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The Energy Crisis as a Game Changer for Sustainable Investing?

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Abstract: This paper examines the financial outcomes of investments in stocks with varying degrees of ESG-rated sustainability before and after the energy crisis that began to unfold in 2021. It was analysed whether the energy crisis has caused improvements or deteriorations in the performance of more-sustainable compared to less-sustainable stock investments. The paper addresses an apparent gap in the existing literature, where interdependencies among the risk–return profiles of stocks and the ESG ratings of their issuers have so far garnered little attention in the context of the energy crisis. The results suggest that the energy crisis has triggered significant changes in the risk-return profile of securities issued by companies deemed sustainable versus those classified as less sustainable. Compared to previous crises with other economic backgrounds, more-sustainable stocks showed similar behavior relative to less-sustainable ones. The findings carry implications for asset managers and economic policymakers in terms of their decision-making with regard to the configuration of subsidies.

Keywords: investment, shares, ESG, sustainability, exogenous shock, stock performance, risk and return

Die Energiekrise als Game-Changer für nachhaltiges Investieren?

Zusammenfassung: Der vorliegende Beitrag untersucht die finanzielle Performance von Investitionen in Aktien mit unterschiedlichen ESG-Nachhaltigkeitsratings vor und nach der ab 2021 aufkeimenden Energiekrise. Es wird analysiert, ob die Energiekrise zu einer Verbesserung oder Verschlechterung der Performance von nachhaltigeren Aktieninvestitionen im Vergleich zu weniger nachhaltigen Aktieninvestitionen geführt hat. Die bestehende Literatur hat sich bislang noch nicht adäquat mit der Beziehung zwischen dem Risiko-Rendite-Profil von Aktien und dem ESG-Rating ihrer Emittenten vor dem Hintergrund der Energiekrise auseinandergesetzt. Die Ergebnisse deuten darauf hin, dass die Energiekrise erhebliche Veränderungen im Risiko-Rendite-Profil von Aktien nachhaltiger Unternehmen im Vergleich zu Titeln weniger nachhaltiger Unternehmen ausgelöst hat. In früheren Krisen mit anderen ökonomischen Hintergründen zeigten nachhaltige im Vergleich zu weniger nachhaltigen Aktien ein ähnliches Verhalten. Die Analyseergebnisse liefern Entscheidungshilfen für Asset-Manager sowie für wirtschaftspolitische Entscheidungsträger bei der Gestaltung von Subventionen.

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Stichwörter: Investition, Aktien, ESG, Nachhaltigkeit, Exogener Schock, Aktienperformance, Risiko und Rendite

1. Introduction

There is evidence in the literature that the sustainability practices of publicly traded companies have a measurable impact on risk and return indicators for equity investments in these share-issuing firms. Broadly speaking, a useful definition of sustainability as a desirable goal for society emerges in the much-cited report *Our Common Future* by the World Commission on Environment and Development (1987), which states that sustainable development should „[…] ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.“ Sustainability thus defined comprises the three ESG dimensions of environment/ecology („E“), social/society („S“) and responsible corporate governance/transparency („G“) (Tober, 2016, p. 66).

In a financial context, it is worth exploring whether the links between the risk–return indicators of stocks and the sustainability scores of stock-issuing companies are sensitive to extraordinary economic events. History has recorded several such system shocks, and one recent example is the energy supply crisis that lasted for an extended period from 2021[1]. Triggered (among other things) by a rapid economic recovery after the coronavirus pandemic and exacerbated by Russia's war against Ukraine (International Energy Agency, 2024), literature variously describes it as either a European[2] or a global[3] crisis. It caused a dramatic spike in the price of natural gas, accompanied by an increase in electricity costs in some countries, and raised the price of oil to its highest level since 2008 (International Energy Agency, 2024). Then by late 2023, a growing number of analysts concluded that the energy crisis had subsided (Moore, 2024, DWS Investment GmbH, 2024, Stagg, 2024, and Kemp, 2023). At this point, one could question whether the events described were actually of such great significance that they warrant being labeled a „crisis“ and require more in-depth consideration. Meier and Slembeck introduce the term „crisis problem“ in the context of economic policy (Meier/Slembeck, 1998, p. 74). Typical characteristics of crisis problems are, among other things, that their widespread perception attracts considerable media interest and that the government is under strong pressure from the public to take action (Meier/Slembeck, 1998, p. 78). Both factors were observable in connection with the events described above: Strong media interest is evident, for example, from the internet search engine of Google Ireland Limited: For the period from January 2021 to December 2024, the number of web pages displayed for the term „energy crisis“ was approximately 236 million, more than three times higher than in the same period before (around 75 million for January 2017 to December 2020). As proof of the pressure on political leaders to act, we can point for example to the laws on the introduction of energy price brakes („Erdgas-Wärme-Preisbremsengesetz“ and „Strompreisbremsegesetz“) passed at the end of 2022[4] in the Federal Republic of Germany. The foregoing arguments justify

1 Concerning increasing tension on energy markets beginning in 2021, see International Energy Agency (2024), for a timeline of the energy crisis see Emiliozzi et al. (2023), p. 7.
2 See Emiliozzi et al., 2023, p. 3 and Erkan et al. (2023), pp. 145–146.
3 See International Energy Agency (2024) and Ozili/Ozen (2023), p. 1.
4 See Deutscher Bundestag (2022), Bundesrepublik Deutschland (2025a), and Bundesrepublik Deutschland (2025b).

the understanding of the scenario emerging from 2021 onwards as an economic crisis and thus its closer examination.

Looking back through the lens of stock markets, this article fills a crucial knowledge gap by examining the characteristics of risk and return indicators for stock investments along a spectrum from „least sustainable“ to „highly sustainable“ issuers before and after the outbreak of the energy crisis. The aim is to answer the question whether the performance of more-sustainable compared to less-sustainable stock investments has improved or deteriorated since the onset of the energy crisis. To this end, the analysis correlates the ESG ratings of publicly traded companies with the risk–return indicators of their shares for representative periods before and after the onset of the crisis.

The existing literature already contains various studies on the links between share-value risk–return indicators and issuers' ESG performance, including in the context of economic crises. It is therefore all the more surprising to find a shortage of studies exploring the 2021 energy crisis in this regard. Further contributions to the literature seem warranted, given its potential impact.

Indeed, the energy crisis may have acted as a fundamental disruption—the proverbial game changer—in two respects: First, there are indications that its onset changed the patterns of risk-and-return indicators for ESG-weak and ESG-strong stock issuers; and second, this time around the indicators may have shifted in ways that deviate from other recent crises.

The research findings documented here are relevant for capital market participants as well as less directly involved market actors. Among all market participants, one group worth noting are the managers of third-party assets who acquire their mandates through commitments to sustainable investment strategies. For them, the impact of sustainability metrics on the risk–return investment profile is an essential piece of information, including for communication with their customers. As for the group of indirect capital market actors, the research may be germane to political decision-makers. If, for example, the risk–return behavior of sustainable investments turns out to be consistently deteriorating compared to less sustainable investments, policymakers may choose to increase state subsidies in a bid to steer capital in socially desirable directions.

This paper examines the stated research question in six chapters. Chapter II considers theoretical foundations and provides an overview of the relevant literature. Chapter III describes the study's design with a particular view towards the construction of observational periods, sourcing of raw data, and application of analytical methods. Chapter IV documents the results of these analyses in comprehensive detail and answers the research question. The final two chapters offer a discussion of the findings and a concluding review of the research process.

As its subject of investigation, this work uses the companies in the STOXX Europe 600 (Gross Return) share index. That particular focus precludes any of the aforementioned debate on whether the energy crisis was of a European or global dimension—either way, the analysis rests on the stock market of a region that was affected by the event under review.

2. Theoretical Background and Literature Review

2.1 Sustainability and General Stock Performance

Why do ESG scores have the potential to influence the risks and returns of equity investments? ESG scores are intended to reflect the sustainability performance of companies (Diebecker et al., 2021, pp. 12–13 and p. 17), which in turn is an important factor for the investment decisions of capital market participants (PricewaterhouseCoopers International Limited, 2023, pp. 3–5; Diebecker et al., 2021, p. 15[5]). As a result, the sustainability behaviour of companies—as expressed in ESG scores—could influence price dynamics on the stock market and thus the risk–return performance for investors. Principle scenarios are, for example:

a) Investors may assume that companies' increased sustainability efforts are associated with rising costs for them (Hartzmark/Sussman, 2019, p. 1). Amid expected declines in profits, shareholders could feel pressured to sell their holdings in companies with high ESG ratings and/or potential new investors would refrain from outset. This could trigger price fluctuations on the stock market: Securities issued by companies with low ESG ratings could benefit by generating outsized returns compared to high-ESG issuers.
b) Investors may be inclined to enhance their social image by acquiring sustainable securities (Riedl/Smeets, 2017, p. 2506). Due to the growing importance of social image in public communications, institutional investors may increasingly decide to focus on shares of top ESG performers. Increased demand for such shares could lead to higher returns compared to weak ESG performers.

Concerning the impact of issuers' sustainability performance on the risk–return metrics of their capital market shares, empirical studies abound. For instance, a meta-study by Whelan et al. (2021) offers a comprehensive summary of published results from 2015 to 2020. The analysis reveals that 59 % of studies find an equal or better performance of sustainable investments compared to conventional approaches. Another study focused on US securities finds that the shares of companies with stronger sustainability scores engender less idiosyncratic risk than those of firms with weaker sustainability performance (Horn, 2023, pp. 418, 421 and 426). Lopez-Prol and Kim (2022) examined return- and risk-optimized stock portfolios, finding that shares in companies with higher sustainability ratings were more likely to produce lower returns but also less volatility and a lower Sharpe ratio than shares in low-ESG issuers.

2.2 Stock Performance, Sustainability and Energy Prices

Rising energy prices generally weaken the profitability of companies. Empirical evidence to this effect, and specifically in the case of rising oil prices, is found in studies by Xu et al. (2022, pp. 4–8 and p. 12) or Rentschler and Kornejew (2017, pp. 244–250). However, the impact on profitability may vary depending on the degree of ESG implementation. For example, less sustainable companies may primarily cover their energy needs through fossil fuels. An increase in crude oil prices could thus have a greater impact on their profits in relation to highly sustainable companies who are more likely to source their energy

5 Sources cite other authors.

from renewables and are therefore less vulnerable to volatility in the price of crude oil. This could neutralize outsized gains for low-ESG securities described in scenario (a) under section 2.1, prompting shareholders to divest from them in favor of more sustainable alternatives. This could, in turn, affect the returns on their respective shares, with the share price of ESG-performant companies rising while lower-rated companies lose value. This assumption is at least partially supported by empirical evidence in Maraqa and Bein, who find statistically significant positive correlations between the returns on crude oil prices and the indices of high-ESG stocks in their analysis of volatility spillover effects (Maraqa and Bein, 2020, p. 7).

In relation to the present research question, the chain of effects just described would suggest that in the wake of the energy crisis, the financial performance of sustainable stocks, expressed in terms of their returns, has improved compared to less sustainable equity.

