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Risk-Adjusted Performance of American and European Clean-Energy Portfolios

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Abstract:

This study constructs two eight-asset green-energy portfolios, featuring stocks from the U.S. and Europe, to assess which portfolio delivers superior risk-adjusted performance. The analysis utilizes advanced performance metrics, the Stutzer and Omega ratios, with the traditional Sharpe ratio serving as a benchmark. Portfolios are evaluated across both pre-crisis and crisis periods. The results reveal differences in the structures of the Sharpe and Stutzer portfolios, underscoring the Stutzer ratio's ability to improve portfolio performance. Additionally, the Omega portfolio enhances the analysis by allowing the selection of varying thresholds, offering greater adaptability to align with diverse investor preferences. When comparing the U.S. and European portfolios, the U.S. portfolio consistently demonstrates better risk-adjusted performance. This advantage stems from factors such as favorable market dynamics, supportive government policies, greater access to capital, advanced technological innovation, and effective corporate strategies.

Keywords: green-energy portfolios, sophisticated performance metrics

JEL classification: G11, G32, P28

1. Introduction

Clean energy, as a sustainable alternative to fossil fuels, is fundamental to addressing global climate challenges. Its adoption is key to achieving international objectives like the 2015 Paris Climate Agreement and the United Nations Sustainable Development Goals (Stoian, 2021; Li et al., 2024). Sustainable finance has emerged as a pivotal mechanism for directing investments into clean energy initiatives, enabling the growth of renewable technologies that are crucial for long-term carbon reduction (Zaharia et al., 2019; Demiralay et al., 2023). Investing in green-energy stocks can be a strategic choice for various financial, ethical, and economic reasons. According to Radpour et al. (2021), many countries offer financial incentives for renewable energy projects, which not only boost the profitability of companies in this sector but also encourage a transition from fossil fuels to cleaner alternatives. Some green-energy companies have delivered strong returns in recent years, driven by growing investor interest and robust expansion in renewable energy demand. For example, between 2019 and 2023, the S&P Global Clean Energy Index demonstrated remarkable long-term growth, outperforming traditional energy benchmarks by delivering a 41% return compared to 15% from the S&P Oil Index. Finally, many investors aim to align their portfolios with their values, and green-energy investments often play a central role in Environmental, Social, and Governance (ESG) strategies (Tan et al., 2023).

However, green investments face both unique and broad economic risks that can disrupt capital inflows to the sector (Dong et al., 2023). The clean-energy market has experienced notable fluctuations in recent years due to challenges such as increasing interest rates, logistical constraints in global supply chains, and complex regulatory environments. In 2023, for example, the S&P Global Clean Energy ETF experienced a sharp decline of over 30%, reflecting broader market pressures. One significant issue is the high leverage often used by clean-energy companies, which leaves them particularly exposed to rising borrowing costs. Elevated interest rates have amplified financing expenses, dampened profitability, and slowed the pace of expansion in the renewable energy space.

Conducting a thorough evaluation of the risk-return dynamics of green investments is crucial for stakeholders aiming to eliminate barriers to sustainable development and effective environmental management, as contended by Lu et al. (2023).. Accurate and timely insights into the performance of clean-energy assets are indispensable for investors to optimize their climate-focused portfolios while balancing risks and returns. Pingkuo and Junqing (2024) argued that, from a global perspective, the United States and Europe are the leading regions where green-energy finance and clean-energy awareness has been extensively developed. Hence, this paper examines the performance of eight-asset green-energy portfolios, composed of the most prominent clean-energy companies from the U.S. and Europe, with a focus on risk-adjusted returns. Table 1 presents the list of selected companies for both portfolios and highlights their contributions to clean energy. All selected companies were chosen based on their highest market value and revenue in the renewable energy sector. Moreover, each company has been in the market for more than 10 years, which is important to mention as our sample starts from

2015. This allows us to evaluate the performance of companies both before and during (or after) the COVID-19 pandemic and the war in Ukraine. Referring to Sikiru and Salisu (2023), we divide the entire sample into two subsamples, with December 31, 2019, as the splitting point.

Table 1. Selected green-energy companies from the U.S. and Europe

U.S. companies		European companies	
	Renewable energies		**Renewable energies**
AES	Hydro, solar and wind	**EDP (PRT)**	Hydro, solar, wind and geothermal
Duke	Hydro, solar and wind	**Enel (ITA)**	Solar and wind
Enphase	Solar	**Engie (FRA)**	Wind, solar, hydro and biomass
First solar	Solar	**Fortum (FIN)**	Hydro, solar and wind
NextEra	Wind and solar	**Iberdrola (ESP)**	Hydro, solar and wind
Ormat	Geothermal	**RWE (DEU)**	Hydro, solar and geothermal
Southern co.	Hydro, solar and wind	**SMA (DEU)**	Solar
Tesla	Electric cars and solar panels production	**Vestas (DNK)**	Wind

Note: Three-letter acronyms in parentheses indicate the country of origin.
Source: Authors' own selection based on information retrieved from company websites, sustainability reports, and energy profiles.

Following Nemec et al. (2022) and Liang and Nasruddin (2024), there are several compelling reasons to explore this topic, which underscore its importance in the context of sustainable finance and investment. First, investors in green-energy aim to balance returns with risks to maximize their portfolio efficiency. Second, the green-energy sector is particularly susceptible to unique risks, including high capital costs, technological uncertainties and dependence on policy support. Evaluating risk-adjusted performance helps investors understand how these factors impact returns and whether the rewards justify the risks in this sector. Third, the U.S. and European markets differ in regulatory frameworks, energy policies, and investor behaviour. For instance, the U.S. relies heavily on market-driven approaches, supported by incentives like the Inflation Reduction Act, while Europe is policy-centric, with strong commitments under the EU Green Deal and carbon pricing mechanisms. Comparing risk-adjusted performance across these regions highlights the effectiveness of their respective approaches to fostering green-energy investment. Fourth, both regions play a central role in achieving international climate goals, such as the 2015 Paris Agreement and the UN Sustainable Development Goals. Understanding the performance of their green-energy portfolios informs stakeholders about progress toward these objectives and identifies areas for improvement.

When constructing optimized portfolios with the best risk-adjusted characteristics, we begin with the classical Sharpe ratio, which helps investors understand how much additional return they are receiving for the risk they take compared to a risk-free benchmark. While the Sharpe ratio is straightforward to use and interpret, it has several shortcomings that may mislead investors in their decision-making process (Yoon, 2017). In particular, the Sharpe ratio assumes that returns are normally distributed, which is not true for many assets, especially those with skewed or fat-tailed return distributions. Additionally, it treats all volatility, both upside and downside, as risk, which may not align with investor preferences, as positive volatility is often desirable (Atmaca, 2022). Investments with asymmetric risk profiles may also have misleading Sharpe ratios because standard deviation fails to account for tail risks. Moreover, the Sharpe ratio ignores the magnitude of losses (drawdowns), which is a critical factor in assessing investments during periods of market stress. Considering these limitations, the Sharpe ratio is a useful starting point for evaluating risk-adjusted performance, but it should be complemented with other metrics to obtain a more comprehensive understanding of investment risk and return.

