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ORIGINAL ARTICLE

Sustainability in calm and rough waters: an empirical investigation of european ESG ETFs

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Abstract
Since the Paris Agreement in 2015 and the European Union's commitment to leading the transition toward a sustainable economy, the European market for passively managed ESG products has experienced remarkable growth. This study examines the financial performance of 34 European ESG ETFs linked to the MSCI Europe Index from 2015 to 2024, taking into account key events like the Paris Agreement, COVID-19, and the Russia-Ukraine conflict. To assess ESG ETF performance, we apply the Sharpe (Sharpe, Management Science 9:277–293, 1963) index model and the Fama French (Fama and French, Journal of Financial Economics 116:1–22, 2015) five-factor model. Furthermore, we analyze how geopolitical crises, health crises, and the choice of ESG strategy are related to ETF performance. The results indicate that the ESG strategy itself shows only a limited relationship with alpha values, but is related with the sensitivity to market fluctuations. Moreover, we find that ESG ETFs tend to underperform their non-sustainable benchmarks during periods of geopolitical turmoil, accompanied by increased risk exposure, as observed during the Russia–Ukraine conflict.

Keywords ESG ETF · Performance · Sensitivity · ESG strategy · COVID-19 pandemic · Russian–Ukraine conflict · Paris agreement · Taxonomy

JEL Classification G12 · G13 · G14

Introduction

In light of global and regional efforts to promote sustainable finance, it is essential for investors to understand the risk and return characteristics of sustainable investment products. This study analyzes exchange-traded funds (ETFs)[1] that follow environmental, social, and governance (ESG) criteria and compares their performance to a non-sustainable benchmark index. Our sample enables us to explore how financial performance is linked to major crisis events, such as the COVID-19 pandemic and the Russia–Ukraine war, while also examining differences across various ESG investment strategies.

In recent years, the popularity of sustainable investments has risen sharply, driven by legislative initiatives following the Paris Agreement on climate change. The European Union (EU), in particular, has set ambitious goals in its transition toward a sustainable economy. Consequently, ESG criteria have become a central benchmark for investment decisions, as reflected by the rapid increase in assets under management (AUM). While in 2006 only USD 5 billion was invested in sustainable assets, by 2022 this figure had grown to USD 403 billion worldwide.[2]

The contributions of Lena Gebauer and Christoph Schmidhammer to this study represent the authors' personal opinions and do not necessarily reflect the views of Deutsche Bundesbank.

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[1] We chose ETFs because of their popularity. In 2024, for example, assets under management (AUM) exceeded USD 14 trillion worldwide.

[2] We apply data from Statista.

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The growth of assets under management in ESG ETFs signals a clear trend in the investment landscape, where sustainable investments are no longer just a niche strategy but an integral part of the global financial system. The Paris Agreement of 2015, to limit global warming to well below 2 °C, has underscored the urgency of promoting sustainable investment practices. Since then, the EU has initiated regulatory efforts to channel capital flows into sustainable investments. Regulatory frameworks, such as the EU Taxonomy Regulation and the Sustainable Finance Disclosure Regulation (SFDR), were established to convey a clearly defined common understanding of sustainability in order to assist market participants in identifying and promoting environmentally friendly economic activities. The EU taxonomy regulation is a critical step in directing capital flows towards a more climate-sensitive path. It offers a significant advantage by establishing a unified definition of sustainability, enabling the standardized categorization of ESG products based on their sustainability criteria. Consistent with this objective, the financial services sector must now disclose more climate- and sustainability-related information, see regulation (EU) 2019/2088, denoted as SFDR. For passively managed products, this includes disclosing information about the sustainability classification. They can be classified as Article 6 products, defined as assets without sustainability integration. Articles 8 and 9 outline criteria for sustainable products, with Article 8 promoting the inclusion of environmental and social characteristics as well as good governance, while Article 9 products purely target sustainable investments. The Paris Agreement and resulting initiatives, such as the EU taxonomy regulation, highlight the growing recognition of directing financial resources towards sustainable and responsible projects and companies.

Given these global and regional efforts, investors should understand the relationship of the transition process with the performance of sustainable investment products. Regarding the growing popularity of traditional ETFs during the past two decades, ESG ETFs are now of particular interest to investors and researchers alike. The current state of research indicates a predominant focus on sustainable mutual funds. However, to the best of our knowledge, there is a notable gap in the academic literature for ETFs that follows a precise, unified, and comparable definition of sustainability with clearly defined ESG strategies. Relying on the EU taxonomy regulation and exclusively focusing on products that meet SFDR criteria, this work aims to fill this gap. Besides, this study contributes to the literature in several ways. First, prior research has primarily examined ESG mutual funds or U.S.-listed ESG ETFs, with little attention given to European ESG ETFs. Since the introduction of the EU Taxonomy, Europe has been at the forefront of the sustainability movement worldwide with a clearly defined set of rules for sustainable products. We build on this development and analyze European ESG ETFs that comply with Articles 8 and 9 of the SFDR. By focusing exclusively on SFDR Article 8 and Article 9 products, this study investigates a homogenous and comparable sample of ETFs with well-defined ESG strategies. Second, this paper is to the best of our knowledge the first to systematically examine the performance of ESG ETFs during the Russia-Ukraine conflict, a geopolitical shock not yet addressed in ETF literature. Third, in contrast to studies relying on monthly or weekly returns, we employ daily returns to maximize sample coverage and capture short-term market dynamics. Finally, this paper explicitly links ETF-level ESG strategies with financial outcomes, offering deeper insights into how variations in ESG integration affect risk and performance.