2.3 Stock Performance and Sustainability in Crisis Situations

The onset of the energy crisis brought about an exogenous shock to the economy and, in this context, to the stock market. The International Monetary Fund defines an exogenous shock as „[…] a sudden event beyond the control of the authorities that has a significant negative impact on the economy […]“ (International Monetary Fund, 2003, p. 4). Besides the influence of an issuer's ESG performance on the risk–return profile of its shares in general (see 2.1), the scientific literature also addresses the question of how sustainable and non-sustainable shares behave specifically in moments of economic crisis. In this domain, studies have focused mainly on the financial crisis (end of the noughties) and the more recent COVID-19 pandemic. In each of these two crisis moments, evidence suggests that shares backed by higher ESG ratings have proven more resilient than their less sustainable counterparts chiefly because:

- they achieved higher returns (Gianfrate et al., 2021, p. 26; Lins et al., 2017, pp. 1797–1802; Albuquerque et al., 2020, pp. 10–12 and 14–18); and
- the returns were less volatile (Albuquerque et al., 2020, pp. 12–13; Engelhardt et al., 2021, p. 8).

The authors elaborate on several possible reasons for this:

1. Companies that invest in sustainability can expect increased loyalty from their customers. Demand for these companies' products is less price-elastic, enabling higher overall margins (Gianfrate et al., 2021, p. 26; Albuquerque et al., 2020, p. 2; Albuquerque et al., 2019).
2. Stocks of companies with higher ESG ratings are more frequently held by socially conscientious shareholders who are more resilient to shocks and less likely to participate in sell-offs (Gianfrate et al., 2021, p. 26; Renneboog et al., 2011, pp. 575–579).
3. Sustainable companies invest in social capital (Gianfrate et al., 2021, p. 26), which has the effect of strengthening shareholder trust and causes a better performance of such companies' shares in times of crises (Gianfrate et al., 2021, p. 26; Lins et al., 2017, pp. 1797–1802).

In contrast to the studies by Gianfrate et al. (2021) and Engelhardt et al. (2021), the work of Albuquerque et al. (2020) and Lins et al. (2017) analyzes differences in stock performance both within and beyond the actual crisis. It becomes apparent that:

- higher returns on ESG-strong versus ESG-weak stocks occurred mainly during the crisis scenario and tended not to occur outside of it (Albuquerque et al., 2020, pp. 11–12 and p. 25; Lins et al., 2017, pp. 1805–1806); and
- lower volatility of ESG-strong versus ESG-weak stocks also occurred beyond the crisis scenario, although the difference was more pronounced throughout the crisis itself (Albuquerque et al., 2020, pp. 12–13 and p. 27).

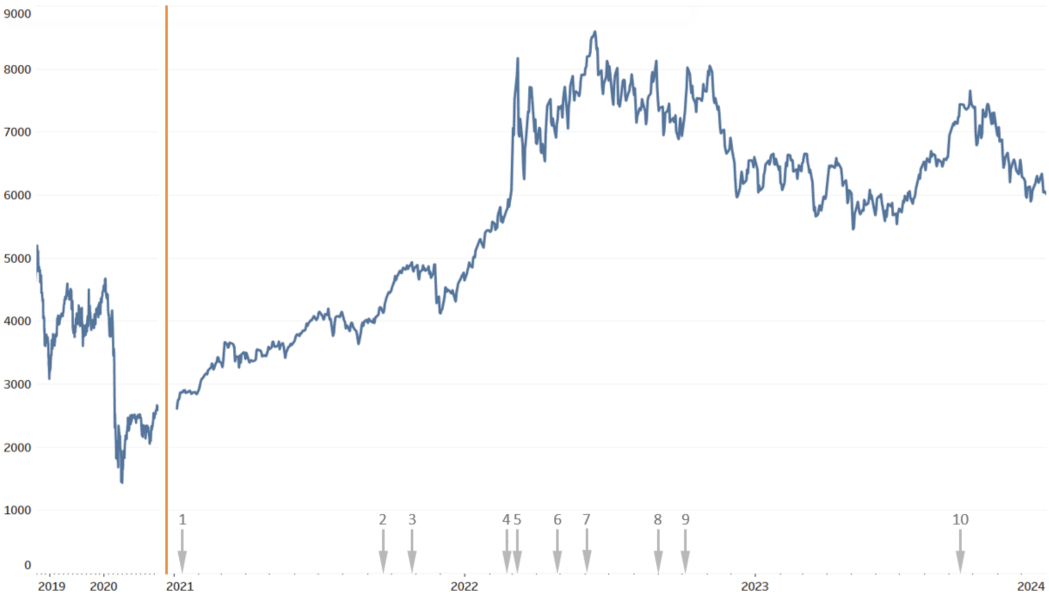
If the findings of Albuquerque et al. and Lins et al. are transferable to the energy crisis, in the context of the research question one could expect the performance of sustainable versus non-sustainable stocks to improve with the onset of the crisis, analogous to the scenario described in section 2.2. Specifically, one might assume that a pre-crisis return disadvantage of ESG-strong stocks compared to ESG-weak stocks would decrease – or that, conversely, a return advantage of ESG-strong stocks compared to ESG-weak stocks would increase. The same logic would reasonably apply to risk assessment: If ESG-strong shares had lower risks than ESG-weak shares before the crisis, we should expect the gap to have widened further, while risk-related disadvantages of ESG-strong versus ESG-weak stocks that existed before the crisis should have been reduced.[6]

2.4 Progression of the Energy Crisis and Comparison to Previous Crises

Figure 1 shows the course of the energy crisis over time, taking into account particularly significant events. The unfolding crisis is viewed through the lens of the Brent Crude Oil Benchmark Index due to the role of oil as an important energy source and thus a useful indicator for the intensity of this crisis over time.

6 In addition to the influences described in this section, the constructed causal chain could have been additionally supported by salience effects. In behavioral finance theory, the concept of „salience“ is linked with the phenomenon of availability heuristics, in the context of which people tend among others to make decisions on associations that are easy to recall (Sulphey, 2014, p. 63; da Silva Rosa/Durand, 2008; Gigerenzer et al., 1999, pp. 213–214; Tversky/Kahneman, 1974, pp. 1127–1128; and Tversky/Kahneman, 1973). The strong focus on the energy crisis in the media (see section 1) may have heightened investors' awareness of the problem and motivated them to focus more on ESG-strong shares, as their issuers are less dependent on fossil fuels (see explanations in section 2.2). This may have favored improved returns and reduced volatility of ESG-strong versus ESG-weak stocks during the energy crisis.

Progression of the energy crisis illustrated through price trends in the Brent Crude Oil Benchmark Index



No.	Date	Incident
1	Beginning of 2021	Energy prices climb steadily in 2021 due to factors such as rapid economic recovery from the pandemic-induced recession and enduring under-investment policies in fossil fuels.
2	21/9/2021	International Energy Agency urges Russia to ramp up gas supplies to Europe.
3	27/10/2021	Russian President Putin orders Gazprom to fill Europe's gas storage only after Russia completely refills its own reserves.
4	24/2/2022	Russia invades Ukraine.
5	8–10/3/2022	Canada, Great Britain, and the United States announce a ban on oil and petroleum products from Russia.
6	27/4/2022	Poland and Bulgaria are the first European nations cut off from Russian gas supplies.
7	3/6/2022	The European Union announces an import ban on Russian seaborne crude oil and petroleum products.
8	1/9/2022	Gazprom announces an indefinite shutdown of the Nord Stream 1 pipeline; 25 days later, explosions along the Nord Stream 1 and 2 pipelines and gas leaks.
9	5/10/2022	The Organization of Petroleum Exporting Countries Plus (OPEC+) announces production cut of two million barrels per day.
10	September 2023	After a decline, crude oil price begins to rise again following production cuts by Saudi Arabia and Russia as well as supply concerns resulting from the conflict in the Middle East.

Figure 1: Progression of the energy crisis (data sourced from LSEG Group, 2025; Emiliozzi et al., 2023, pp. 6–7; International Energy Agency, 2022, pp. 87–88; and Deutsche Bundesbank, 2023, p. 7).

The energy crisis began to unfold at the start of 2021, slowly at first, as seen in the chart after the orange vertical line. From this point on, the price of crude oil began a steady ascent, among other reasons due to rising economic output after COVID-19. The crisis escalated significantly in February 2022 with Russia's invasion of Ukraine, whereupon oil prices rose sharply and peaked in June 2022. The situation did not ease until the end of 2022, although prices never fully recovered to their pre-2022 levels. From mid-2023, prices began to rise again, although this trend levelled off again by the beginning of 2024.

A comparison of the energy crisis with the 2008 financial crisis and the 2020 pandemic reveals fundamental differences in the macroeconomic backdrop to each scenario. For this reason, insights gleaned from previous crises (cf. section 2.3) are not necessarily transferable to the energy crisis. In general, with regard to macroeconomic triggers for a crisis, we can distinguish between demand shocks and supply shocks. The 2008 financial crisis was predominantly characterized by demand-side shock, whereas the COVID-19 pandemic brought about demand- and supply-side shock simultaneously (*Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung*, 2008, p. 9; Bofinger et al., 2020). In contrast, the most recent energy crisis represents a pure supply shock (Dullien, 2024; Zhao et al., 2023; Kilian/Plante, 2022). While negative demand shocks to the market generally lead to a decline in overall demand with corresponding reductions in price and sales volume—as was the case during the financial crisis and COVID-19 pandemic—a negative supply shock—as during the energy crisis—leads to rising market prices with falling sales volumes (for the aforementioned shock effects, see Mankiw, 2022, p. 271 and Mishkin, 2015, pp. 351–361).

Regarding stock investments with different sustainability ratings, it is questionable whether the effects identified in the financial crisis (demand-side crises) and the COVID-19 pandemic (simultaneous demand- and supply-side shock) occurred analogously in the exclusively supply-side energy crisis. It is reasonable to assume that certain impact channels only occur in the context of demand shocks and therefore had no influence in the case of the energy crisis. Moreover, an exclusive supply shock could create impact channels that exist neither in the case of simultaneous demand and supply shocks nor in exclusive demand shocks. Possible scenarios include:

- Increased energy prices lead to higher costs for companies. As there is only a supply shock and no change in demand, sustainable and non-sustainable companies can pass on the increased costs to supply-side market prices in equal measure. Any lower price elasticity of demand in sustainable companies becomes irrelevant. The energy crisis does not cause any deviations in the margins of sustainable and non-sustainable companies as reflected in unchanging share price trends.
- Supply-shock–induced inflationary tendencies force sustainable and non-sustainable investors alike to liquidate their stock holdings due to declining real incomes. The greater resilience of sustainable investors to falling prices is no longer a given, as they also face pressure to sell their investments due to economic necessities.

As outlined above, previous analyses of variously sustainable stocks under exogenous shock have focused primarily on the financial crisis and the COVID-19 pandemic. Given the macroeconomic scenarios associated with these events, the existing literature provides ample treatment of demand-side shock as well as simultaneous demand-and-supply shock. However, the supply-side has been largely ignored to date. By looking at ESG-strong and ESG-weak stocks in the context of an exclusive supply shock, this paper offers an important contribution to the academic discourse on ESG equity ratings in times of macroeconomic crises.