Therefore, we employ two alternative and more sophisticated risk measures – the Stutzer ratio and the Omega ratio – that provide significant improvements and offer more detailed insights compared to the Sharpe ratio. The Stutzer ratio, introduced by Stutzer (2000), focuses on the probability of underperformance, effectively capturing deviations from normality by penalizing asymmetry and extreme outcomes more robustly than the Sharpe ratio. Unlike the Sharpe ratio, which treats all volatility (both positive and negative) as risk, the Stutzer ratio concentrates on downside risk, emphasizing the likelihood of underperforming a given benchmark or target return (Bessler et al., 2021). According to Zakamouline and Koekebakker (2009), it evaluates the probability of achieving a specific level of return, making it a more intuitive metric for assessing how well an investment aligns with investor goals, especially in managing losses. The Stutzer ratio is derived by identifying the exponential tilting parameter (theta) that maximizes the probability of achieving returns above the benchmark. Although its calculation is more complex than that of the Sharpe ratio, the Stutzer ratio provides a more accurate measure of risk-adjusted performance for non-normal return distributions, such as those typically observed in stock portfolios.

On the other hand, the Omega ratio was proposed by Keating and Shadwick (2002), and it also improves upon the Sharpe ratio by offering a more nuanced approach to risk and return dynamics. According to Bernard et al. (2019), it provides a comprehensive view of the risk-return trade-off by evaluating the entire distribution of returns rather than relying solely on the mean and standard deviation. Unlike the Sharpe ratio, which assumes a normal distribution of returns, the Omega ratio evaluates the full return distribution, making it more suitable for assets with skewness and heavy tails (Balder and Schweizer, 2017). The Omega ratio explicitly distinguishes between downside risk (returns below a chosen threshold) and upside potential (returns above the threshold), offering a more intuitive measure of performance relative to an investor's target. Moreover, while the Sharpe ratio is benchmarked against a single risk-free rate, the Omega ratio allows investors to define specific target returns as the threshold for evaluating performance (Yu et al., 2022a). This flexibility makes it particularly useful for addressing customized investment goals and varying risk tolerances.

This paper makes several significant contributions to the literature. First, it constructs multivariate portfolios of green-energy stocks from the U.S. and Europe to identify which portfolio achieves superior risk-adjusted performance across both pre-crisis and crisis periods. Second, it employs two advanced performance evaluation metrics, the Stutzer and Omega ratios. Traditional methods, such as the Sharpe ratio, may favor portfolios with higher average returns, even if they come with significant downside risk. On the other hand, the Stutzer and Omega ratios may downgrade portfolios with excessive tail risk or volatility clustering, instead favoring those with more consistent or asymmetrically favorable return profiles. This may lead to different investment choices, particularly in volatile sectors like green energy, where traditional metrics may underestimate risk. To the best of our knowledge, this is the first time these tools have been applied in this context. This gap in the literature serves as the key motivation for our research.

Following the introduction, the paper is organized as follows. Section 2 provides a review of the relevant literature. Section 3 details the methodology for constructing the Stutzer and Omega portfolios. Section 4 introduces the dataset and presents descriptive statistics. Section 5 outlines the portfolio results in two subsections. Section 6 discusses these findings, and the final section offers the conclusion.

2. Literature review

Relatively few studies have examined the risk-adjusted performance of green energy companies, and none have employed sophisticated measures in this process. This is where we see an opportunity to address this gap. For example, Kranias et al. (2024) investigate how Corporate Environmental Responsibility impacts Corporate Financial Performance among S&P500 companies. Their analysis considers factors such as Jensen's alpha, stock returns, return on assets, firm size, sales, and profits. The study finds that while environmentally responsible practices are associated with higher sales and profitability, they do not lead to an increase in the firm's market value. Sen and Chakrabarti (2024) delve into the risk characteristics of the U.S. green energy sector, particularly during periods of market turmoil. They introduce a unique metric, the Green Energy Time-Varying Beta (GETVB), to evaluate the risk exposure of green energy stocks under varying market conditions. Their findings indicate that these stocks are generally high-risk, with a GETVB typically ranging between 1.2 and 1.6. Despite this, green energy stocks demonstrate strong resilience to market volatility, as market stress has minimal influence on their GETVB values.

Rahat and Nguyen (2022) investigate potential advantages for investors in green energy. Using a decade-long dataset of firms from BRICS countries, they classify stocks into green and black portfolios based on various criteria. Their analysis reveals that green portfolios consistently outperform black ones, with this outperformance holding steady across metrics such as adjusted Sharpe and Sortino ratios, as well as Jensen's alpha. Demiralay et al. (2023) analyse the risk and return profiles of clean energy stocks in the U.S. at a granular level, applying a range of performance measures. Their study reveals that fuel cell and solar stocks exhibit greater downside risk compared to other clean energy segments, while developer/operator stocks are identified as the least risky. Additionally, the results suggest that clean energy stocks delivered superior risk-adjusted returns during the COVID-19 pandemic. When compared to traditional industries, clean energy equities outperformed several sectors, including those associated with high-emission assets.

3. Methodologies

3.1 The Stutzer ratio portfolio

To better evaluate the performance of green-asset portfolios, we use the unconventional Stutzer ratio, which is a significantly more powerful and informative measurement tool than the Sharpe ratio. In other words, the Stutzer ratio can be seen as an improvement over the Sharpe ratio, addressing several of its shortcomings. While the Sharpe ratio evaluates risk-adjusted returns by comparing excess returns to volatility, the Stutzer ratio refines this method by offering a more detailed view of risk, particularly in the case of non-normal return distributions (Haley and McGee, 2011). Unlike the Sharpe ratio, which relies on a standard volatility measure, the Stutzer ratio employs an exponentially tilted likelihood ratio, better capturing risks associated with skewness and kurtosis – factors that the Sharpe ratio may miss (Bondarenko, 2014). The Sharpe ratio's sensitivity to outliers can lead to distorted risk-adjusted returns, either inflating or deflating them unfairly. In contrast, the Stutzer ratio mitigates this effect by adopting a likelihood framework that focuses on the overall shape of the return distribution rather than just volatility (Benson et al., 2008). The key strength of the Stutzer ratio lies in its ability to provide a more reliable assessment of long-term return consistency. Specifically, it favours portfolios that deliver stable returns over time, rather than those with high but erratic peaks and troughs, which could still score well on the Sharpe ratio despite higher inherent risk.

We create portfolios with the goal of optimizing the Stutzer ratio. This ratio is assessed in comparison to a chosen benchmark asset, with $R_{p,t}$ denoting the return of portfolio p at time T, adjusted for the benchmark return. The average excess return (R_p) is subsequently defined as follows:

$$\overline{R}_p\left(T\right)=\frac{1}{T}\sum_{t=1}^{T}R_{p,t} \tag{1}$$

Stutzer (2000) explains that when a portfolio is expected to generate a positive excess return, the law of large numbers indicates that the probability of observing a negative sample excess return, $\overline{R}_p\left(T\right)$, diminishes as the sample period T increases. In this context, an investor focused on minimizing the risk of underperformance may seek to construct a portfolio where the likelihood of achieving a non-positive average excess return rapidly approaches zero. The rate at which this probability declines, referred to as I_p, is known as the 'portfolio performance index'. This index quantifies how quickly the probability of underperformance reduces to zero, and is calculated as shown in equation (2):

$$I_p = \max_{\theta}\left(-\ln E\left(e^{\theta \overline{R}_p(T)}\right)\right), \text{ where } \theta < 0 \tag{2}$$

For investors aiming to minimize underperformance relative to a benchmark, the portfolio with the highest decay rate is considered optimal. Stutzer (2000) shows that if stock returns are normally distributed, the I_p index is directly linked to the traditional Sharpe ratio, meaning that portfolio rankings remain the same whether assessed using the Stutzer or Sharpe ratio.