Following regulatory developments that require ESG-index products to be derived from a not sustainable mother index (SFDR), we chose sustainable products based on the MSCI Europe, Europe's leading (not sustainable) index. To address investors' risk and return preferences, we first analyze the performance of ESG ETFs relative to the not sustainable mother index MSCI Europe, as illustrated in the first research question.

Research Question 1 Are there significant performance differences between ESG ETFs and their non-sustainable benchmark indices for the total sample?

This initial inquiry seeks to examine the performance of ESG ETFs relative to their non-sustainable parent index. Following Schmidhammer et al. (2011 and 2014) and Feder-Sempach and Miziołek (2022) , we apply the Sharpe (1963) index model, which allows considering both the performance and the sensitivity of an ESG ETF relative to the non-sustainable mother index. Analyzing the period after the Paris Agreement between Dec 2015 and Oct 2024, our findings indicate that, in general, ESG ETFs closely reflect the not-sustainable parent index in risk and return characteristics. However, it is interesting to observe whether results remain stable over time. Additionally, we also apply a Fama and French (2015) five-factor model to investigate potential over- or underperformance during the overall sample period.

Research Question 2 Does the performance of ESG ETFs differ during crisis events such as the COVID-19 pandemic or the Ukrainian war in comparison to their non-sustainable parent index?

Following Nofsinger and Varma (2014), we conduct an analysis that considers recent macroeconomic events for

socially responsible products. While Nofsinger and Varma (2014) study mutual funds, the goal of this study is to determine the relation of crisis events with the performance of ESG ETFs relative to their parent index. Results uncover a significant relationship between crisis events and the performance of ESG ETFs. In general, sustainable products are more sensitive than MSCI Europe during crisis events. However, with varying effects based on the type of crisis and market conditions.

Research Question 3 What impact does ESG strategy have on ETF performance?

To construct ESG ETFs, various strategies such as positive or negative screening as well as combinations of strategies can be applied, where assets are selected from a non-sustainable mother index. In this study, we analyze the link between different ESG strategies, ranging from the avoidance of carbon-intensive branches to mitigation technologies, and ETF performance. Product prospectuses allow us to identify ESG-specific strategies. On the one hand, strategy information is crucial for investors' sustainability preferences. On the other hand, this information allows us to explore the relationship between the issuer's various strategies and the performance of ESG ETFs. Although sensitivity characteristics significantly vary for the different strategies, interestingly, the performance does not diverge. This leads us to the assumption that investor's sustainability preferences are not to the disadvantage of performance results.

Literature review

Replication quality and benchmarking

When evaluating passive investment strategies such as ETFs, a body of literature agrees that replication quality plays a crucial role. Roll (1992) defines tracking error as a pivotal measure of passive management performance. Low tracking errors, indicative of high replication quality, mitigate the risk of significant underperformance against benchmarks. The initial focus of ETF replication quality research centers on American ETFs. The justification for this focus on the American ETF market stems from its status as the most developed, in comparison to other global regions where ETF markets are smaller and less developed. Elton et al. (2002) examine the performance of the first American ETFs, Standard and Poor's Depositary Receipts (SPDRs), highlighting significant underperformance against benchmark indices. In subsequent studies, Shin and Soydemir (2010) and Qadan and Yagil (2012) continue to evaluate ETFs listed in the US, thereby contributing to our understanding of the effects of exchange rates or volatility on tracking errors. Hassine and Roncalli (2013) examine the performance of 31 ETFs from November 2011 to November 2012, tracking five benchmarks: S&P 500, Euro Stoxx 50, MSCI World, MSCI Emerging Markets, and MSCI Japan/Topix. They develop their own value-at-risk measure to assess tracking efficiency and found efficient tracking for four out of six examined ETFs replicating returns of the Euro Stoxx 50 Index. Elton et al. (2019) explore passive fund management by examining the return differences between index funds and ETFs relative to their indices. Their comprehensive study emphasizes the role of expense ratios and operational efficiencies in influencing ETF and index fund selections, showing how these elements contribute significantly to tracking accuracy and overall fund performance.

With the growing popularity of ETFs outside the US market, research extends to other countries. Lang and Röder (2008) offer a detailed analysis of the DAX EX, Germany's first ETF replicating the DAX index, demonstrating its high replication quality. Also, Kundisch and Klein (2009) corroborate these findings by observing a low tracking error of the DAX EX compared to DAX index funds. Schmidhammer et al. (2014) analyze the pricing quality of five DAX-ETFs during the Volkswagen short squeeze extreme event, causing a breakdown of the futures-cash arbitrage relationship. They reveal DAX-future contracts as the real benchmark for ETFs rather than the underlying index. Feder-Sempach and Miziołek (2022) investigate the tracking efficiency of 14 European equity ETFs replicating the Euro Stoxx 50 Index over the 2012–2021 period. Their study reveals that ETFs are effectively managed, with a lower tracking error for ETFs with accumulating share classes compared to distributing share classes.

Inspired by Schmidhammer et al. (2011, 2014) and, more recently, Feder-Sempach and Miziołek (2023), we also apply the Sharpe (1963) index model to analyze the replication quality of ESG ETFs. This approach is particularly relevant because EU regulation (SFDR) requires that ESG products be derived from a non-sustainable benchmark. Using the index model, we examine both the risk and performance characteristics of ESG ETFs relative to their non-sustainable benchmark, which is an aspect that is essential for rational investment decision-making. Furthermore, we estimate the Sharpe (1963) model using daily return data, which allows us to include the largest possible number of ETFs in our analysis.