2.5 Stock Indicators Included for Analysis

A set of risk and return indicators can help answer the question of whether stock investments have performed better or worse along the ESG sustainability spectrum since the start of the energy crisis. The parallel consideration of return and risk follows the Markowitz maxim (1952), which states that investment decisions should take into account the expected return and its variance. The indicators used in this analysis are:

- Stock return
- Volatility of Stock returns
- Beta factor
- Sharpe ratio
- Treynor measure
- Jensen measure

In addition to the volatility of stock returns, beta serves as a measure of risk. In contrast to volatility, this is not an indicator of the overall risk of an investment, but reflects its sensitivity to market fluctuations. With the Sharpe ratio (Sharpe, 1966), the Treynor measure (Treynor, 1965), and the Jensen measure (Jensen, 1968[7]), this analysis includes three indicators that ensure a synthesis of return and risk variables.

2.6 Systematization of the research basis

Figure 2 shows the theoretical outline of the problem, the research question, and the research contribution in a systematized form.

7 On the Jensen measure, see also Söhnholz et al. (2010), p. 126; Heidorn and Schäffler (2017), p. 152; and Stahlhut (2002), p. 51.

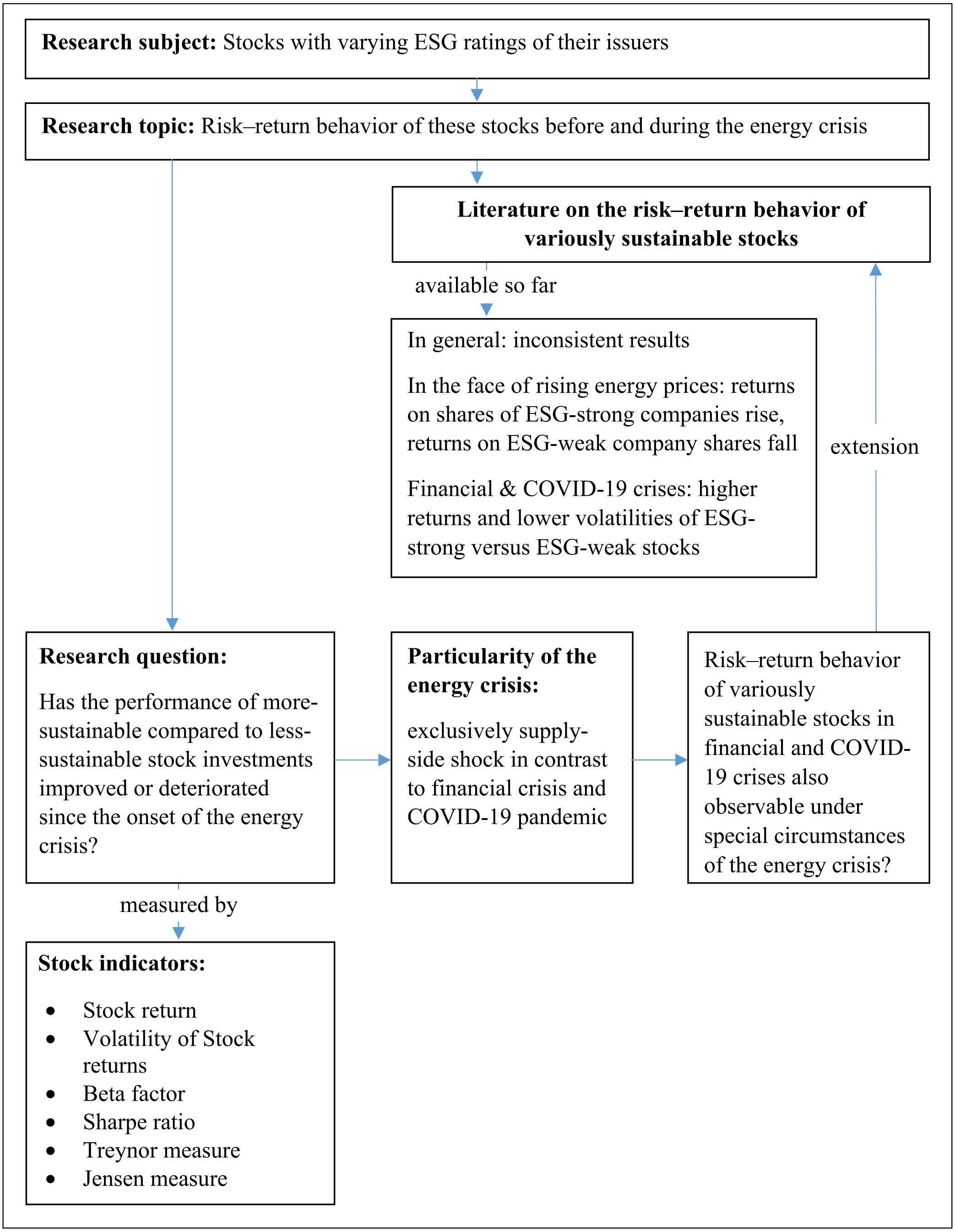


Figure 2: Theoretical problem outline, research question, and research contribution

As previously noted, all analyses relate to European stock markets.

3. Research Design

3.1 Observation Periods

The analysis requires a definition of the periods under consideration. In particular, it is necessary to clarify which periods should represent the *time before the onset of the crisis* and the *time after the onset of the crisis*. In order to enable the comparability and traceability of these investigations, the observational periods are designed to be of equal duration and to cover as many complete calendar years as possible.

The observation periods are defined as follows:

1. Observation Period 1 (before the onset of the energy crisis): 1 January 2017 to 31 December 2020
2. Observation Period 2 (after the onset of the energy crisis): 1 January 2021 to 31 December 2024

1 January 2021 serves as the start date for the energy crisis and thus for the start of Observation Period 2 because the energy crisis began to unfold at this time, as explained in section 2.4. We can assume that from this point on, the crisis gradually began to impact the stock markets.

The term *total investigation period* denotes cases in which the analytical context demands a view of the complete timeframe by aggregating both observational periods (1 January 2017 through 31 December 2024).

3.2 Data Set

The analytical basis constitutes all companies listed on 5 August 2024 in the EUR-quoted STOXX Europe 600 (Gross Return) share index. For these companies, the available daily total return values for the period from 1 January 2017 to 31 December 2024 were collected from the LSEG Eikon information system.[8]

Moreover, the available yearly ESG scores of the companies included in the index for the total investigation period were extracted from the information system. LSEG Eikon publishes ESG scores for the end of the fiscal year of these companies. In constructing the data set, ESG scores were classified as belonging to a specific year when the end of the fiscal year of a given company falls between 1 July of the previous year and 30 June of the year in question.[9]

To analyze the relationships between stock performance indicators and the ESG ratings of stock-issuing companies, the ESG scores were not used per se; rather, the companies in question are classified into deciles as a function of their ESG scores for each year under review. Each decile generally comprises 10 % of the companies to be analyzed.[10] Organizations with the lowest ESG scores are assigned to decile 1, companies with the

8 The calculation of total returns takes into account both share-price changes and dividends, see LSEG Group (2024).

9 If, for example, a company's fiscal year ends on 31 December 2021, the ESG score for 2021 is first available in 2022. As a result, when stock indicators from 2022 are examined for their ESG susceptibility as in this analysis, ESG scores that were known to investors in 2022 should serve as the analytical basis. In that instance, the ESG score for 31 December 2021 is used for the investigation year 2022.

10 The number of companies per decile follows this formula:
Number of analyzed companies ÷ 10 = X, where X is the number of companies per decile.

next-best ESG scores to decile 2, and so on. Companies with the highest ESG scores thus form decile 10. In this model, membership of a particular decile reflects the sustainability performance of respective companies for the purposes of analysis.[11]

This data set excludes index members with major data gaps. For example, not included in the set are companies for which no total return values were available in LSEG Eikon for more than two complete years in the period from 1 January 2017 to 31 December 2020 and/or from 1 January 2021 to 31 December 2024. The same procedure applies to companies for which no ESG scores were available for more than two of the years 2016–2019 and/or 2020–2023.[12] All other companies (561 of the 600 listed in the index) form part of the data set as research subjects.

In addition to the subject-related characteristics (total return values and ESG scores), the data set includes general market data relevant to the calculation of stock indicators; specifically:

- discrete returns[13] derived from changes in the STOXX Europe 600 (Gross Return) index on each trading day (source: LSEG Eikon); and
- current yields (German: *Umlaufsrenditen*) on public bonds of the Federal Republic of Germany with outstanding maturities of more than nine to ten years (source: Deutsche Bundesbank, 2024).

These values were collected for the individual trading days in the period from 1 January 2017 to 31 December 2024.

3.3 Analytical Content and Procedures

From the data set, first the annual values for the stock indicators to be observed were calculated separately for each of the 561 objects under investigation for 2017 to 2024. If a company's stock returns, volatilities, or ESG scores are absent for individual years due to a lack of data, the arithmetic mean of existing values for the relevant period serves as a substitute; for example, if an ESG score is missing for 2017, the arithmetic mean of scores from 2018 to 2020 takes its place.[14]

Annual stock returns for the various titles are calculated as arithmetic averages of daily total returns[15] (end of day) for the year in question, and annual volatilities as standard deviations of these daily returns. To determine the beta factor (covariance of market and

If X does not return an integer, the following procedure applies:
X rounds down to the nearest lower integer and the size of each decile initially corresponds to this rounded X. Starting with the first decile, each decile receives one more company up to the point where the sum of companies in all deciles = the number of analyzed companies.

11 The categorization of companies into deciles already features in other studies on the influence of sustainability on stock investments (cf. Teti et al., 2023; Lopez Prol/Kim, 2022).

12 Larger data gaps, which require the exclusion of relevant STOXX Europe 600 members from the data set, result for example from the fact that the companies in question did not exist throughout the total investigation period, as their founding occurred during this period. One example is Siemens Energy AG (founded and entered in the commercial register in 2019, see Amtsgericht München, 2025).

13 On the concept of ‚discrete return' see Auer/Rottmann (2020), p. 40.

14 This so-called *mean imputation* is common practice for dealing with missing values in data analyses. In this regard, see also Toutenburg et al. (2004), p. 16. It is safe to assume that this procedure has not caused any significant biases in the present data analyses, as only a small number of values found their way into the data set by this method (2.1 % of observed ESG scores and 0.2 % of stock returns and volatilities in the data set).

15 The daily total return values are discrete returns in financial mathematical terms.

stock returns divided by variance of market return), the market returns are represented by the daily returns of the STOXX Europe 600 (Gross Return). The three integrated indicators (Sharpe Ratio, Treynor measure, Jensen measure) require a determination of the risk-free interest rates modeled as annual arithmetic means of current yields (*Umlaufsrenditen*).

A panel regression for each stock indicator addresses the research question.[16] Each regression is based on a fixed-effects model, thereby eliminating both subject- and time-specific effects.