From a portfolio construction perspective, I_p can be a useful tool for designing portfolios in advance. Imagine there are N potential assets for the portfolio, each with a time series of T observed excess returns ($R_{i,t}$) for asset i. The excess return of the portfolio at any given time t is then calculated as follows:

$$R_{p,t}=\sum_{i=1}^{N}w_iR_{i,t}\, , \tag{3}$$

where w_i denotes the weight assigned to asset i in the portfolio. The sample estimate for the expression on the right-hand side of equation (2) is calculated as follows:

$$\hat{I}_p = \max_{\theta}\left(-\ln \frac{1}{T}\sum_{t=1}^{T} e^{\theta \bar{R}_p(T)} \right) \tag{4}$$

The optimal asset weights, according to the portfolio performance index criterion, are obtained by solving the maximization problem outlined in equation (5). When optimizing the Stutzer portfolio, it is crucial to choose suitable starting values for both the asset weights and the portfolio performance index. Stutzer (2000) suggests using the asset weights that maximize the Sharpe ratio as an initial approximation for the optimization in equation (5). Similarly, a reasonable starting value for θ is the negative of the average excess return divided by its variance.

$$I_m = \max_{w_1,\ldots,w_n} \max_{\theta}\left(-ln \frac{1}{T}\sum_{t=1}^{T} e^{\theta \bar{R}_p(T)} \right) \tag{5}$$

Key features of the Stutzer ratio include: 1) the Stutzer Ratio is derived from large deviations theory, which focuses on how frequently a portfolio's return distribution deviates from an idealized exponential growth path; 2) the Stutzer Ratio accounts for asymmetries and fat tails in return distributions; 3) It incorporates an exponential penalty on negative deviations, meaning it explicitly penalizes frequent and severe losses.

3.2 The Omega ratio portfolio

To provide a more comprehensive assessment of portfolio performance, we additionally optimize the Omega ratio portfolio. Similar to the Stutzer ratio, the Omega ratio accounts for the entire distribution of returns rather than assuming normality. Also, the Omega ratio balances risk and reward relative to a threshold value andcan be customized based on the investor's preferences or risk aversion (Fong, 2016). This flexibility allows investors to tailor the metric to align with their specific performance objectives or risk tolerance.

According to Asl et al. (2024), the Omega ratio is described in Equation (6). It relies on $F(x)$ to denote the cumulative probability distribution, where τ represents the threshold value determined by the investor, and a and b define the lower and upper bounds of the investment range. Fundamentally, it evaluates the balance between probability-weighted returns above the threshold and probability-weighted losses below it, relative to the specified τ.

$$\Omega(\tau) = \frac{\int_{\tau}^{a} \left(1 - F(x)\right) dx}{\int_{b}^{\tau} F(x) dx} \tag{6}$$

Vilkancas (2014) highlights that the Omega ratio does not depend on assumptions about risk preferences or utility functions. Instead, it requires only the selection of a threshold value, providing a simple decision-making framework where higher values of the ratio indicate more desirable assets. Assessing the Omega ratio across multiple thresholds allows for a more detailed analysis of asset or portfolio performance. In this study, we calculate the Omega ratio at five distinct thresholds, forming the Omega function. The thresholds, expressed as daily values, are 0%, 0.002%, 0.004%, 0.006%, and 0.008%, corresponding to annual returns of 0%, 0.654%, 1.734%, 3.515%, and 6.448%, respectively. These thresholds are consistently applied to both individual assets and portfolios. The resulting Omega functions exhibit a declining trend, reflecting the reduced likelihood of achieving significant returns as the threshold increases.

To optimize portfolios using the Omega ratio, we implement a non-parametric linear modeling framework as proposed by Yu et al. (2022b). The optimization process for the Omega ratio can be formulated as a linear model:

$$\text{Max } \Omega, \tag{7}$$

$$\text{subject to: } \delta\left(\sum_{i=1}^{n} w_i \mu_i - \tau\right) - (1-\delta)\frac{1}{T}\sum_{t=1}^{T}\eta_t \geq \Omega, \tag{8}$$

$$\eta_t \geq \tau - \sum_{i=1}^{n} \mu_{it} w_i, \qquad t = 1, 2, \ldots, T, \tag{9}$$

$$\eta_t \geq 0, \qquad t = 1, 2, \ldots, T, \tag{10}$$

$$\sum_{i=1}^{n} w_i = 1 \tag{11}$$

$$\sum_{i=1}^{n} w_i \mu_i \geq \tau \tag{12}$$

$$w_i \geq 0, \qquad i = 1, 2, \ldots, n \tag{13}$$

The objective function aims to maximize the Omega ratio, which evaluates the balance between portfolio gains and losses. Here, μ_i represents the average return of asset (i), and w_i is the weight assigned to asset (i) in the portfolio. The parameter δ adjusts the trade-off between return and risk, while τ specifies the threshold for acceptable portfolio returns. The first term in Equation (8), $\sum_{i=1}^{n} w_i \mu_i - \tau$, represents the excess returns of the portfolio above the threshold, while the second term, $\frac{1}{T}\sum_{t=1}^{T}\eta_t$, captures the portfolio losses. Equations (9) and (10) are used to quantify periodic losses over time. For optimization, several constraints are imposed. Equation (11) ensures that the total weight of all assets equals one, maintaining a fully invested portfolio. Equation (12) requires that the portfolio returns meet or exceed the threshold level, reflecting the desired return objective. Lastly, Equation (13) restricts all asset weights to non-negative values, prohibiting short selling in the portfolio.

Key features of the Omega ratio are: 1) the Omega ratio considers both the upside potential and downside risk beyond a chosen threshold; 2) the Omega Ratio differentiates bad volatility (losses below the threshold) from good volatility (excess returns above the threshold). This means it is better suited for non-normal return distributions, especially those with skewness or heavy tails.

4. Dataset

This study constructs eight-asset portfolios consisting of daily green-energy stocks from leading companies in the U.S. and Europe. The dataset covers an extended period, from January 2015 to November 2024, enabling a detailed comparison of portfolios before and after a major market disruption, with January 1, 2020, serving as the dividing point. Data are obtained from the investing.com platform, and all stock price series are transformed into log-returns ($\mu_{i,t}$) using the formula $\mu_{i,t} = 100\times \log(P_{i,t} / P_{i,t-1})$, where P_i represents the stock price. To ensure consistency, all time-series are synchronized based on available observations. The Global Clean-Energy ETF is chosen as the benchmark asset for constructing the Stutzer portfolio. This ETF provides broad exposure to a diverse range of companies in the global clean and renewable energy industry, making it a suitable reference choice. ETF is chosen and not a broader ESG market index because ETFs are liquid and easy to trade, making them more practical for investors. Also, ETFs are actively managed or rebalanced to reflect sector changes. This ensures that the portfolio remains representative of the evolving green-energy market.