ESG mutual funds

The academic literature in the field of ESG ETFs is rare; therefore we initially focus on ESG-related literature in the context of mutual funds. Presently, there exists no

unanimous consensus on the impact of ESG criteria on investment performance. The prevailing discourse can be broadly categorized into three perspectives: ESG funds exhibit no measurable over- or underperformance, studies suggest a potential financial benefit (overperformance), and those indicate an adverse effect (underperformance).

Regarding the first literature strand, certain studies assert that ESG funds do not confer a significant financial advantage when compared to conventional funds. Former investigations (Hamilton et al. 1993; Kreander et al. 2005; Gregory and Whittaker 2007; Cortez et al. 2012; Halbritter and Dorfeitner 2015) reveal no significant differences regarding returns between ethical and non-ethical funds. Additionally, evidence that supports ESG funds exhibit no significant over- or underperformance can be found in the studies of Jacobsen et al. (2019); Niblock et al. (2020); Plagge et al. (2020); and Yue et al. (2020).

Conversely, there are studies proposing potential financial benefits of ESG investments. Investigations by Nofsinger and Varma (2014) find an overperformance of ESG funds in times of market crises and underperformance in non-crisis periods. Bauer et al. (2006) also observed mixed results. They observe evidence regarding the overperformance of ESG funds only in certain periods while observing underperformance in others. However, the literature also presents studies indicating a potential negative impact of ESG investments on financial performance. Research conducted by Renneboog et al. (2008), Muñoz et al. (2014), and Silva and Cortez (2016) reports instances of underperformance of socially responsible (SR) funds across various regions. This diversity of findings underscores the complexity of the relationship between ESG criteria and financial performance.

ESG index ETFs

The performance of mutual funds is highly compressed, influenced by both ESG screening measures and active fund management. Thus, we now shift attention from mutual funds to index ETFs. By examining the passive replication of an ESG index through ETFs, one can isolate and measure the influence of the ESG screening strategy. Kanuri (2020) investigates the performance of 36 US ESG ETFs since their inception in February 2005 through July 2019. The author compares equal- and value-weighted ESG portfolios with the Russell 3000 ETF (IWV) and the SPDR Global Dow ETF (DGT) to assess risk and return dynamics. Kanuri divides the study period into two bull markets and one bear market and utilizes CAPM, the Carhart (1997) four-factor model, as well as the Fama-French (2015) fivefactor Model. The findings reveal that ESG ETFs attract investors whose personal values align with them, and while those ESG portfolios outperformed traditional benchmarks in specific periods, they underperform in others. However, IWV and DGT consistently demonstrated higher absolute- and risk-adjusted performance over the entire study period. Rompotis (2022) investigates the financial returns of 49 ESG ETFs traded on the London Stock Exchange. Employing standard single-factor and multifactor models, the author reveals that, on average, ESG ETFs do not outperform their benchmarks. He also compares the ESG ETFs with the FTSE 100 Index as a proxy for the UK stock market, uncovering overperformance and lower associated risks with ESG ETFs. Rompotis (2023) examines 61 U.S.-traded ESG equity ETFs from January 2019 to December 2021 and reveals that ESG ETFs outperform the S&P 500 index in raw return terms. Here, approximately 16% of the examined ESG ETFs exhibit positive and significant alphas, challenging the prevailing notion that ESG investing is inherently detrimental from a financial perspective. Dai et al. (2023) investigate the impact of SR investment screens on risk and returns by comparing the performance of SR ETFs with a matched group of conventional ETFs. Matching criteria include fund age, size, investment objectives, and active status. The control group consists of 276 conventional ETFs matched with 92 SR ETFs. Applying the CAPM, Carhart (1997) four-factor model, and the Fama-French (2015) five-factor model, the authors find that SR ETFs exhibit significantly negative abnormal returns (alphas) compared to conventional ETFs, with underperformance ranging from 0.019 to 0.022% per day, depending on specifications.

The mixed evidence regarding ESG ETFs can be partly attributed to structural factors and, to a greater extent, to differences in research design. For example, Kanuri (2020) compares the performance of ETF portfolios with the IWV and DGT equity indices, reporting an overall advantage for these indices over the period 2005–2019, while also identifying subperiods of under- and outperformance. Rompotis (2022) finds that UK-traded ESG ETFs generally do not outperform their benchmarks, although there is some evidence of outperformance relative to the FTSE 100, which may reflect sectoral tilts, particularly toward growth-oriented and technology stocks that benefited during the sample period. In contrast, Dai et al. (2023) observe that socially responsible ETFs underperform matched conventional ETFs only during non-crisis periods between 2005 and 2020, a pattern they attribute to the restrictive nature of screening methods and the consequent loss of diversification benefits.

ETFs and ESG screening strategies

Various strategies exist for implementing ESG criteria to construct ETFs. In addition to negative screening, which involves excluding certain industries, mostly traditional sin stock industries like tobacco, weapon/defense, or adult entertainment, from the investment universe, positive screening focuses on the inclusion of high-performing ESG

companies rather than the a-priori exclusion of industries/companies. However, only a few authors investigate the impact of such screening processes in the context of ETFs. Dumitrescu et al. (2023) observe that positive screening in SRI (Socially Responsible Investing) ETFs generates a significant annual underperformance of 6.31% against the market throughout the entire examined period from 2010 to 2020. However, during the period from 2018 to 2020, positive screening results in a significant annual outperformance of 7.81%. Furthermore, environmental inclusion achieved a significant alpha of −5.61% (13.80%) over the entire period (last two years). No significant results can be obtained from the remaining investigated strategies. However, in this work, we examine combinations of various screening methodologies, a practice that is adopted by numerous ESG ETFs in Europe. Our exclusive concentration on SFDR Article 8 and Article 9 ETFs allows us to analyze well comparable products concerning ESG and sustainability considerations. Our focus is to explore the relationship between different screening strategies and the risk and performance of ESG ETFs.