Each of the six defined stock indicators requires a corresponding regression equation to control for:

- the effect of increasing ESG levels on stock indicators across the total investigation period from 1 January 2017 to 31 December 2024; and
- the change between Observation Periods 1 and 2 in the rate of growth or decline for stock indicators with rising ESG levels.

In each of the regression equations, the stock indicators act as dependent variables.

Independent variables include:

- ESG deciles, shown below with the formula symbol E; and
- an interaction variable consisting of:
  - a dummy variable („Dummy“) to characterize the two observation periods; and
  - the ESG deciles.

The interaction variable takes the form of *Dummy × ESG decile*[17] and is represented below with the formula symbol R. The dummy variable uses the values 0 (for the first observation period) and 1 (for the second observation period). The interaction term aims to detect structural breaks induced by the energy crisis in the relationship between a company's ESG performance and its respective stock indicator. If the estimate of the slope parameter belonging to the interaction term is significant, we may assume the presence of a structural break; otherwise, we may reject this assumption.

All six regression equations are based on the following formula:

$$S_{it} - \overline{S}_{i.} - \overline{S}_{.t} + \overline{S}_{..} = \left(E_{it} - \overline{E}_{i.} - \overline{E}_{.t} + \overline{E}_{..}\right) * \beta_1 + \left(R_{it} - \overline{R}_{i.} - \overline{R}_{.t} + \overline{R}_{..}\right) * \beta_2 + \upsilon_{it} - \overline{\upsilon}_{i.} - \overline{\upsilon}_{.t} + \overline{\upsilon}_{..}$$

where S_{it} is the stock indicator of share i in year t; $\overline{S}_{i.}$ is the mean value of S_{it} in the case of subject-specific but no time-specific effects; $\overline{S}_{.t}$ is the mean value of S_{it} in the case of time-specific but no subject-specific effects; and $\overline{S}_{..}$ is the mean value of S_{it} across all observations. The variable E_{it} expresses the ESG decile to which company i belongs in year t. $\overline{E}_{i.}$ then stands for the mean value of E_{it} in the case of subject-specific but no time-specific effects; $\overline{E}_{.t}$ for the mean value of E_{it} in the case of time-specific but no subject-specific effects; and $\overline{E}_{..}$ for the mean value of E_{it} across all observations. In analogous continuation of this nomenclature, R_{it} represents the interaction variable of Dummy and ESG decile that company i belongs to in year t. $\overline{R}_{i.}$, $\overline{R}_{.t}$, and $\overline{R}_{..}$ express the corresponding mean values of R_{it} (mean value in the case of subject-specific but no time-specific effects,

16 The following descriptions of the regression analyses are based on the explanations in Baltagi (2021), pp. 15, 17 and 47–48; Brooks (2008), p. 487 and 490–494; Gehrke (2022), pp. 107, 110–112 and 115; Giesselmann/Winzio (2021), pp. 33–47; Greene (2020), pp. 415–416; Gujarati/Porter (2009), pp. 593–605; von Auer (2023), pp. 1–17 and 22–23.

17 Use of the interaction variable and realisation described here based among others on Urban/Mayerl (2011), pp. 286–290.

mean value in the case of time-specific but no subject-specific effects, and mean value across all observations). The characters β_1 and β_2 represent the two slope parameters to be estimated by the regression: β_1 is the slope parameter for the independent variable ESG decile and β_2 for the (independent) interaction variable Dummy × ESG decile. On the right-hand side of the above regression equation, we find the error term v_{it}, which reflects unobserved effects of share i in year t, supplemented by the respective mean value variables ($\overline{v}_{i.}$: mean value of v_{it} in the case of subject-specific but no time-specific effects; $\overline{v}_{.t}$: mean value of v_{it} in the case of time-specific but no subject-specific effects; and $\overline{v}_{..}$: mean value of v_{it} across all observations).

The analyzed stock indicators were tested for the simultaneous presence of subject-specific and time-specific fixed effects (using an F test for two-way effects). Such effects emerge in five of the six indicators, with only the Treynor measure yielding no significant outcome. These results suggest that the fixed-effects model for both subject- and time-specific issues is a suitable method for the intended analysis.

All regressions were tested for the presence of possible limitations on the validity of results with a particular focus on signs of:

- heteroscedasticity (Test method: Breusch-Pagan test),
- autocorrelation (Test method: Wooldridge test) and
- cross-sectional correlation (Test method: Pesaran-CD test).[18]

All three limitations can be addressed using the Driscoll-Kraay estimator, which was used to adjust the results whenever at least one of these problems occurred in a regression.[19]

For the analyses, the statistical software R (RStudio 2024.09.1+394) was used, with the packages dplyr (Wickham et al., 2023), tidyr (Wickham et al., 2024), lmtest (Hothorn et al., 2022), sandwich (Zeileis et al., 2024), plm (Croissant et al., 2025), moments (Komsta/Novomestky, 2022), rms (Harrell, 2025), Hmisc (Harell et al., 2025), tseries (Trapletti et al., 2024) and rugarch (Galanos, 2025) (partly in earlier versions).

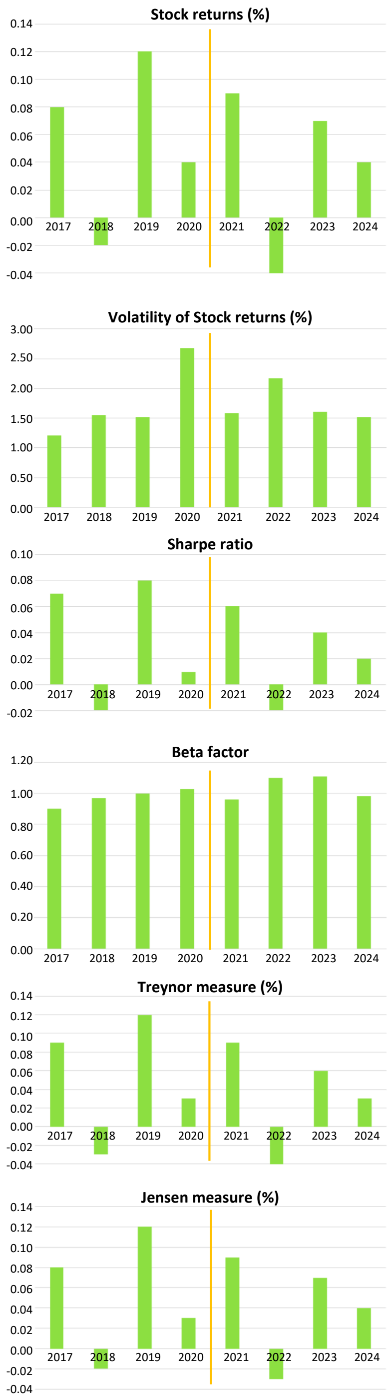
4. Analysis

4.1 Descriptive Statistics

Figure 3 initially shows the medians of dependent variables for individual years of the total investigation period, wherein the ESG performance of underlying shares is not yet accounted for. The vertical lines in the graphs between 2020 and 2021 symbolize the separation between Observation Periods 1 (pre-crisis) and 2 (crisis period). It is apparent that the risk-adjusted earnings indicators (Sharpe ratio, Treynor measure, and Jensen measure) change over time in a similar way to stock returns. Risk-adjusted profit indicators therefore appear to be influenced primarily by the returns included in their calculation and less by their inherent risk components. Risk indicators (volatility and beta factor) show similar trends over the total investigation period in terms of directional change—but not in terms of the strength of the changes.

18 Regarding the definitions of the three problems mentioned and possible tests see Gehrke (2022), pp. 123–129.

19 The use of the Driscoll-Kraay estimator (Driscoll/Kraay, 1998) follows the interpretation of Gehrke. Gehrke describes the Driscoll-Kraay estimator as a further development of the Arellano estimators (Arellano, 1987), with which by means of different procedures either cross-sectional correlation or both heteroskedasticity and autocorrelation can be corrected (Gehrke, 2024; Gehrke, 2022, pp. 126–129).



Medians							
2017	2018	2019	2020	2021	2022	2023	2024
0.08	-0.02	0.12	0.04	0.09	-0.04	0.07	0.04

Medians							
2017	2018	2019	2020	2021	2022	2023	2024
1.21	1.55	1.52	2.68	1.58	2.17	1.61	1.52

Medians							
2017	2018	2019	2020	2021	2022	2023	2024
0.07	-0.02	0.08	0.01	0.06	-0.02	0.04	0.02

Medians							
2017	2018	2019	2020	2021	2022	2023	2024
0.90	0.97	1.00	1.03	0.96	1.10	1.11	0.98

Medians							
2017	2018	2019	2020	2021	2022	2023	2024
0.09	-0.03	0.12	0.03	0.09	-0.04	0.06	0.03

Medians							
2017	2018	2019	2020	2021	2022	2023	2024
0.08	-0.02	0.12	0.03	0.09	-0.03	0.07	0.04

Figure 3: Medians of dependent variables, disregarding ESG performance of underlying shares

Figure 4 also shows the medians of dependent variables over the total investigation period but differentiates according to the ESG performance of stock issuers. Here, too, the boundary between Observation Periods 1 (pre-crisis) and 2 (crisis period) is shown as a line between 2020 and 2021. It is noteworthy that the values for stock returns and related variables (Sharpe ratio, Treynor measure, and Jensen measure) tend to deteriorate with improved ESG performance before the crisis. After the onset of the crisis, however, the disadvantages of ESG-strong stocks appear to largely erode. In terms of volatility, no systematic changes are apparent in the comparison of values for Observation Periods 1 and 2. The beta factor shows a tendency toward higher values with better ESG performance in the years preceding the crisis, but this tendency is no longer observable after its outbreak. The following section shows, within the framework of the central analysis, to what extent these initial data impressions are confirmed.