Table 2 presents descriptive statistics for the selected companies, distinguishing between two sub-periods. It is evident that the companies exhibit varying growth rates and levels of risk. Additionally, the level of risk is higher during the crisis period compared to the pre-crisis period, which justifies splitting the sample. However, the risk during the crisis period is not much higher than the risk in the pre-crisis period, indicating the resilience of green energy stocks and their inherent robustness against extreme market conditions, which is in line with Sen and Chakrabarti (2024). It is worth noting that solar energy companies, such as Enphase, First Solar, and SMA, exhibit the highest levels of risk, coinciding with the findings of Demiralayet al. (2023). However, this is expected, as these companies experience revenue variability due to the dependence of solar energy production on weather conditions and sunlight availability, which can vary significantly. Such variability can result in unpredictable revenue streams. The four moments listed in Table 2 can be used to interpret the structures of the created portfolios. In addition, Table 3 shows pairwise Pearson correlations for the two subsamples. However, it is important to note that the Table 3' results are relevant only for interpreting the Sharpe and Stutzer ratio portfolio, as the level of correlation does not influence the Omega ratio.

Table 2. Descriptive statistics

		Pre-crisis period				Crisis period			
		Mean	St. dev.	Skew.	Kurt.	Mean	St. dev.	Skew.	Kurt.
US companies	AES	0.013	0.694	–0.168	5.431	–0.015	1.114	–0.804	10.526
	Duke	0.003	0.433	–0.760	5.597	0.008	0.679	–0.174	15.494
	Enphase	0.021	2.344	–0.168	12.862	0.036	2.058	–0.102	10.162
	First solar	0.008	1.164	0.258	8.523	0.044	1.448	0.407	7.391
	NextEra	0.028	0.442	–0.368	5.592	0.008	0.840	–0.450	10.712
	Ormat	0.035	0.669	0.025	10.360	0.003	1.037	–0.021	7.665
	Southern co.	0.009	0.435	–0.551	4.870	0.012	0.729	0.332	22.004
	Tesla	0.022	1.227	0.001	7.705	0.088	1.835	–0.108	6.276
European companies	EDP	0.011	0.592	–0.200	6.306	–0.013	0.745	–0.671	9.983
	Enel	0.031	0.608	–0.080	4.921	–0.016	0.725	–2.303	30.853
	Engie	–0.003	0.605	–0.220	6.215	–0.002	0.747	–1.886	21.288
	Fortum	0.008	0.681	–1.605	15.041	–0.019	0.932	–0.548	7.305
	Iberdrola	0.020	0.471	–0.001	4.914	0.011	0.638	–0.890	15.892
	RWE	0.001	0.997	–0.157	8.130	–0.003	0.810	–1.109	13.940
	SMA	0.035	1.586	–0.018	11.280	–0.036	1.550	0.267	7.884
	Vestas	0.034	0.906	–1.039	14.924	–0.016	1.257	–0.051	7.107

Source: Authors' own elaboration

Table 3. Pairwise Pearson correlation in the pre-crisis and crisis periods

Panel A: US companies

	AES	Duke	Enphase	First solar	NextEra	Ormat	Southern	Tesla
AES	1	0.408	0.107	0.235	0.417	0.324	0.365	0.160
Duke	0.485	1	0.024	0.120	0.752	0.254	0.765	0.028
Enphase	0.435	0.187	1	0.286	0.050	0.118	0.040	0.128
First solar	0.419	0.151	0.595	1	0.156	0.272	0.089	0.164
NextEra	0.558	0.701	0.355	0.327	1	0.274	0.696	0.075
Ormat	0.466	0.368	0.439	0.416	0.447	1	0.262	0.124
Southern	0.468	0.856	0.180	0.154	0.702	0.375	1	0.035
Tesla	0.306	0.123	0.408	0.322	0.223	0.253	0.110	1

Panel B: European companies

	EDP	Enel	Engie	Fortum	Iberdrola	RWE	SMA	Vestas
EDP	1	0.527	0.493	0.389	0.525	0.386	0.156	0.271
Enel	0.584	1	0.629	0.426	0.653	0.472	0.214	0.275
Engie	0.477	0.615	1	0.491	0.603	0.548	0.169	0.253
Fortum	0.355	0.470	0.498	1	0.387	0.452	0.134	0.213
Iberdrola	0.668	0.705	0.565	0.430	1	0.423	0.146	0.244
RWE	0.628	0.603	0.605	0.461	0.637	1	0.122	0.212
SMA	0.319	0.264	0.194	0.191	0.271	0.303	1	0.284
Vestas	0.454	0.313	0.238	0.235	0.377	0.373	0.483	1

Note: White (shaded) correlations are in the pre-crisis (crisis) period.

Source: Authors' own elaboration

5. Results

5.1 The Sharpe and Stutzer ratio portfolios

This section presents the results of the constructed Sharpe and Stutzer ratio portfolios, distinguishing between two subsamples. The detailed results are provided in Table 4. In the pre-crisis period, NextEra and Ormat have the highest weights in the Sharpe ratio portfolio, at 43% and 31%, respectively, due to their higher average returns. However, Ormat exhibits higher risk compared to NextEra, resulting in a lower portfolio weight for Ormat. During the crisis period, First Solar and Southern Co. each hold a 25% share in the portfolio, followed by Enphase and Tesla, with 20% and 18%, respectively. First Solar achieves a high portfolio weight due to its relatively high returns, while Southern Co. benefits from its relatively low risk. On the other hand, Enphase and Tesla, despite being the two riskiest companies, have relatively high portfolio weights due to their low correlation with First Solar and Southern Co. (see Table 3).

In the European Sharpe portfolio, Enel and Vestas dominate in the pre-crisis period, with weights of 49% and 34%, respectively, due to their combination of relatively high returns and low risk. In the crisis period, Vestas holds a 44% share despite its relatively high risk, as it exhibits a low correlation with Iberdrola and RWE. Conversely, Iberdrola and RWE outperform Vestas individually in terms of returns and risk during the crisis period but are highly correlated (63.7%), resulting in lower portfolio weights.

Table 4. Structure of Sharpe and Stutzer portfolios

US portfolio					European portfolio				
	Pre-crisis		Crisis			Pre-crisis		Crisis	
	Sharpe	Stutzer	Sharpe	Stutzer		Sharpe	Stutzer	Sharpe	Stutzer
AES	0%	0%	1%	0%	**EDP**	0%	0%	0%	0%
Duke	0%	0%	4%	0%	**Enel**	49%	60%	0%	0%
Enphase	0%	3%	20%	20%	**Engie**	0%	0%	0%	0%
First solar	13%	5%	25%	32%	**Fortum**	0%	0%	0%	0%
NextEra	43%	41%	1%	1%	**Iberdrola**	14%	0%	37%	100%
Ormat	31%	51%	6%	0%	**RWE**	0%	0%	19%	0%
Southern co.	0%	0%	25%	26%	**SMA**	3%	6%	0%	0%
Tesla	13%	0%	18%	21%	**Vestas**	34%	34%	44%	0%
Σ	100%	100%	100%	100%	**Σ**	100%	100%	100%	100%