ESG ETFs and crisis periods

As academic literature on ESG ETFs continues to evolve, it seems a logical next step to consider major and unexpected events, such as the COVID-19 pandemic and the Ukraine war, that potentially influence their financial performance. The unprecedented market dynamics triggered by these events raise questions such as how ESG ETFs respond to periods of heightened uncertainty, economic instability, and geopolitical tensions. Recent studies by Omura et al. (2021) and Pavlova and Boyrie (2022), alongside the work of Folger-Laronde et al. (2022), investigate the performance of ESG ETFs during the COVID-19 crisis. Omura et al. (2021) applied asset-pricing models to assess ESG ETFs from January 2018 to June 2020 in the US and MSCI SRI indices globally but found no evidence of outperformance against benchmarks. Similarly, Pablova and Boyrie (2022) focus on the risk-adjusted returns of ESG ETFs before (November 14, 2019–February 19, 2020) and after (February 20, 2020–May 29, 2020) the COVID-19 market crash. Their findings indicate that lower-rated sustainable ETFs tend to outperform the market pre-COVID, while higher-rated ones underperform, and higher sustainability ratings do not prevent losses during the crash. Folger-Laronde et al. (2022) examine the financial returns of ETFs and their Eco-fund ratings from January 11, 2019, to March 3, 2020, during the COVID-19 financial market crash. Their results add to the consensus that higher sustainability ratings do not safeguard investments from financial losses during severe market downturns. However, ElBannan (2023) provides a different perspective. Exploring the significance of ESG performance from December 2004 to December 2021 in explaining the returns and volatility of ETFs during the COVID-19-induced market crash, ElBannan (2023) finds robust evidence for the resilience of sustainable ETFs during the crisis. While the impact of the Ukraine war on stocks, foreign exchange, and commodity markets is, to the best of our knowledge, hardly examined, there has been no academic literature regarding its linkage with ETFs, particularly ESG ETFs. Thus, our study also aims to fill this gap in the academic literature.

Data and methodology

Since the EU decided to be the market leader in the transition to a sustainable economy, we chose to analyze the development of the European market. Le Sourd und Safaee (2021) show that the European market clearly surpasses the U.S. in the field of environmental, social, and governance (ESG) investments and describe ETFs as the appropriate instrument to integrate ESG-related topics in investment decisions in a systematic way. As Europe's leading market index, the MSCI Europe Index tracks the performance of stock markets across 15 developed countries and is the most widely replicated European index by ETFs traded at XETRA. The methodology is based on various factors such as size, liquidity, and market capitalization of the companies. Free-float market capitalization is employed for weighting assets, ensuring a realistic representation of the market.[3] Covering 11 sectors and 418 companies, the MSCI Europe Index provides a clear picture of the European market.

To analyze return and risk developments for ESG ETFs after the Paris Agreement, we employ MSCI Europe data from December 15, 2015, to October 2, 2024[4]. The analyzed time span includes interesting key events such as the pandemic and the Ukrainian war that potentially correlate with the performance of ESG ETFs.

To effectively analyze diverse market phases and events (as intended in research question 2), the dataset containing daily XETRA closing prices from December 15, 2015, to October 02, 2024, is segmented into three sub-periods. The periods are illustrated in Fig. 1. The Paris Agreement period is defined as beginning on 15 December 2015, the date of its adoption, which represents a pivotal moment in global climate policy. The COVID-19 period commences on 11 March 2020, following the World Health Organization's (WHO) official declaration of COVID-19 as a global

[3] Information is provided by MSCI.

[4] We also examine the timeframe before the Paris Agreement, covering the period between January 2, 2012 and December 15, 2015 (i.e., Period 0). The results can be found in Appendix A. However, data from only three ETFs are available in this period, limiting the conclusiveness of these results.

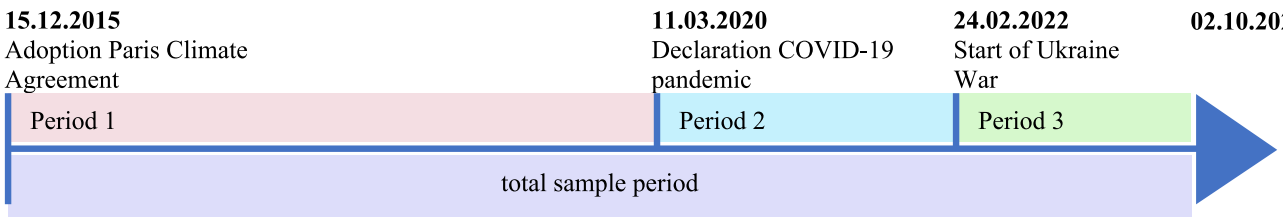

Fig 1: Overview of the time periods examined for the analysis of ESG ETF risk and performance characteristics in the context of crisis and non-crisis events.

pandemic. The Russia–Ukraine war period begins on 24 February 2022, marked by Russia's full-scale invasion of Ukraine.