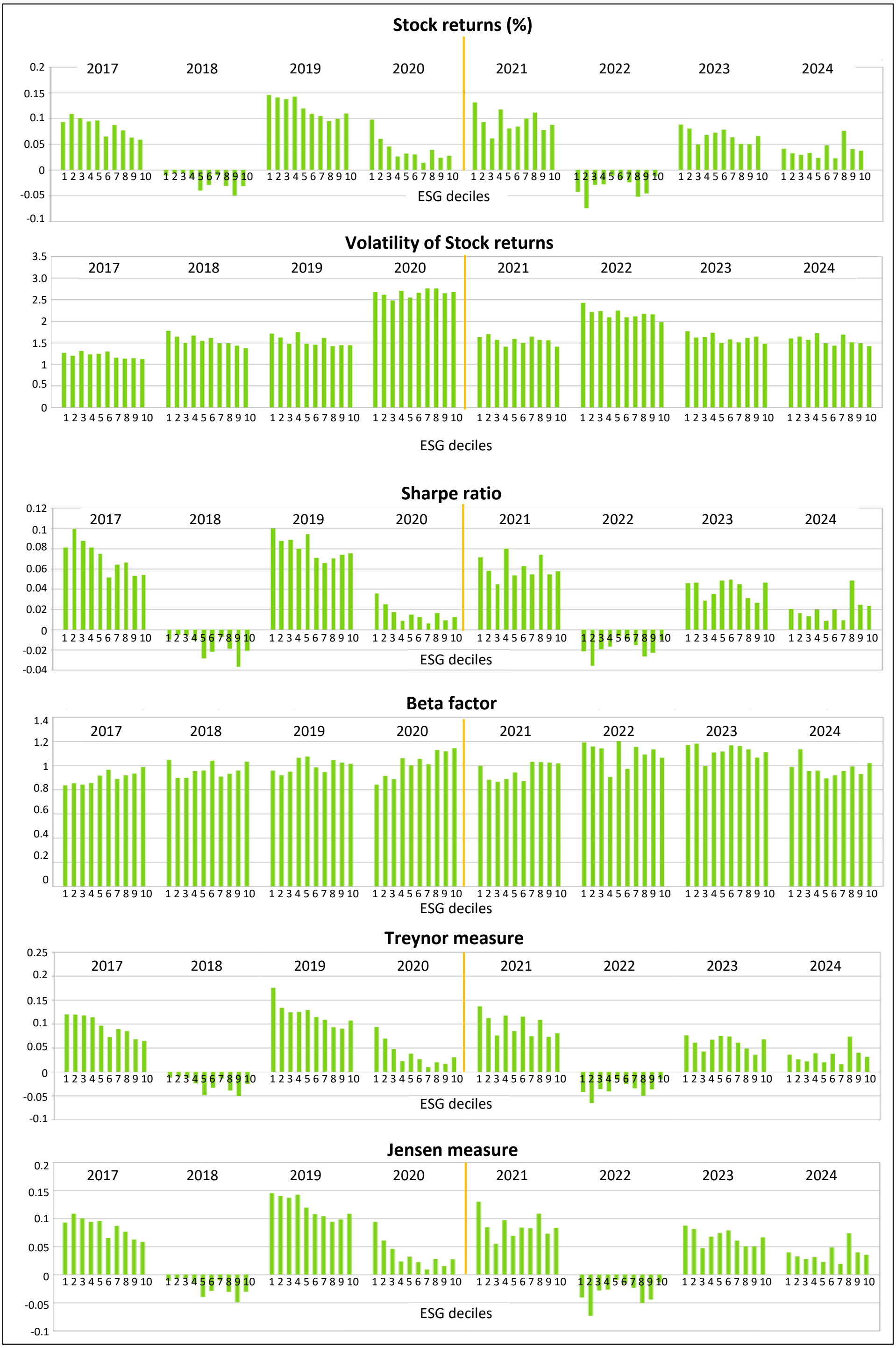


Figure 4: Medians of dependent variables, including ESG performance of underlying shares

4.2 Results of the Regression Analysis

The following table shows the slope parameters of regressions for single stock indicators; the test results for heteroscedasticity; autocorrelation and cross-sectional correlation; and resulting necessary adjustments to the values of slope parameters („Driscoll-Kraay estimator“ column).

Stock indicator	Slope parameters ESG-decile variable	Slope parameters interaction variable	Test values: Breusch-Pagan (BP) Wooldridge (F) Pesaran-CD (Z)	Driscoll-Kraay estimator	
				Slope parameters ESG-decile variable	Slope parameters interaction variable
Stock return	-0.00782***	0.00743***	4.2 14.3*** -0.5	-0.00782***	0.00743***
Volatility of Stock returns	0.00961	-0.01045*	44.2*** 139.8*** 3.7***	0.00961	-0.01045*
Sharpe ratio	-0.00381***	0.00363***	12.9** 10.7** -0.9	-0.00381***	0.00363***
Beta factor	0.01459***	-0.02139***	2.7 343.3*** -0.4	0.01459*	-0.02139***
Treynor measure	0.01926	0.01499	4.0 2.2 123.3***	0.01926	0.01498*
Jensen measure	-0.00796***	0.00738***	4.0 20.9*** -0.9	-0.00796**	0.00738***

Notes:

*** estimation significant at a level ≤ 0.1 %

** estimation significant at a level > 0.1 % and ≤ 1 %

* estimation significant at a level > 1 % and ≤ 10 %

Table 1: Regression parameters, test values, and adjusted regression parameters

The stock return for the total investigation period indicates a significant correlation with the ESG performance of corresponding companies. An increase in ESG performance by one decile leads to a reduction in the stock return by almost 0.8 basis points (estimation significant at level ≤ 0.1 %). Sustainably-minded investors were forced to accept lower returns. The slope parameter for the interaction variable shows a change for the period after the onset of the energy crisis: The parameter is greater than 0 and the estimation is significant at the level ≤ 0.1 %. This means that the disadvantages in returns of sustainable compared to less sustainable investments has been noticeably reduced since the onset of the crisis. In contrast to the returns, the volatility analyses yields more ambiguous results. Looking at the total investigation period, there are signs of rising volatility with increasing ESG performance—nearly one full basis point per decile—but the estimate of the slope parameter is not significant. For the slope parameter of the interaction variable, the result is a value below 0, putting the estimate barely within the significant range. This indicates, albeit not especially strongly, that the volatility of returns on sustainable stocks has decreased relative to non-sustainable stocks since the onset of the energy crisis. The result for the second risk indicator, the beta factor, is somewhat clearer: Over the total investigation period, the factor increases for higher ESG values (slope parameter 0.01459, significant at levels between > 1 % and ≤ 10 %). Investors in more sustainable stocks therefore generally had to bear higher market risks. The negative slope parameter of the interaction variable (estimation significant at the level ≤ 0.1 %) shows that the difference narrowed in the second observation period (i.e., after the onset of the crisis). With rising ESG performance, we can expect a less pronounced increase in market risks compared to the previous period. Overall, the energy crisis can be understood as a systemic shock that affected the entire capital market. That the market sensitivity of ESG-strong stocks converged with the lower market sensitivity of ESG-weak stocks in Observation Period 2 could result from the fact that ESG-weak companies are more dependent on fossil fuels and were therefore more heavily affected by crisis-related market fluctuations than ESG-strong companies.

In conclusion, both risk indicators (volatility of stock returns and beta factor) show improvements for sustainability-oriented investors since the onset of the energy crisis, albeit to varying degrees. As already suggested in section 4.1, the results for the Sharpe ratio appear to be driven by stock returns: In other words, sustainably orientated investors were poorly compensated for their risk over the total investigation period compared to less sustainable investors (Sharpe ratio reduced by more than 0.003 per higher ESG decile). However, the shares of sustainable issuers caught up noticeably compared to those of less sustainable issuers after the onset of the crisis (slope parameter of the interaction variable higher than 0 with a highly significant estimation).

The Treynor measure, on the other hand, only reveals weak correlations between the analyzed variables. Over the total investigation period, the indicator increases in the case of a rising ESG performance of the stock issuers, however, the estimate is not significant. The slope parameter for the interaction variable is greater than 0 at the significance level between > 1 % and </= 10 %. This suggests that any advantages of sustainable over non-sustainable stocks that may have existed before the energy crisis could have increased after the onset of the crisis.

In contrast to the Treynor measure, the Jensen measure, like other indicators in this study, exhibits a more conclusive ESG sensitivity; i.e., the relevant values decrease as the ESG performance of stock issuers increases (slope parameter for the ESG-decile variable less than 0, estimation significant at a level between > 0.1 % and ≤ 1 %). ESG-weaker stocks were therefore generally better positioned than ESG-stronger stocks relative to the Capital Asset Pricing Model benchmark. However, the disadvantage of more sustainable stocks diminished after the onset of the crisis (slope parameter of the interaction variable greater than 0, estimation significant at the level ≤ 0.1 %).

In answering the research question of this study, the overall result supports the idea that the performance of more-sustainable over less-sustainable stock investments has improved since the outbreak of the energy crisis, with improved values for more-sustainable stocks across all indicators. These findings further suggest that sustainable stock investments were more resilient to the effects of the energy crisis than non-sustainable ones.

Presumably, the causes described in sections 2.2 and 2.3 are simultaneously responsible for this; to wit:

a. Rising oil prices lead to rising share prices of ESG-strong companies, as they are less affected by cost increases due to the use of non-fossil energy sources (see 2.2).
b. Demand for products from sustainable companies is less price-elastic in times of crisis, which translates into higher margins compared to non-sustainable companies (see 2.3).
c. The stocks of companies with higher ESG ratings are more likely to be held by socially conscientious investors who are less likely to participate in sell-offs (see 2.3).
d. Sustainable companies invest in social capital, which builds trust with investors and leads to better performance for such companies in times of crisis (see 2.3).

These causes are of a two-fold nature: Some are fundamental (a and b), while others result from certain forms of investor behavior (c and d).

The results of this analysis align with the findings described in section 2.3 for the financial crisis and the COVID-19 pandemic (higher returns and lower volatility of ESG-strong stocks), warranting the assumption that effects on variously sustainable stock investments in crises associated with demand shocks occurred in similar ways in the energy crisis, which represented an exclusive supply-side shock.

In conclusion, we observed significant changes in terms of the risk–return behavior of stocks along the ESG spectrum before and after the outbreak of the energy crisis, but we cannot understand the crisis as a game changer with regard to the behavior of those stocks in relation to previous crises.

4.3 Robustness Checks

The regressions show, among other things, that the advantages of non-sustainable over sustainable stocks have diminished since the outbreak of the energy crisis in terms of stock returns and risk indicators (volatility, beta factor). The aim of the robustness checks is to examine whether these results also materialize within a different analytical methodology. Two portfolios were initially formed for this purpose:

- *ESG-strong* portfolio consisting of all shares in the highest ESG decile; and
- *ESG-weak* portfolio consisting of all shares in the lowest ESG decile.

The structure of these portfolios is adjusted annually as a result of the new composition of deciles due to changes in ESG scores. All securities in the portfolios receive the same proportional weighting. The regressions in section 4.2 apply to an analysis across all ESG deciles. The robustness test, which only considers the two most extreme deciles, should therefore at least confirm if not amplify any differences previously detected between sustainable and non-sustainable stocks.

4.3.1 Robustness Analysis for Stock Returns

The robustness test for stock returns proceeds as follows: The first step is to calculate daily return differences between the ESG-strong and ESG-weak portfolios (expressed formulaically: $d_n = rl_n - rh_n$; i.e., return difference d of day n results from the daily return rl_n of the ESG-weak portfolio minus the daily return rh_n of the ESG-strong portfolio). Calculated return differences for Observation Period 1 were assigned to the *pre-crisis* analysis group, differences for Observation Period 2 to the *crisis* analysis group. In the next step, we compare the two analysis groups in a one-sided Mann–Whitney U test[20] to determine whether the differences changed significantly from Observation Period 1 to 2. At this stage, the comparison of mean values for both groups in a box plot (see Figure 5) offers an early indication that the differences are reduced from the first to the second observational period (mean value pre-crisis: 0.06802; mean value crisis: 0.00151).