Source: Authors' own elaboration

The Sharpe ratio traces its foundation to the Markowitz mean-variance framework (1952), which assumes that investors focus exclusively on two key factors: the expected return and the variability of asset returns. Benson et al. (2008) argue that investors can focus solely on the first two moments of the return distribution when returns are either normally distributed or when their preferences align with a quadratic utility function. However, since these conditions are rarely met in practice, the Sharpe ratio can often provide misleading results, highlighting the need for alternative performance metrics. From this perspective, the Stutzer ratio shifts the focus to the probability of failing to achieve a target return and demonstrates that if a portfolio is expected to outperform a given benchmark, the likelihood of underperformance diminishes to nearly zero as the length of the sample period increases. Moreover, this decline occurs at a calculable exponential rate (theta), which Stutzer (2000) proposes as a performance metric. The Stutzer ratio incorporates significantly more factors than the Sharpe ratio, making it a more informative and reliable indicator for investors seeking sound investments. Consequently, the composition of Sharpe and Stutzer portfolios differs considerably, as shown in Table 4. Table 5 presents the Stutzer ratios of the selected companies, which can help explain the structure of Stutzer portfolios. While the absolute value of the Stutzer ratio is not easily interpretable, it is desirable to be as high as possible.

Referring to Table 5, Ormat and NextEra have the highest Stutzer ratios in the pre-crisis period and consequently hold the largest shares in the Stutzer portfolio:51% and 41%, respectively. The Stutzer ratio favours stocks with positively skewed returns, which is in line with the finding that Ormat exhibits relatively high positive skewness (0.025), while most other companies show negative skewness. In the crisis period, Tesla has the highest Stutzer ratio (0.001425), but this is not fully reflected in its portfolio dominance, as Tesla holds the third-highest share at 21%. The strong returns of Tesla during the crisis period (0.088) likely offset its other less favourable characteristics, such as high risk and negative skewness. As Benson et al. (2008) noted, the asset with the highest Stutzer ratio does not necessarily dominate the portfolio, as the joint distribution of all assets plays a critical role. First Solar and Southern Co. have the highest positive skewness values (0.407 and 0.332, respectively), which likely explains their significant positions in the portfolio.

Table 5. Stutzer ratio of the selected companies

US companies			European companies		
	Pre-crisis	**Crisis**		**Pre-crisis**	**Crisis**
AES	0.000043	0.000164	**EDP**	0.000001	0.000055
Duke	0.000017	0.000025	**Enel**	0.000484	0.000046
Enphase	0.000021	0.000274	**Engie**	0.000210	0.000002
First solar	0.000001	0.000786	**Fortun**	0.000002	0.000049
NextEra	0.000662	0.000031	**Iberdrola**	0.000213	0.000108
Ormat	0.000861	0.000002	**RWE**	0.000026	0.000001
Southern co.	0.000007	0.000056	**SMA**	0.000130	0.000055
Tesla	0.000090	0.001425	**Vestas**	0.000551	0.000086

Source: Authors' own elaboration

In the European pre-crisis portfolio, Enel holds the dominant position with a 60% share, followed by Vestas at 34%. Although Vestas has a higher Stutzer ratio than Enel (0.000551 vs. 0.000484), the relatively low negative skewness of Enel (-0.080) compared to the highly significantly negative skewness of Vestas (-1.039) is likely to be the reason explaining its stronger position in the portfolio. SMA, with relatively high returns (0.035) and low skewness, holds a 6% share in the pre-crisis period. In contrast, Iberdrola is the sole asset included in the crisis Stutzer portfolio, with all other companies being excluded. This is likely because Iberdrola is the only European company with positive average returns (0.011), which offsets its relatively high negative skewness (-0.890).

Table 6 presents the Sharpe and Stutzer ratios for the respective Sharpe and Stutzer portfolios. It is evident that the Sharpe ratio is higher in the Sharpe portfolios, while the Stutzer ratio is higher in the optimized Stutzer portfolios. This strongly suggests that all portfolio optimizations are effective. When comparing the performance of the U.S. and European portfolios, the U.S. portfolio demonstrates a higher Sharpe ratio in both the pre-crisis (0.123 vs. 0.102) and crisis (0.129 vs. 0.121) periods. Similarly, the Stutzer portfolios perform better for U.S. companies compared to European companies in both the pre-crisis (0.001427 vs. 0.001073) and crisis (0.002757 vs. 0.000174) periods.

Table 6. Performances of the Sharpe and Stutzer ratio portfolios

	Pre-crisis period		Crisis period	
	US portfolio	**European portfolio**	**US portfolio**	**European portfolio**
Panel A: Sharpe ratio				
Sharpe portfolio	0.123	0.080	0.129	0.012
Stutzer portfolio	0.102	0.078	0.121	0.007
Panel B: Stutzer ratio				
Sharpe portfolio	0.000418 (−0.022018)	0.000999 (−0.079711)	0.000697 (−0.022018)	−0.001821 (−0.079711)
Stutzer portfolio	**0.001427** (−0.105256)	0.001073 (−0.079711)	**0.002757** (−0.134268)	0.000174 (−0.022018)

Note: The values in parentheses represent theta. Bolded values indicate a higher value in the comparison between the US and European portfolios.

Source: Authors' own elaboration

Table 7 provides the descriptive statistics for both the Sharpe and Stutzer portfolios, emphasizing the differences in their statistical moments. Unlike the Sharpe ratio, which focuses primarily on the mean return and standard deviation, the Stutzer ratio considers the entire distribution of returns, with particular emphasis on the mean and the skewness. As shown in Table 7, the Stutzer portfolio consistently shows higher average returns compared to the Sharpe portfolio in all four cases. However, in the crisis European portfolio, the skewness in the Sharpe portfolio is lower than in the Stutzer portfolio, likely due to the fact that this portfolio consists solely of Iberdrola, which has the highest returns. In this instance, the returns dominate over the skewness factor. It is also noteworthy that in this case, the Stutzer portfolio exhibits lower volatility than the Sharpe portfolio. Volatility plays an important role in the Stutzer ratio, as it is sensitive to the stability and predictability of returns. The Stutzer ratio penalizes inconsistent or highly volatile returns more than the Sharpe ratio does. When volatility is high, returns tend to deviate more from expectations, reducing the likelihood of achieving returns consistently above the benchmark, which in turn lowers the Stutzer ratio.

Table 7. Descriptive statistics of Sharpe and Stutzer portfolios

	US portfolio					European portfolio			
	Pre-crisis		Crisis			Pre-crisis		Crisis	
	Sharpe	Stutzer	Sharpe	Stutzer		Sharpe	Stutzer	Sharpe	Stutzer
Mean	0.027	0.030	0.037	0.043	**Mean**	0.031	0.032	−0.004	0.011
St. dev.	0.442	0.465	0.987	1.062	**St. dev.**	0.538	0.576	0.775	0.638
Skewness	−0.150	−0.101	−0.326	−0.281	**Skewness**	−0.348	−0.328	−0.452	−0.890
Kurtosis	7.651	9.168	10.007	9.134	**Kurtosis**	8.771	8.898	10.920	18.892

Source: Authors' own elaboration

The Omega ratio portfolios

To be more thorough in the analysis, we additionally calculate the Omega portfolios. The Omega portfolio can complement the Stutzer portfolio in several ways. First, the Omega ratio allows for the selection of any threshold (tau), making it adaptable to different investor preferences or required rates of return. In contrast, the Stutzer ratio assumes a specific threshold in its calculation, which may not align with all investors' objectives. Second, the Omega ratio is based on cumulative probabilities, making it more intuitive for comparing scenarios of gains versus losses (Bi et al., 2019). It directly compares the probabilities of exceeding or falling short of the target return (Bertrand and Prigent, 2011), whereas the Stutzer ratio is derived from entropy and less interpretable for users. Third, the Omega ratio better captures downside risks and potential upside asymmetry, which the Stutzer ratio may oversimplify when considering deviations from mean returns. Generally speaking, the Omega ratio is particularly advantageous when: 1) return distributions are not normal, 2) investor prioritizes downside risk avoidance, but also wants to account for upside potential, and 3) the flexibility in choosing thresholds.