Data

This study analyzes 34 ESG ETFs from 2015 to 2024, covering both longstanding and newly issued funds issued between 2008 and 2023.[5] Our dataset is derived from LSEG (formerly Refinitiv) and includes all ESG ETFs tradable on XETRA, focusing on MSCI Europe-based funds.

The analysis relies on total returns of ETFs and the MSCI Europe Net Index EUR, which allows us to examine distributing and accumulating ETFs simultaneously. Total Return prices also account for all capital changes and dividend payouts, offering a comprehensive view of performance. To ensure the comparability of ETF returns with their mother index, we follow Schmidhammer et al. (2011 and 2014) and correct the total returns of the observed ETFs through the addition of their respective costs, since those are not incorporated in the MSCI Europe index returns.

Table 1 summarizes key attributes of the analyzed ETFs. They are classified under SFDR Article 8 or 9, with only one meeting the strict criteria of Article 9.[6] Emission date and product issuers are depicted in columns 3 and 4. The "income" column indicates whether dividends are retained or paid out. Replication strategies include full (exact index replication, 24 ETFs), optimized (selecting a subset of index assets, 9 ETFs), and swap-based replication (using swap contracts, 1 ETF). The total expense ratio (TER) reflects annual costs. Further, the strategy of how a sustainable index is derived from the not-sustainable mother index and includes negative screening (N), best-in-class (BIC), positive tilt (PT), thematic (THEM), and Paris-aligned (PA), with most ETFs using combined strategies. EUR is used as the analysis currency, as only one ETF is denominated in USD.

[5] Note that our dataset also includes ETFs that have already been closed. Consequently, this sample is not subject to survivorship bias.

[6] Article 9 requirements are corresponding to the sustainability definition in Article 2 (17) SFDR.

ESG strategies

One objective of this study is to provide a comprehensive overview of various ESG investment strategies and to highlight the approaches investors can use to achieve financial and ethical goals when selecting their portfolios. A closer examination of our data reveals that the analyzed ETFs combine a diverse range of ESG strategies. To categorize ETFs regarding their investment approaches, we analyze the index factsheets by using specific keywords (see Table 2).

Negative and positive screening strategies are already described in the literature review. "Positive tilt" is closely related to "positive screening", since the weight of assets increases with their positive contribution to sustainability characteristics. Negative screening emerges as a particularly popular approach, employed by 28 ETFs. Two ETFs exclusively utilize this method. Negative screening means that companies or industries that do not meet certain ESG criteria are deliberately excluded from investments. Grégoire (2019) states that particularly companies operating in areas such as nuclear weapons, tobacco, coal, nuclear energy, or oil are particularly likely to be excluded from the investment universe. We see a strong alignment between many of these ESG criteria and the principles of the United Nations Global Compact, which calls on companies worldwide to respect fundamental values in areas such as human rights, labor standards, environmental protection, and anti-corruption. (see United Nations Global Compact 2023).

Fifteen ETFs follow the "best in class" approach. The "best-in-class" approach involves investing in companies within their industry that are considered leaders in terms of ESG criteria, such as the transition to a low-carbon economy and the best ESG ratings in a benchmark portfolio.

"Thematic investing" is applied to 22 ETFs, with a focus on specific, often cross-sector themes such as the transition to a low-carbon economy. ETF 34, for example, tracks the MSCI Europe Climate Action Net Total Return Index. This index optimizes the weighting of companies in the MSCI Europe using MSCI Low Carbon Transition Scores by increasing investments in companies that actively exploit opportunities in the transition to a low-carbon economy, while reducing exposure to companies with significant

Table 1 Product description

ETF	SFDR	Emission	Issuer	Income	Replication	TER (%)	ESG strategy	Currency
ETF 1	8	17.01.2008	Xtrackers	Retained	Full	0.12	N	USD
ETF 2	8	25.02.2011	iShares	Retained	Optimized	0.20	N, BIC	EUR
ETF 3	8	12.02.2016	EasyETF	Retained	Optimized	0.15	N	EUR
ETF 4	8	19.02.2016	EasyETF	Retained	Swap	0.25	N, BIC, PA	EUR
ETF 5	8	12.06.2017	iShares	Paid	Optimized	0.28	N, PT, THEM	EUR
ETF 6	8	13.03.2018	EasyETF	Paid	Full	0.25	N, BIC, PA	EUR
ETF 7	8	22.03.2018	Amundi	Retained	Full	0.12	N, THEM	EUR
ETF 8	8	08.05.2018	Xtrackers	Retained	Full	0.20	N, BIC, THEM	EUR
ETF 9	8	11.09.2018	Amundi	Retained	Full	0.18	N, BIC, PA	EUR
ETF 10	8	19.10.2018	iShares	Retained	Optimized	0.12	N, THEM	EUR
ETF 11	8	19.10.2018	iShares	Paid	Optimized	0.12	N, THEM	EUR
ETF 12	8	06.12.2018	iShares	Paid	Optimized	0.20	N, BIC, THEM	EUR
ETF 13	8	23.01.2019	Invesco	Paid	Full	0.30	N, BIC, THEM	EUR
ETF 14	8	12.02.2019	Amundi	Retained	Full	0.20	N, BIC, PT	EUR
ETF 15	8	15.02.2019	EasyETF	Retained	Full	0.25	N, BIC, PA	EUR
ETF 16	8	16.04.2019	iShares	Retained	Optimized	0.12	N, THEM	EUR
ETF 17	8	06.05.2019	iShares	Paid	Optimized	0.12	N, THEM	EUR
ETF 18	8	13.06.2019	Invesco	Retained	Full	0.16	N, PT	EUR
ETF 19	8	24.10.2019	Amundi	Paid	Full	0.18	N, BIC, PA	EUR
ETF 20	8	05.03.2020	Amundi	Retained	Full	0.15	N, PT	EUR
ETF 21	8	10.03.2020	Amundi	Retained	Full	0.13	N, BIC	EUR
ETF 22	8	17.04.2020	iShares	Retained	Optimized	0.25	THEM	EUR
ETF 23	9	29.06.2020	Deka ETF	Paid	Full	0.27	N, THEM	EUR
ETF 24	8	26.02.2021	UBS ETF	Retained	Full	0.18	N, BIC, THEM	EUR
ETF 26	8	26.02.2021	UBS ETF	Paid	Full	0.18	N, BIC, THEM	EUR
ETF 25	8	26.02.2021	UBS ETF	Retained	Full	0.23	N, BIC, THEM	EUR
ETF 27	8	09.03.2021	UBS ETF	Retained	Full	0.15	N, THEM, PA	EUR
ETF 28	8	20.07.2021	UBS ETF	Retained	Full	0.12	N, BIC, PT, THEM	EUR
ETF 29	8	27.07.2021	iShares	Retained	Full	0.15	THEM, PA	EUR
ETF 30	8	05.08.2021	HSBC ETF	Retained	Full	0.15	N, THEM, PA	EUR
ETF 31	8	06.12.2021	Invesco	Retained	Full	0.16	THEM, PA	EUR
ETF 32	8	04.03.2022	SPDR	Retained	Full	0.15	THEM, PA	EUR
ETF 33	8	31.01.2023	Xtrackers	Retained	Full	0.12	THEM	EUR
ETF 34	8	24.05.2023	Amundi	Paid	Full	0.09	THEM	EUR