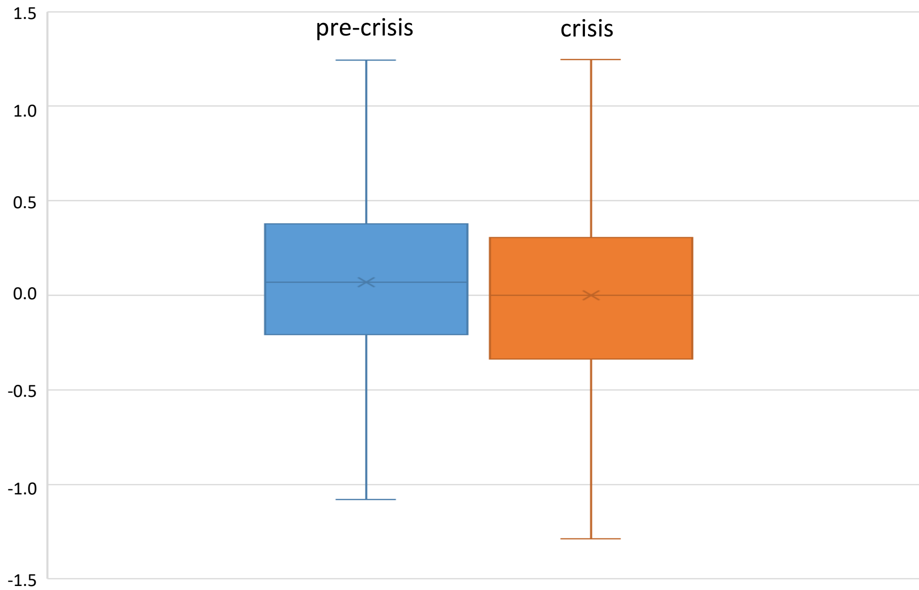


Figure 5: Return differences ESG decile 1 vs. ESG decile 10 compared between *pre-crisis* and *crisis* (without breakout points)

The one-sided Mann–Whitney U test is directed at confirming or rejecting the null hypothesis „differences in both groups are identical“ at the expense or in favor of the alternative hypothesis „differences in the *crisis* group are significantly lower than in the *pre-crisis* group“. A necessary precondition for the comparability of these two analysis groups is to determine whether the time series of the differences in the two groups exhibit the characteristic of stationarity. This check was performed through Augmented Dickey–Fuller tests[21]. The results of the two tests are shown in Table 2.

20 Regarding this test, see Black (2010), pp. 678–682.
21 Regarding this test, see Gehrke (2022), pp. 363–364.

The Augmented Dickey–Fuller test provides evidence of the stationarity of the difference time series for both analysis groups. We can thus reject the null hypothesis on which the test is based („time series is not stationary“) for both the *pre-crisis* and *crisis* analysis groups (significance level of both tests < 1 %). The subsequent one-sided Mann–Whitney U test reveals significant deviations among the differences contained in the two groups.

Group	***pre-crisis* (N=1026)**	***crisis* (N=1028)**
Augmented Dickey-Fuller test (Test value *DF* and significance *p*)	DF = -9.9104 p < 1 %	DF = -8.773 p < 1 %
Mean	0.06802	0.00151
Mann-Whitney U test (rank sum W and significance p)	W=577973 p < 0.1 %	

Table 2: Results robustness analysis for stock returns

The null hypothesis („both populations are identical“) is rejected at a significance level below 0.1 %, meaning that the alternative hypothesis („significant difference between the two groups“) is valid. In other words, the outbreak of the energy crisis has lessened the return advantages of the ESG-weak portfolio compared to the ESG-strong portfolio. This result confirms the corresponding findings from the regression analysis.

4.3.2 Robustness Analysis for Risk

The results concerning risk behavior of variously sustainable stocks before and after the onset of the energy crisis are verified using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) modeling according to Bollerslev (1986).

The specific GARCH(1,1) variant used here follows this formula (Bollerslev, 1986, pp. 308–311; Hull, 2016, pp. 248–253):

$$\sigma_t^2 = \gamma V_L + \alpha u_{t-1}^2 + \beta \sigma_{t-1}^2$$

where σ_t^2 is the variance of the current day (dynamic variance); V_L is the long-term variance; u_{t-1} is the previous day's return (i.e., the return from day *t-2* to day *t-1*); and σ_{t-1}^2 is the volatility of the previous day. The characters γ, α, and β represent the weights assigned to V_L, u_{t-1}^2 and σ_{t-1}^2 when determining σ_t^2. The GARCH analyses are each based on an AR(1) process as a mean model.[22] Such a first-order autoregressive process can be formally represented as follows (Franke et al., 2004, pp. 143–144):

$$X_t = c + \rho X_{t-1} + \varepsilon_t$$

where X_t is the random variable to be estimated (here the return on day *t*); X_{t-1} is the value of X_t on the previous day; and ρ is the autoregression parameter on which the process is based. The character ε_t denotes a random variable in the sense of „white noise," and c acts as a constant that is inherent to the process. Table 3 shows the key parameter

22 The GARCH modelling with the AR(1) process as a mean model was realised using ‚R‘ software. This was done based on Becker et al. (2025) and Ghalanos (2025).

characteristics of the separate GARCH models for the ESG-strong and ESG-weak portfolios. The calculations for the two portfolios were based on daily log returns[23] and a Students t distribution of the returns was assumed in each case.

Parameter	ESG-weak portfolio	ESG-strong portfolio
ρ	0.01717	-0.00259
γV_L	0.02716***	0.03974***
α	0.13833***	0.13831***
β	0.84093***	0.82700***
Shape parameters of the Student t-distribution	7.46933***	5.09240***

Notes:
*** estimation significant at a level ≤ 0.1 %
** estimation significant at a level > 0.1 % and ≤ 1 %
* estimation significant at a level > 1 % and ≤ 10 %

Table 3: GARCH model parameters for the ESG-weak and ESG-strong portfolios

Once the variances are in place, calculating the corresponding dynamic volatilities for returns on the two portfolios is a trivial matter of taking the square root. Figure 6 shows the trend in these volatilities over the two observational periods. While the volatilities of both portfolios exhibit fairly similar movements prior to the onset of the crisis, the ESG-strong portfolio afterward tends toward lower volatilities compared to the non-sustainable portfolio, especially from the beginning of 2022.

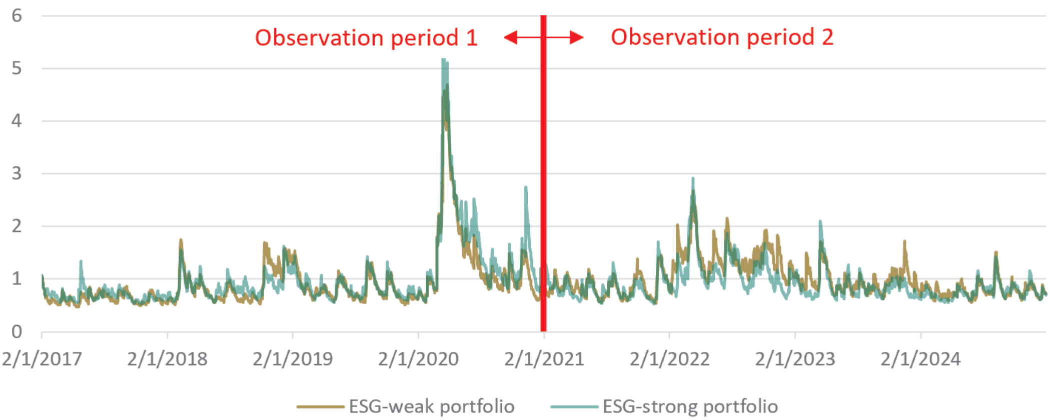


Figure 6: GARCH volatilities of the ESG-strong and ESG-weak portfolios

The described changes become even more significant once we subtract dynamic volatilities of the ESG-weak portfolio from those of the ESG-strong portfolio on a daily basis (see

23 Augmented Dickey–Fuller tests confirmed the stationarity of the two return time series.

Figure 7): The 100-day average line of these differences largely approaches zero or above during Observation Period 1. At the start of Observation Period 2, this average line continually falls.

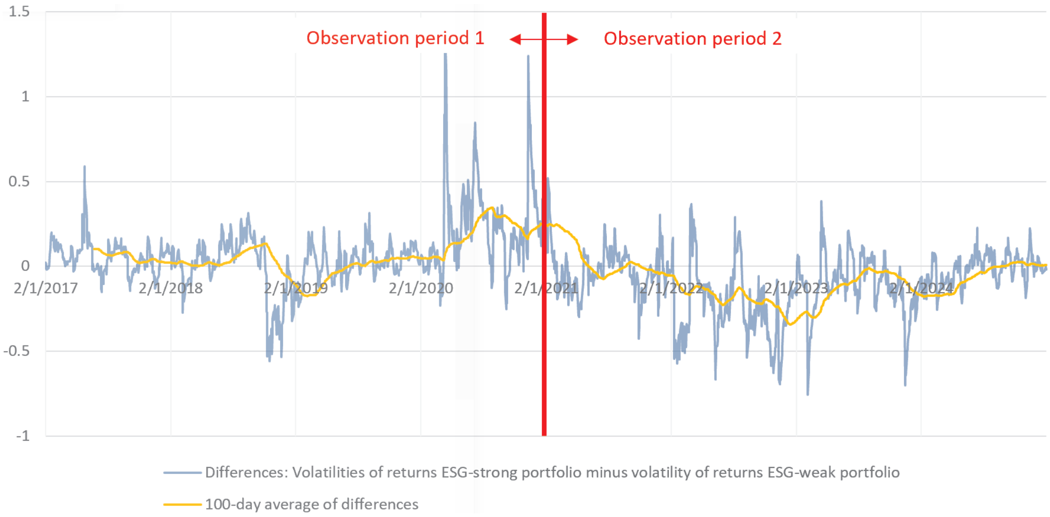


Figure 7: Differences in GARCH volatilities for the ESG-strong and ESG-weak portfolios

At the end of 2021, the line finally reaches negative territory, where it then remains for a longer period of time. The negative difference is an indication that the volatilities of the returns on the ESG-strong portfolio were lower than those on the ESG-weak portfolio. The results of the regression analysis with regard to risk exposure—diminishing advantages of non-sustainable compared to sustainable shares since the outbreak of the energy crisis—are therefore robust.

5. Discussion of the results

The gap in investment performance of more-sustainable versus less-sustainable shares, where present, depends on energy prices. This finding deserves greater scrutiny in practice and research. Rational investors will only favor more sustainable investments under the following incentive scheme:

Investment performance of more sustainable assets	+	**Monetary value of other benefits from sustainable investments**	>	**Investment performance of less sustainable assets**

Investment performance should be understood in this context as a risk-adjusted measure of return that takes into account all risks relevant to the investor—especially price, credit and liquidity risks—and also others that may not be measurable from historical data, such as regulatory changes or human error. „Other benefits“ of a sustainable investment could arise, among other factors, from investors communicating their sustainability efforts to their stakeholders and thereby achieving reputational gains. For example, investors could try to obtain higher sales prices from their clients on the basis of their enhanced reputation as a means of raising corporate profits. The results of the present analysis imply that the energy crises has augmented the chances of fulfilling the incentive condition: Insofar as sustainable stocks underperformed their less-sustainable counterparts, which was the case across four indicators, this gap has narrowed noticeably since the outbreak of the crisis. From an investor's perspective, this suggests that ESG-strong shares have become more attractive. Investors might now take them into greater consideration in their future decision-making. Regulatory initiatives such as the EU taxonomy already provided a path for investors to more reliably identify sustainable corporate behavior. This provides in combination with the outcomes described herein support for capital flows into sustainable securities, which could reduce overall capital costs for sustainable companies.