Table 8 shows the Omega ratio results for the selected companies, and these findings can be used to explain the structure of the Omega portfolios in Table 9. On the other hand, Figure 1 presents the Omega functions, where a visual representation can provide a clearer depiction of the relationship between Omega values. According to the results in Table 8, the majority of Omega ratios are close to one, with values above one indicating greater outperformance compared to downside risk, while values below one suggest the opposite. Furthermore, as the threshold level rises, the Omega ratio generally declines, reflecting diminished opportunities for outperformance.

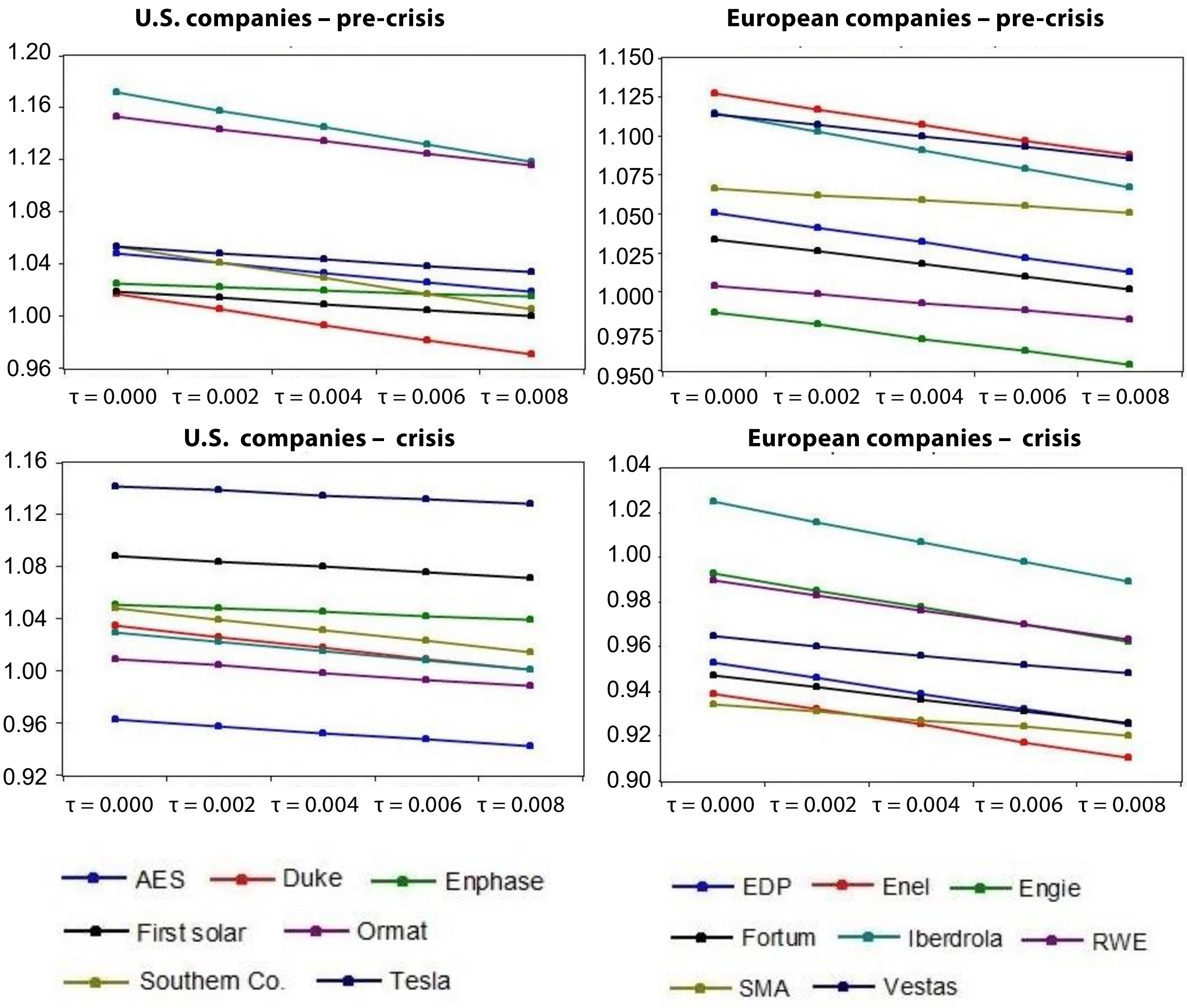
Table 8. Omega ratios of the clean-energy companies

		AES	Duke	Enphase	First solar	NextEra	Ormat	Southern	Tesla
Pre-crisis period	τ = 0.000	1.048	1.017	1.025	1.018	1.172	1.153	1.053	1.053
	τ = 0.002	1.041	1.005	1.022	1.014	1.158	1.143	1.041	1.048
	τ = 0.004	1.033	0.993	1.019	1.009	1.145	1.134	1.029	1.043
	τ = 0.006	1.026	0.981	1.017	1.004	1.132	1.125	1.017	1.038
	τ = 0.008	1.018	0.970	1.015	1.000	1.118	1.116	1.005	1.034
		EDP	**Enel**	**Engie**	**Fortum**	**Iberdrola**	**RWE**	**SMA**	**Vestas**
	τ = 0.000	1.051	1.127	0.987	1.034	1.115	1.004	1.066	1.114
	τ = 0.002	1.041	1.117	0.979	1.026	1.103	0.999	1.062	1.107
	τ = 0.004	1.032	1.107	0.970	1.018	1.091	0.993	1.059	1.100
	τ = 0.006	1.022	1.097	0.962	1.010	1.079	0.988	1.055	1.093
	τ = 0.008	1.013	1.088	0.953	1.002	1.067	0.982	1.051	1.086
Crisis period		**AES**	**Duke**	**Enphase**	**First solar**	**NextEra**	**Ormat**	**Southern**	**Tesla**
	τ = 0.000	0.962	1.035	1.051	1.088	1.029	1.009	1.048	1.142
	τ = 0.002	0.957	1.026	1.048	1.084	1.022	1.004	1.039	1.139
	τ = 0.004	0.952	1.018	1.045	1.080	1.015	0.998	1.031	1.135
	τ = 0.006	0.947	1.009	1.042	1.076	1.008	0.993	1.023	1.132
	τ = 0.008	0.942	1.001	1.039	1.071	1.001	0.988	1.014	1.128
		EDP	**Enel**	**Engie**	**Fortum**	**Iberdrola**	**RWE**	**SMA**	**Vestas**
	τ = 0.000	0.953	0.939	0.993	0.947	1.025	0.990	0.934	0.965
	τ = 0.002	0.946	0.932	0.985	0.942	1.016	0.983	0.931	0.960
	τ = 0.004	0.939	0.925	0.978	0.936	1.007	0.976	0.927	0.956
	τ = 0.006	0.932	0.917	0.970	0.931	0.998	0.970	0.924	0.952
	τ = 0.008	0.925	0.910	0.962	0.926	0.989	0.963	0.920	0.948

Source: Authors' own elaboration

Figure 1 indicates that Omega functions have different slopes. Botha (2007) explains that the Omega function provides two important observations. A slower downward slope indicates greater potential for positive returns, whereas a sharper decline reflects reduced risk levels. Accordingly, Duke and Iberdrola exhibit the steepest slopes during the pre-crisis period, indicating that these two companies carry the lowest risk. Conversely, Enphase and Enel demonstrate the best outperformance in the pre-crisis period, while Tesla and Iberdrola achieve the highest Omega ratios during the crisis period.

