiently, and for researchers striving to deepen understanding of how global events shape financial markets.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix

Data definition:

Data Definition		
Ticker Symbol	Definition	Source
NEE	NextEra Energy Inc	Google Finance
NDAQ	Nasdaq	Google Finance
FSLR	First Solar Inc	Google Finance
ENPH	Enphase Energy Inc	Google Finance
TSLA	Tesla	Google Finance