This Table provides an overview of key product attributes for each ETF, including ticker symbols, SFDR classification, emission dates, ETF issuer, income operation, replication methods, Total Expense Ratio (TER), ESG strategy, and currency.

transition risks. The index therefore promotes companies that proactively contribute to combating climate change and minimizes exposure to risky companies during the ecological transition. Other issues addressed by ETFs include reducing greenhouse gases, promoting "green revenues", investing in companies that are less vulnerable to climate-related risks, and contributing to the fight against climate change through reduced water emissions and lower hazardous waste intensity. Ten ETFs are explicitly aligned with the goals of the Paris Agreement and are referred to below as "Paris-aligned." One example is ETF 29, which tracks the MSCI Europe Climate Paris-aligned Benchmark Select Index and aims to exceed the technical requirements of the EU Delegated Act and achieve at least a 50 percent reduction in physical risks from extreme weather events.

ETF 28 combines most of these approaches. This ETF tracks the MSCI Europe ESG Universal Low Carbon Select 5% Issuer Capped Index and integrates various strategies in several steps. Step 1 involves negative screening, which excludes companies with low ESG ratings and exposure to controversial sectors. Step 2 focuses on thematic investments, particularly on reducing CO_2 emission intensity, by excluding the 5% of companies with the highest intensity, taking into account sector-specific weights. In step 3, companies are reweighted based on their current and trend-related ESG profiles. This means that negative screening, positive tilt, thematic investments, and the "best-in-class" approach are used.

Due to various possible combinations, we observe 12 different strategies for the analyzed ESG ETFs. The various combinations observed are represented as strategy dummies

Table 2 Keywords used to assign ESG ETFs to an ESG strategy.

Negative screening (N)	Positive screening	Paris aligned (PA)
Exclusion	Positive	Paris aligned
Avoid	Prefer	Paris agreement
Not invest	Promote	Climate goals
Exclude	Support	CO_2 reduction
		Renewable energies
		Paris
		PAB
	Best in class (BIC):	
	Best-in-class	
	Leading	
	Top	
	Positive tilt (PT):	
	ESG trend	
	ESG tilt	
	Thematic (THEM):	
	Thematic	
	Theme ETF	
	Specific themes	
	Transition	
	Carbon	
	Low carbon	

in the respective regression specifications (see Sect. "Results of Fama and French (2015) five-factor model").

Risk and performance analysis

Analyzing daily returns allows for a detailed examination of investment performance by capturing short-term fluctuations. Returns are calculated as follows:

$$R_{i,t} = \frac{CP_{i,t} - CP_{i,t-1}}{CP_{i,t-1}} \tag{1}$$

The daily return of ETF i and the underlying index at time t is the difference between the closing price CP at time t and the closing price at time $t-1$, divided by the closing price at time $t-1$.

Index model

To address research question 1, we analyze the risk and performance of European ESG ETFs relative to their non-sustainable benchmark. We follow Schmidhammer et al. (2011 and 2014) and Feder-Sempach and Miziołek (2022), who explain the risk and performance of ETFs with index returns applying the Sharpe (1963) index model. In the following regression specification, we explain European ESG ETF returns with MSCI Europe index returns as illustrated in equation (2):

$$R_{i,t} = \alpha_i + \beta_i * R_{MSCI,t} + \varepsilon_{i,t} \tag{2}$$

Returns of ESG ETF i at time t are explained by returns of the MSCI Europe $R_{MSCI,t}$ at time t. The constant α_i reflects the performance of ESG ETF i relative to the benchmark index. A value above (below) zero indicates an outperformance (underperformance) of an ETF relative to the index. Coefficient β_i represents the sensitivity of ETF i relative to the benchmark index. A value above (below) one suggests a higher (lower) sensitivity of an ETF to price changes relative to the benchmark index. Since we chose the non-sustainable mother index MSCI Europe, ESG ETF results can be interpreted as the risk of a sustainable strategy relative to the non-sustainable index market. The same is valid for α which reflects the performance of an ESG ETF relative to the non-sustainable benchmark. Coefficient $\epsilon_{i,t}$ represents error terms of ETF i at time t. To address heteroskedasticity and autocorrelation, the Newey and West (1987) procedure is applied.