Figure 1. Omega functions of the selected companies in the two sub-periods



Source: Authors' own elaboration

Tables 9 and 10 reveal the structure of the optimized Omega portfolios during the pre-crisis and crisis periods, respectively. NextEra and Ormat are the top-performing U.S. companies in the pre-crisis period, while Enel and Vestas hold this position among European companies. These findings closely align with the Stutzer results, enhancing the overall credibility of the analysis. The Omega results demonstrate how portfolio structures shift with changes in the threshold level, an insight not apparent in the Stutzer ratio results. This feature can be particularly appealing to investors with diverse investment objectives.

Table 9. Omega portfolios structure in the pre-crisis period

Precious metals portfolio						**Industrial metals portfolio**					
	Tau						**Tau**				
	0.000	**0.002**	**0.004**	**0.006**	**0.008**		**0.000**	**0.002**	**0.004**	**0.006**	**0.008**
AES	0%	0%	0%	0%	0%	**EDP**	0%	0%	0%	0%	0%
Duke	0%	0%	0%	0%	0%	**Enel**	58%	57%	58%	56%	52%
Enphase	0%	0%	0%	0%	0%	**Engie**	0%	0%	0%	0%	0%
First solar	0%	0%	0%	0%	0%	**Fortum**	0%	0%	0%	0%	0%
NextEra	59%	58%	54%	53%	50%	**Iberdrola**	3%	3%	0%	0%	3%
Ormat	38%	39%	43%	44%	48%	**RWE**	0%	0%	0%	0%	0%
Southern co.	0%	0%	0%	0%	0%	**SMA**	0%	0%	0%	0%	0%
Tesla	3%	3%	3%	3%	2%	**Vestas**	39%	40%	42%	44%	48%
Σ	100%	100%	100%	100%	100%	**Σ**	100%	100%	100%	100%	100%

Source: Authors' own elaboration

On the other hand, it is evident that the structure of the Stutzer and Omega portfolios differs significantly during the crisis period. The Stutzer ratio incorporates more factors than the Omega ratio when determining the best-performing portfolio, which likely becomes more prominent during times of crisis. For instance, Tesla dominates the Omega portfolio with over 80%, compared to just 21% in the Stutzer portfolio. Similarly, Iberdrola leads in the European portfolio at lower threshold levels, while Vestas takes the dominant position at higher threshold levels.

Table 10. Omega portfolios structure in the crisis period

US companies portfolio						European companies portfolio					
	Tau						Tau				
	0.000	0.002	0.004	0.006	0.008		0.000	0.002	0.004	0.006	0.008
AES	0%	0%	0%	0%	0%	**EDP**	0%	0%	0%	0%	0%
Duke	0%	0%	0%	0%	0%	**Enel**	0%	0%	0%	0%	0%
Enphase	0%	0%	0%	0%	0%	**Engie**	0%	0%	0%	0%	0%
First solar	19%	17%	17%	17%	16%	**Fortum**	0%	0%	0%	0%	0%
NextEra	0%	0%	0%	0%	0%	**Iberdrola**	76%	66%	27%	0%	0%
Ormat	0%	0%	0%	0%	0%	**RWE**	0%	0%	0%	0%	0%
Southern co.	1%	1%	0%	0%	0%	**SMA**	0%	0%	0%	0%	0%
Tesla	80%	82%	83%	83%	84%	**Vestas**	24%	34%	73%	100%	100%
Σ	100%	100%	100%	100%	100%	**Σ**	100%	100%	100%	100%	100%

Source: Authors' own elaboration

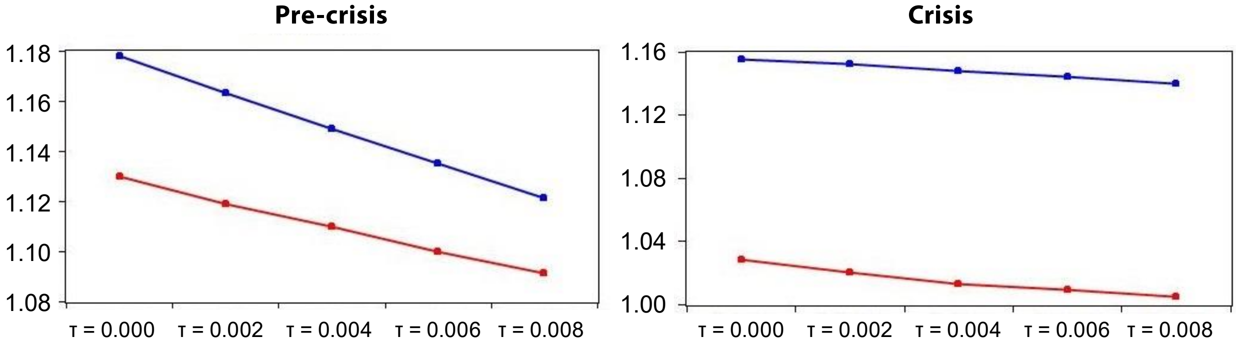
Table 11 presents the comparative performance of the two portfolios, while Figure 2 offers a visual representation. The results indicate that the U.S. portfolio exhibits a significantly better Omega function, particularly during the crisis period. Additionally, the steeper slope of the blue line in the pre-crisis period suggests a lower risk associated with the U.S. portfolio.

Table 11. Omega ratios of the two clean-energy portfolios

Period	Portfolio	Threshold levels				
		τ = 0.000	τ = 0.002	τ = 0.004	τ = 0.006	τ = 0.008
Pre-crisis	**US**	1.178	1.163	1.149	1.135	1.121
	Europe	1.130	1.119	1.110	1.100	1.091
Crisis	**US**	1.155	1.152	1.148	1.144	1.140
	Europe	1.028	1.020	1.013	1.009	1.005

Source: Authors' own elaboration

Figure 3. Omega functions of the two portfolios



Source: Authors' own elaboration

To analyse the factors that influence the Omega portfolios, the first four moments of the portfolios are calculated and presented in Table 12. During the crisis period, average returns are relatively equal between the portfolios, as are skewness and kurtosis. However, the European portfolio exhibits higher variance compared to the U.S. portfolio, which lowers its Omega ratio across all threshold levels. On the other hand, in the crisis period, the European portfolio has significantly lower risk than the U.S. portfolio, but it also shows considerably higher negative skewness and excess kurtosis. The greater frequency of negative returns, combined with the presence of outliers in the European portfolio, likely outweighs the benefit of lower variance, resulting in a significantly lower Omega ratio compared to the U.S. portfolio. Besides, the U.S. portfolio has significantly higher average returns.