As this analysis omits any corresponding differentiation, it remains to be seen whether the findings are readily applicable to all sectors. For example, it is possible that the identified effects do not occur to the same extent in sectors that are not considered sustainable. Investigating this would be an approach for future research work. In addition, such efforts might examine whether the results found here for the European stock market are also valid in other regions of the world.

In addition to the previously described relevance for individual investors, these findings are important for the economy as a whole. If we assume from the overall social perspective that it is desirable for investor capital to flow into sustainable channels, the probability for that rises with dwindling performance disadvantages for sustainable over non-sustainable investments. With such disadvantages having diminished since the outbreak of the energy crisis, there is a greater chance that future investors will be motivated to spend money on sustainable projects. From an economic policy perspective this would allow for reduced subsidies concerning the promotion of sustainable investments. At the same time, policymakers must be wary of any abrupt changes to existing subsidy schemes, which could lead to a rapid decline in ESG levels for companies and thus erode the market-related financing advantages. A reduction in subsidies should therefore only proceed gradually and in combination with an impact analysis.

Eisenkopf et al. (2023) have shown that return advantages of ESG-strong stocks triggered by the COVID-19 shock diminished over time. The changes identified in the present analysis concerning the energy crisis also require careful monitoring for their stability over time. If the changes prove to be unstable, the reasons must be investigated. If the effects should disappear altogether, particularly in the case of decreasing energy prices, it would make sense for sustainability-oriented investors to hedge against an energy-price decline. The present investigation is based exclusively on market data, and these results should be verified using observational methods for the direct analysis of investor behaviour (e.g. laboratory experiments). This type of experimentation would also enable the search for specific triggers that motivate investors to engage with sustainable companies.

Finally, this analysis shows that the impact of the energy crisis as a pure supply shock is comparable to the effects of the financial crisis and the COVID-19 pandemic, which were accompanied by demand-side shocks. The fact that ESG-strong stocks also proved to be more resilient in the energy crisis than ESG-weak stocks indicates a particularly relevant contribution to the body of evidence: It supports the idea that the risk-reducing effects of ESG-strong stocks that occur during market crises can be generalized and applied to crises of many different types. In the scenario under consideration, sustainable stocks have once again proved their worth as hedges.

6. Conclusion

The research presented here intends to clarify whether the performance of more-sustainable versus less-sustainable stock investments improved or deteriorated after the outbreak of the energy crisis. The analysis rests on shares data from the STOXX Europe 600 (Gross Return) index. Six typical stock indicators from portfolio management served as metrics in the panel regressions performed to answer the research question. Overall, these analyses lead to the conclusion that the performance of more-sustainable stock investments has improved since the onset of the energy crisis. Compared to previous crises with other economic backgrounds, more-sustainable stocks showed similar behavior relative to less-sustainable stocks in the energy crisis. In this respect, the energy crisis cannot be seen as a game changer. The results of this study may prove useful for considerations of capital allocation in ESG-strong areas, sustainable asset management, and the economic policy.

Works Cited

Albuquerque, R./Koskinen, Y./Zhang, C. (2019). *Corporate Social Responsibility and Firm Risk: Theory and Empirical Evidence*. In: Management Science. October 2019. Volume 65. No. 10. pp. 4451–4469. https://doi.org/10.1287/mnsc.2018.3043.

Albuquerque, R., Koskinen, Y., Yang, S., & Zhang, C. (2020). *Resiliency of Environmental and Social Stocks: An Analysis of the Exogenous COVID-19 Market Crash*. Online: http://ssrn.com/abstract_id=3583611.

Amtsgericht München (2025). *Handelsregister des Amtsgerichts München, HRB* 252581. Access: 09/07/2025.

Arellano, M. (1987). *PRACTITIONERS' CORNER: Computing Robust Standard Errors for Within-groups Estimators*. In: Oxford Bulletin of Economics and Statistics. Volume 49. Issue 4. pp. 431–434. https://doi.org/10.1111/j.1468-0084.1987.mp49004006.x.

Auer, B. R./Rottmann, H. (2020). *Statistik und Ökonometrie für Wirtschaftswissenschaftler*. 4th edition. Wiesbaden. https://doi.org/10.1007/978-3-658-06439-6.

Baltagi, B. H. (2021). *Econometric Analysis of Panel Data*. 6th edition. Cham. https://doi.org/10.1007/978-3-030-53953-5.

Becker, R./Sinko, A./Kakaroumpas, G. (2025). *GARCH Modelling*. Online: https://datasquad.github.io/ECLR/R_GarchModelling.html.

Black, K. (2010). *Business Statistics*. 6th edition. Hoboken.

Bofinger, P./Dullien, S./Fuest, C./Hüther, M./Südekum, J./Weder di Mauro, B. (2020). *Wirtschaftliche Implikationen der Corona-Krise und wirtschaftspolitische Maßnahmen*. Online: https://www.boeckler.de/pdf/imk_corona_wirtschaft.pdf.

Bollerslev, T. (1986). *Generalized autoregressive conditional heteroskedasticity*. In: Journal of Econometrics. Volume 31(3). pp. 307–327. https://doi.org/10.1016/0304-4076(86)90063-1.

Brooks, C. (2008). *Introductory econometrics for finance*. 2nd edition. Cambridge/New York. https://doi.org/10.1017/CBO9780511841644.

Bundesrepublik Deutschland. (2025a). *Gesetz zur Einführung von Preisbremsen für leitungsgebundenes Erdgas und Wärme (Erdgas-Wärme-Preisbremsengesetz—EWPBG)*. Online: https://www.gesetze-im-internet.de/ewpbg/BJNR256010022.html.

Bundesrepublik Deutschland. (2025b). *Gesetz zur Einführung einer Strompreisbremse (Strompreisbremsegesetz—StromPBG)*. Online: https://www.gesetze-im-internet.de/strompbg/BJNR251210022.html.

Croissant, Y./Millo, G./Tappe, K./Toomet, O./Kleiber, C./Zeileis, A./Henningsen, A./Andronic, L./Schoenfelder, N. (2025). *plm: Linear Models for Panel Data*. Online: https://cran.r-project.org/web/packages/plm/index.html.

da Silva Rosa, R./Durand, R. B. (2008). *The role of salience in portfolio formation*. In: Pacific-Basin Finance Journal. Volume 16. Issues 1–2. pp. 78–94. https://doi.org/10.1016/j.pacfin.2007.04.008.

Deutsche Bundesbank. (2023). *Monatsbericht Oktober 2023*. Online: https://www.bundesbank.de/resource/blob/912962/7c672acd05d30d9374251de40d95e979/472B63F073F071307366337C94F8C870/2023-10-monatsbericht-data.pdf.

Deutsche Bundesbank. (2024). *Umlaufsrenditen inländischer Inhaberschuldverschreibungen / Anleihen der öffentlichen Hand / RLZ von über 9 bis 10 Jahren / Tageswerte*. Online: https://api.statistiken.bundesbank.de/rest/download/BBSIS/D.I.UMR.RD.EUR.S13.B.A.R0910.R.A.A._Z._Z.A?format=csv&lang=de.

Deutscher Bundestag. (2022). *Bundestag beschließt Strom- und Gaspreisbremse*. Online: https://www.bundestag.de/dokumente/textarchiv/2022/kw50-de-energiepreisbremse-924550.

Diebecker, J./Rose, C/Sommer, F. (2021). *Bewertung unternehmerischer Nachhaltigkeitsleistung mittels Nachhaltigkeitsratings*. In: Controlling. 33. Jahrgang. 6/2021. pp. 12–18. https://doi.org/10.15358/0935-0381-2021-6-12.

Driscoll, J. C./Kraay, A. C. (1998). *Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data*. Review of Economics and Statistics. Volume 80. Issue 4. pp. 549–560. https://doi.org/10.1162/003465398557825.

Dullien, S. (2024). *Erfolgreicher Eingriff*. Online: https://www.boeckler.de/de/boeckler-impuls-erfolgreicher-eingriff-58951.htm.

DWS Investment GmbH. (2024). *Europa hat die Energiekrise überstanden*. Online: https://www.dws.com/de-de/insights/cio-view/chart-of-the-Week/cotw-2024/chart-of-the-week-20240301/.

Eisenkopf, J./Juranek, S./Walz, U. (2023). *Responsible Investment and Stock Market Shocks: Short-Term Insurance without Persistence*. In: British Journal of Management. Volume 34. 2023. pp. 1420–1439. https://doi.org/10.1111/1467-8551.12664.

Emiliozzi, S./Ferriani, F./Gazzani, A. (2023). *The European energy crisis and the consequences for the global natural gas market*. Online: https://www.bancaditalia.it/pubblicazioni/qef/2023-0824/QEF_824_23.pdf?language_id=1, DOI: 10.32057/0.QEF.2023.0824.

Engelhardt, N./Ekkenga, J./Posch, P. (2021). *ESG Ratings and Stock Performance during the COVID-19 Crisis*. In: Sustainability. 13 (13). Article 7133. https://doi.org/10.3390/su13137133.

Erkan, A./Gürsoy, S./Doğan, M./Alshiqi, S. (2023). *Europe's Energy Crisis; Winners of the Crisis with Market Data*. In: Ekonomika. Volume 102(2). pp. 145–165. https://doi.org/10.15388/Ekon.2023.102.2.8.

Franke, J./Härdle, W./Hafner, C. (2004). *Einführung in die Statistik der Finanzmärkte*. 2nd edition. Berlin/Heidelberg. https://doi.org/10.1007/978-3-642-17049-2.

Galanos, A. (2025). *rugarch: Univariate GARCH Models*. Online: https://cran.r-project.org/web/packages/rugarch/index.html.

Gehrke, M. (2022). *Angewandte empirische Methoden in Finance & Accounting*. 2nd edition. Berlin/Boston, https://doi.org/10.1515/9783110767261.

Gehrke, M. (2024). *AW: Frage zu ‚Angewandte empirische Methoden in Finance & Accounting' – E-mail correspondence between Matthias Gehrke and Jörg Müller from 19/09/2024 to 23/10/2024.*

Ghalanos, A. (2025). *Introduction to the rugarch package. (Version 1.4 – 3)*. Online: https://cran.r-project.org/web/packages/rugarch/vignettes/Introduction_to_the_rugarch_package.pdf.

Gianfrate, G./Kievid, T./van Dijk, M. (2021). *On the resilience of ESG stocks during COVID-19: Global evidence*. In: Covid Economics. Issue 83. 2 July 2021. pp. 25–53.