Time period effects

To examine the correlation of time periods with risk and return characteristics of ESG ETFs and to address research question 2, the following regression specification is estimated:

$$\begin{aligned} R_{i,t} =& \alpha_{Period_1} + \beta_{Period_1} * R_{MSCI,t} + E' * Period_j \\ &+ F' \cdot R_{MSCI,t} * Period_j + \varepsilon_{i,t} \end{aligned} \tag{3}$$

We employ a panel structure to address the correlation of $Period_j$ with risk and performance for specified time periods. As a vector of coefficients, E captures time period specific effects. The dimension of vector E corresponds to the dimension of vector $Period_j$. Since period 1 is omitted as the reference, period dummy results as captured in E allow to analyse the performance of crisis periods 2 and 3 relative to the reference. As reference, the constant term α_{Period_1} reflects the performance of ESG ETFs during period 1. Interaction terms between $R_{MSCI,t}$ and $Period_j$ examine the sensitivity of time periods 2 and 3. Again, period 1 is omitted as the reference and coefficient β_{Period_1} captures the sensitivity of ESG ETFs relative to the benchmark index during period 1. The inclusion of interaction terms between the MSCI index and time periods j allows to capture sensitivity differences of ESG ETFs between general market times and crisis periods. Coefficient $\epsilon_{i,t}$ represents error terms of ETF i at time t. To correct for heteroscedasticity and autocorrelation, the Newey and West (1987) procedure is applied.

ESG strategies effects

Further, to answer research question 3, we apply a panel structure to address the relationship of ESG strategies as illustrated in Table 2 on risk and performance. Relying on Nofsinger and Varma (2014), we include dummies to capture the linkage of ESG strategies with risk and performance. Hence, we extend regression specification (2) for ESG strategy dummies denoted as $ESGStrategy_s$, where s represents the ESG strategy of ETF i. As explained in Sect. "ESG strategies", ESG strategies include negative screening, best in class, positive tilt, thematic investing, Paris aligned, and various combination opportunities. Since more than one of these ESG strategies is applied in most of the ETFs, strategy dummies also include these combinations. Equation (4) illustrates the regression specification:

$$\begin{aligned} R_{i,t} =& \alpha_{Strategy_N} + \beta_{Strategy_N} * R_{MSCI,t} + C' * ESG\ Strategies_s \\ &+ D' * R_{MSCI,t} * ESG\ Strategies_s + \varepsilon_{i,t} \end{aligned} \tag{4}$$

Returns of ESG ETF i at time t are explained by returns of the MSCI Europe $R_{MSCI,t}$ at time t. Since "Negative screening" is omitted as the reference, the constant term $\alpha_{Strategy_N}$ captures the performance of this strategy. $ESGStrategies_s$ is a vector of strategy dummies, where s represents an ETF's specific strategy. As a vector of coefficients, C captures ETF-specific strategy results. The dimension of vector C corresponds to the dimension of vector $ESGStrategies_s$. Strategy dummy results as captured in C allow us to analyse the performance between ESG ETF's strategies relative to the benchmark. Interaction terms between $R_{MSCI,t}$ and ESG strategies examine sensitivity differences between the respective ESG strategies. Again, "negative screening" is omitted as the reference. Hence, coefficient $\beta_{Strategy_N}$ captures the sensitivity of ESG ETFs that apply "negative screening". An interaction term significantly deviating from zero indicates that the sensitivity of an ETF is associated with the respective ESG strategy. Coefficient $\epsilon_{i,t}$ represents error terms of ETF i at time t. To correct for heteroscedasticity and autocorrelation, Newey and West (1987) is applied.

Fama French factor model

In addition to previous analyses, we also examine the potential over- or underperformance of our ESG ETFs. In doing so, we apply the well-known Fama and French (2015) five-factor regression, which is based on the following regression specification:

$$\begin{aligned} R_{it} - R_{Ft} =& a_i + b_i\left(R_{Mt} - R_{Ft}\right) + s_i SMB_t \\ &+ h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it}. \end{aligned} \tag{5}$$

In this model, R_{it} is the return of portfolio i for period t, while R_{Ft} indicates the risk-free return. The remaining factors include R_{Mt} (market portfolio return), SMB_t (small-minus-big stock returns), HML_t (high minus low book-to-market), RMW_t (robust minus weak profitability), and CMA_t (conservative minus aggressive). The coefficients $a_i, b_i, s_i, h_i, r_i, c_i$ are estimated via OLS regression, with a_i as the intercept and e_{it} as the residual (assumed to have zero mean).

Since the factors provided in Kenneth French's data library are in USD, we follow Glück et al. (2020) to convert these factors in EUR. This conversion allows us to calculate reliable alpha and beta estimates. The conversion for the market factor is given by:

$$\left(R_{Mt} - R_{Ft}\right)^{EUR} = \frac{\left(1 + \left(R_{Mt} - R_{Ft}\right)^{USD} + R_{F,t}^{USD}\right)}{\left(1 + r_{FX,t}^{\frac{USD}{EUR}}\right)} - 1 - R_{F,t}^{EUR} \tag{6}$$

We obtained daily USD/EUR data from Bloomberg. To calculate $r_{FX,t}^{\frac{USD}{EUR}}$ we use formula (1).