Table 12. Four moments of the 0% threshold Omega portfolios

	Pre-crisis period		**Crisis period**	
	US portfolio	**European portfolio**	**US portfolio**	**European portfolio**
Mean	0.028	0.031	0.091	0.005
Variance	0.164	0.327	2.276	0.434
Skewness	−0.328	−0.324	−0.162	−0.735
Kurtosis	2.691	2.819	3.036	7.949

Source: Authors' own elaboration

6. Discussion

According to all three risk-adjusted performance measures, the U.S. green-energy portfolio outperforms its European counterpart. The following arguments could explain these findings. The first reason may relate to government policy and the regulatory environment. In other words, U.S. government policies have been more favourable toward green energy companies. For example, tax credits (like the Investment Tax Credit for solar energy) and various subsidies have provided long-term certainty for green energy investments, encouraging growth and reducing risk (Comello and Reichelstein, 2016).

Generally speaking, environmental, social, and governance factors can play a crucial role in shaping the performance of green-energy companies for several reasons. Specifically, firms that optimize energy use, water consumption, and waste management tend to have lower operational costs and higher profitability. Well-governed companies with clear ESG disclosure attract institutional investors, boosting stock performance. ESG-aligned green-energy firms are less exposed to climate-related financial risks, regulatory fines, and reputational damage. In addition, sustainable investments often outperform traditional energy stocks in the long run, driven by innovation and policy support.

On the other hand, in Europe, green energy policies are often subject to more frequent changes due to varying political landscapes across EU member states. For instance, energy transitions and incentives can differ drastically between countries, making the investment environment riskier and less predictable.

Second, technological advancements in the U.S. also might be a factor, as the U.S. green energy companies, particularly in solar and wind power, have been able to leverage cutting-edge technology and innovation (Islam, 2025). Companies like Tesla, First solar, and NextEra Energy have made significant strides in developing more efficient and cost-effective renewable technologies. Also, U.S. companies often have better access to venture capital, private equity, and other forms of funding, enabling them to push the boundaries of innovation. This contrasts with European companies, which might have more reliance on government-backed financing or subsidies, which can introduce more risks depending on political shifts.

The third factor might refer to access to capital and investment. This means that U.S. green energy companies have seen higher levels of investment compared to their European counterparts, driven in part by higher confidence in the U.S. economy and financial markets. U.S. investors tend to be more focused on risk-adjusted returns, and the ability to raise capital efficiently allows companies to invest in growth opportunities. On the other hand, European companies still face challenges in accessing capital for green energy projects due to more complex regulatory requirements or less robust venture capital ecosystems in certain regions. This can hinder their ability to scale and achieve the same risk-adjusted returns as their U.S. counterparts.

The fourth factor emphasizes energy transition and geopolitical factors. The U.S. is in a better position than Europe, since the U.S. has benefited from increased energy independence, especially through innovations in shale oil and gas, which have helped reduce the pressure to transition to renewable energy sources at a fast pace (O'Rear et al., 2015). This relative stability in energy supply allows green energy companies to grow at a more sustainable pace. On the other hand, European green energy companies are more susceptible to geopolitical risks, such as energy supply disruptions, as seen during the Russia-Ukraine conflict and the resulting energy crises. The instability of European energy markets has added a layer of uncertainty that U.S. companies are less exposed to, which enhances the risk-adjusted performance of American green energy firms.

Regarding the choice of performance measures, it is evident that the Stutzer and Omega ratio portfolios differ in their structures from the Sharpe ratio portfolio. The two more advanced performance measures are more accurate in assessing downside risk and provide greater informational value compared to the traditional Sharpe ratio. This implies that the Stutzer and Omega ratio portfolios enhance risk-adjusted performance, while the Sharpe ratio portfolio has the potential to mislead investors and result in poor decisions. The general implication of the findings is that profit-seeking green-energy investors should favour U.S. green-energy stocks, while for decision-making, they should rely on more sophisticated risk-adjusted measures, such as the Stutzer and Omega ratios.

6. Conclusion

This paper constructs two eight-asset green-energy portfolios, comprising stocks from the U.S. and Europe, to determine which portfolio demonstrates better risk-adjusted performance. Two advanced performance metrics are used in this process, the Stutzer and Omega ratios, with the classical Sharpe ratio serving as the benchmark. All portfolios are constructed for both the pre-crisis and crisis periods.

The following findings are worth mentioning. First, the structures of the Sharpe and Stutzer portfolios differ, indicating that the Stutzer ratio enhances portfolio performance. During the pre-crisis period, the U.S. companies NextEra and Ormat play a dominant role in the portfolio due to their strong return-to-risk performance. This is attributable to the nature of their businesses. Specifically, Ormat specializes in geothermal and renewable energy solutions, which provide stable and predictable cash flows through long-term contracts and independence from volatile fuel prices. Conversely, NextEra Energy has a diversified portfolio encompassing wind, solar, and traditional energy generation, which mitigates risks associated with reliance on a single energy source. Regarding the European portfolio, Enel and Vestas are the two best-performing companies in the pre-crisis period. Enel integrates renewable energy generation with traditional energy sources, reducing volatility and ensuring stable cash flows. Vestas, a global leader in wind turbine manufacturing and servicing, benefits from economies of scale and technological advancements. Additionally, its service business generates steady revenue through maintenance contracts.

During the crisis period, the U.S. Stutzer portfolio is significantly diversified, with solar-based companies playing a dominant role. In contrast, the Spanish company Iberdrola is the sole asset in the European Stutzer portfolio. This indicates that Iberdrola is able to generate strong returns relative to the risks during the crisis period. By focusing on stable renewable energy revenues, geographic and operational diversification, and favourable market trends, Iberdrola demonstrated resilience and steady performance in an otherwise volatile environment.

The Omega portfolio complements the Stutzer portfolio by allowing the selection of any threshold, providing greater flexibility to suit diverse investor preferences. The share of the most dominant companies in the Omega portfolio closely mirrors their roles in the Stutzer portfolio, reinforcing the robustness of the overall findings. However, the Omega portfolio offers more nuanced insights by accounting for variations across different threshold levels.

Comparing the performance of the two portfolios, we find that the U.S. portfolio tends to have better risk-adjusted performance than European ones due to a combination of favourable market conditions, government policies, access to capital, technological innovation and corporate strategies. European green energy companies face more regulatory, geopolitical, and market-specific risks, which can hinder their performance compared to their U.S. counterparts.

The paper provides new insights into the performance of U.S. and European green-energy portfolios in terms of risk-adjusted returns. The unconventional yet sophisticated Stutzer ratio offers more detailed information relevant for informed decision-making. The results suggest that investors should consider investing in the U.S. green-energy portfolio, as it offers superior risk-adjusted performance. While the traditional Sharpe ratio can serve as a starting point for investors in the green-energy market, more advanced performance metrics should be employed to avoid poor decisions and potential losses.

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