Giesselmann, M./Windzio, M. (2012). *Regressionsmodelle zur Analyse von Paneldaten*. Wiesbaden. https://doi.org/10.5167/uzh-188200.

Gigerenzer, G./Todd, P. M./ABC Research Group. (1999). *Simple Heuristics That Make Us Smart*. New York.

Greene, W. H. (2020). *Econometric Analysis*. 8th edition. Harlow.

Gujarati, D. N./Porter, D. C. (2009). *Basic Econometrics*. 5th edition. New York.

Hartzmark, S. M./Sussman, A. B. (2019). *Do Investors Value Sustainability? A Natural Experiment Examining Ranking and Fund Flows*, In: The Journal of Finance. Volume 74. Issue 6. December 2019. pp. 2703–3392. https://doi.org/10.1111/jofi.12841.

Harrell, F./Beck, C./Dupont, C. (2025). *Hmisc: Harrell Miscellaneous*.Online: https://cran.r-project.org/web/packages/Hmisc/index.html.

Harrell, F. (2025). *rms: Regression Modeling Strategies*. Online: https://cran.r-project.org/web/packages/rms/index.html.

Heidorn, T./Schäffler, C. (2017). *Finanzmathematik in der Bankpraxis*. 7th edition. Wiesbaden. https://doi.org/10.1007/978-3-658-13448-8.

Horn, M. (2023). *The Influence of ESG Ratings On Idiosyncratic Stock Risk: The Unrated, the Good, the Bad, and the Sinners*. In: Schmalenbach Journal of Business Research 75(3). pp. 415–442. https://doi.org/10.1007/s41471-023-00155-1.

Hothorn, T./Zeileis, A./Farebrother, R. W./Cummins, C./Millo, G./Mitchell, D. (2022). *lmtest: Testing Linear Regression Models*. Online: https://cran.r-project.org/web/packages/lmtest/index.html.

Hull, J. C. (2016). *Risikomanagement*. 4th edition. Hallbergmoos.

International Energy Agency. (2022). *World Energy Outlook 2022*. Online: https://iea.blob.core.windows.net/assets/830fe099-5530-48f2-a7c1-11f35d510983/WorldEnergyOutlook2022.pdf.

International Energy Agency. (2024). *Weltweite Energiekrise*. Online: https://www.iea.org/topics/global-energy-crisis?language=de.

International Monetary Fund. (2003). *Fund Assistance for Countries Facing Exogenous Shocks*. Online: https://www.imf.org/external/np/pdr/sustain/2003/080803.pdf.

Jensen, M. C. (1968). *The Performance of Mutual Funds in the Period 1945–1964*. In: The Journal of Finance. Volume 23. Issue 2. May 1968. pp. 389–416. http://dx.doi.org/10.2139/ssrn.244153.

Kilian, L./Plante, M. D. (2022). *The Russian oil supply shock of 2022*. Online: https://www.dallasfed.org/research/economics/2022/0322

Kemp, J. (2023). *Europe's energy crisis is over*. Online: https://www.reuters.com/business/energy/europes-energy-crisis-is-over-kemp-2023-11-28/.

Komsta, L./Novomestky, F. (2022). *moments: Moments, Cumulants, Skewness, Kurtosis and Related Tests*. Online: https://cran.r-project.org/web/packages/moments/index.html.

Lins, K. V./Servaes, H./Tamayo, A. (2017). *Social Capital, Trust, and Firm Performance: The Value of Corporate Social Responsibility during the Financial Crisis*. In: The Journal of Finance. Volume LXXII. No. 4, August 2017, pp. 1785–1824. https://doi.org/10.1111/jofi.12505.

Lopez Prol, J./Kim, K. (2022). *Risk-Return Performance of Optimized ESG Equity Portfolios in the NYSE*. In: Finance Research Letters. Volume 50. Article 103312. https://doi.org/10.1016/j.frl.2022.103312.

LSEG Group. (2024). *LSEG Eikon*.

LSEG Group. (2025). *LSEG Eikon*.

Maraqa, B./Bein, M. (2020). *Dynamic Interrelationship and Volatility Spillover among Sustainability Stock Markets, Major European Conventional Indices, and International Crude Oil*. In: Sustainability. 12 (9). Article 3908. https://doi.org/10.3390/su12093908.

Markowitz, H. (1952). *Portfolio Selection*. In: *The Journal of Finance*. Volume 7. No. 1. March 1952. pp. 77–91. https://doi.org/10.2307/2975974.

Mankiw, N. G. (2022). *Macroeconomics*. 11th edition. New York.

Meier, A./Slembeck, T. (1998). *Wirtschaftspolitik*. 2nd edition. München. https://doi.org/10.1515/9783486795608.

Mishkin, F. S. (2015). *Macroeconomics: Policy and practice*. 2nd edition. Boston et al.

Moore, M. (2024). *Europe's energy crisis is over, signals Shell boss*. Online: https://www.ft.com/content/85eee3eb-6ee7-404b-b89d-778631426f06.

Ozili, P. K./Ozen, E. (2023). *Global energy crisis: Impact on the global economy*. Online: https://mpra.ub.uni-muenchen.de/118791/1/MPRA_paper_118791.pdf.

PricewaterhouseCoopers International Limited. (2023). *PwC's Global Investor Survey 2023—Trust, tech and transformation: Navigating investor priorities*. Online: https://www.pwc.at/de/aktuelle-themen/global-investor-survey-2023.pdf.

Renneboog, L./Ter Horst, J./Zhang, C. (2011). *Is ethical money financially smart? Nonfinancial attributes and money flows of socially responsible investment funds*. In: Journal of Financial Intermediation. Volume 20. Issue 4. October 2011. pp. 562–588. https://doi.org/10.1016/j.jfi.2010.12.003.

Rentschler, J./Kornejew, M. (2017). *Energy price variation and competitiveness: Firm level evidence from Indonesia*. In: Energy Economics. Volume 67. pp. 242–254. https://doi.org/10.1016/j.eneco.2017.08.015.

Riedl, A./Smeets, P. (2017). *Why Do Investors Hold Socially Responsible Mutual Funds?*. In: The Journal of Finance. Volume LXXII. NO. 6. December 2017. pp. 2505–2549. https://doi.org/10.1111/jofi.12547.

Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (2008). *DIE FINANZKRISE MEISTERN – WACHSTUMSKRÄFTE STÄRKEN – Jahresgutachten 2008/09*. Online: https://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/download/gutachten/ga08_ges.pdf.

Sharpe, W. F. (1966). *Mutual Fund Performance*. In: The Journal of Business. Volume 39. No. 1. Part 2: Supplement on Security Prices. January 1966. pp. 119–138.

Stagg, I. (2024). *GlobalData: EU energy crisis ‚is over' – but could it happen again?* Online: https://www.worldpipelines.com/business-news/14022024/globaldata-eu-energy-crisis-is-over-but-could-it-happen-again/.

Stahlhut, B. (2002). *Messung und Analyse der Performance von Aktienportfolios*. 2nd edition. Frankfurt am Main.

Söhnholz, D./Rieken, S./Kaiser, D. G. (2010). *Asset Allocation, Risiko-Overlay und Manager-Selektion*. 1st edition. Wiesbaden. https://doi.org/10.1007/978-3-8349-6315-4.

Sulphey, M. M. (2014). *BEHAVIOURAL FINANCE*. Dehli.

Teti, E./Dallocchio, M./L'Erario, G. (2023). *The impact of ESG tilting on the performance of stock portfolios in times of crisis*. In: Finance Research Letters. Volume 52. Article 103522. https://doi.org/10.1016/j.frl.2022.103522.

Tober, C. (2016). *Der Markt für nachhaltige Geldanlagen in Deutschland und Europa – Standards und Trends*. In: CSR und Finanzratings, Management-Reihe Corporate Social Responsibility. Edited by H. E. Kopp. Berlin/Heidelberg. pp. 65–77. DOI: 10.1007/978-3-662-47461-7_7.

Toutenburg, H./Heumann, C./Nittner, T. (2004). *Statistische Methoden bei unvollständigen Daten*. Online: https://epub.ub.uni-muenchen.de/1750/1/paper_380.pdf.

Trapletti, A./Hornik, K./LeBaron, B. (2024). *tseries: Time Series Analysis and Computational Finance*. Online: https://cran.r-project.org/web/packages/tseries/index.html.

Treynor, J. L. (1965). *How to Rate Management of Investment Funds*. In: *Harvard Business Review*. January/February 1965. Volume 43. Issue 1. pp. 63–75.

Tversky, A./Kahneman, D. (1973). *Availability: A heuristic for judging frequency and probability.* Cognitive Psychology. Volume 5. Issue 2. September 1973. pp. 207–232.

Tversky, A./Kahneman, D. (1974). *Judgment under Uncertainty: Heuristics and Biases*. Science. Volume 185. No. 4157. pp. 1124–1131.

Urban, D./Mayerl, J. (2011). *Regressionsanalyse: Theorie, Technik und Anwendung*. 4th edition. Wiesbaden. https://doi.org/10.1007/978-3-531-93114-2.

von Auer, L. (2023). *Ökonometrie*. 8th edition. Wiesbaden.

Whelan, T./Atz, U./Clarke, C. (2021). *ESG AND FINANCIAL PERFORMANCE: Uncovering the Relationship by Aggregating Evidence from 1,000 Plus Studies Published between 2015 – 2020*. Online: https://www.icgn.org/sites/default/files/2021-08/ESG%20and%20Financial%20Performance%20Uncovering%20the%20Relationship%20NYU%20Stern.pdf.

Wickham, H./François, R./Henry, L./Müller, K./Vaughan, D./Posit Software, PBC. (2023). *dplyr: A Grammar of Data Manipulation*. Online: https://cran.r-project.org/web/packages/dplyr/index.html.

Wickham, H./Vaughan, D./Girlich, M./Ushey, K./Posit Software, PBC. (2024). *tidyr: Tidy Messy Data*. Online: https://cran.r-project.org/web/packages/tidyr/index.html.

World Commission on Environment and Development. (1987). *Report of the World Commission on Environment and Development—Our Common Future*. Oslo. Online: https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf.

Xu, J./Akhtar, M./Haris, M./Muhammad, S./Abban, O. J./Taghizadeh-Hesary, F. (2022). *Energy crisis, firm profitability, and productivity: An emerging economy perspective*. In: Energy Strategy Reviews. Volume 41 (Article 100849). https://doi.org/10.1016/j.esr.2022.100849.

Zeileis, A./Lumley, T./Graham, N./Koell, S. (2024). *sandwich: Robust Covariance Matrix Estimators*. Online: https://cran.r-project.org/web/packages/sandwich/index.html.

Zhao, Y./Feng, C./Xu, N./Peng, S./Liu, C. (2023). *Early warning of exchange rate risk based on structural shocks in international oil prices using the LSTM neural network model*. In: Energy Economics. Volume 126 (Article 106921). https://doi.org/10.1016/j.eneco.2023.106921.

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