As a proxy for the risk-free return in EUR, $R_{F,t}^{EUR}$, we follow Schmidt et al. (2019) and use the minimum of the one-month EURIBOR and the Overnight Index Swap (OIS) rate, which was last conducted on December 31, 2021. From January 2022 onwards, we used €STR instead of the Overnight Index Swap rate. Data was collected from Bloomberg. The conversion for the daily long-short factors SMB, HML, RMW and CMA is given by

$$LS_t^{EUR} = \frac{1}{\left(1 + r_{FX,t}^{\frac{USD}{EUR}}\right)} LS_t^{USD} \tag{7}$$

Results

Index model results

In this section, insights derived from the Sharpe (1963) index model are presented, with a particular focus on how ESG ETFs perform compared to the non-sustainable parent index in the specified periods.

Period 1 – Paris Agreement

Table 3 illustrates index model results for period 1. Coefficient α uncovers the performance of an ESG ETF relative to the benchmark index. From the Paris Agreement on climate change up to the pandemic, only positive alpha values can

Table 3 Sharpe index model results (Period 1)

ETF	Alpha	t-Stat.	Beta	t-Stat.	F-Stat.	adj. R^2	Obs.	Spanning test
								H_0: ß=1 and α =0
								F-Stat.
ETF 1	0.003	0.458	1.016***	42.609	10844.784	0.910	1069	0.458
ETF 2	0.009*	1.935	0.981***	111.849	28636.424	0.964	1069	3.771**
ETF 3	0.001	0.284	0.999***	126.626	32686.960	0.974	869	0.042
ETF 4	0.005	0.451	0.929***	37.148	4136.904	0.826	872	4.126**
ETF 5	0.002	0.155	0.931***	28.047	3790.656	0.851	662	2.211
ETF 6	0.020***	3.142	0.948***	80.644	11720.036	0.961	477	18.279***
ETF 7	0.001*	1.813	1.008***	247.118	105540.275	0.990	1069	3.112**
ETF 8	0.018***	2.855	0.952***	75.464	11172.918	0.961	456	9.489***
ETF 9	0.024***	2.943	0.962***	45.958	7517.095	0.958	334	8.313***
ETF 10	0.004	0.818	0.999***	86.472	7449.913	0.956	344	0.370
ETF 11	0.005	1.118	0.996***	99.169	18660.703	0.982	344	0.793
ETF 12	0.028***	3.023	0.964***	84.568	7915.180	0.968	259	8.629***
ETF 13	0.002	0.274	1.025***	96.754	10469.348	0.974	280	2.741*
ETF 16	0.005	1.274	0.978***	122.662	19920.366	0.989	223	4.747***
ETF 17	0.006	1.137	0.999***	156.141	18357.047	0.989	213	0.654
ETF 18	0.016***	2.834	0.970***	138.004	12942.572	0.986	183	15.249***

This table displays α- and β-values, associated t-statistics, F-statistics, significance levels, adjusted R^2, the number of observations, and a spanning test. Significance levels are 10% = *, 5% = **, and 1% = ***.

be observed. This is the case, although management fees are charged for all ETFs.

Out of 16 products, seven ETFs show a significant outperformance. β-coefficients of the 16 analyzed ETFs range from 0.929 to 1.025, with a mean of 0.978 and a median of 0.979 which indicates that the risk of ESG products is slightly below the non-sustainable mother index. According to Hubermann and Kandel (1987), the application of a spanning test allows for jointly testing the hypothesis of H_0: α=0 and H_0: ß=1. In the case where the spanning test is not significantly rejected, a perfect replication of the underlying benchmark can be assumed. Although all products apply a sustainable strategy (Article 8 and Article 9 SFDR), for six ESG ETFs, risk and performance characteristics closely one-on-one correspond to the underlying index.

Period 2 – Covid-19

In the second period, including the Corona pandemic, 30 ETFs are included in the sample. Results are depicted in Table 4. During the pandemic, α coefficients slightly decrease to a negative mean of −0.009 and a median of −0.003. For three ETFs, a significant underperformance relative to the MSCI can be observed. β-values range from 0.769 to 1.091, with a comparable mean of 0.986 and median of 0.994. Relying on the spanning test, for 17 ETFs a perfect replication quality can be observed.

Period 3 – Russia–Ukraine conflict

In the third period, including the Ukraine war, 34 ETFs are included in the sample. Table 5 shows the results. α coefficients remained slightly negative with a mean of −0.001 and a median of 0.000. For no ETFs, a significant under- or overperformance relative to the MSCI can be observed. β-values range from 0.846 to 1.122, however, for 32 ETFs a value exceeding one can be observed, which indicates that the risk of ESG ETFs has increased relative to the non-sustainable index. This is also reflected in a mean of 1.020 and a median of 1.024. The spanning test reveals a perfect replication quality for 15 ETFs relative to the MSCI.

Total sample

Table 6 illustrates the total sample results. Overall, α coefficients are slightly positive with a mean of 0.0001 and a median of 0.0001. For the total sample, β-coefficients range between 0.809 and 1.066. With a mean of 1.002 and a median of 1.007, the risk of ESG ETFs is comparable to the MSCI Europe. The spanning test reveals a perfect replication quality for 20 ETFs relative to the MSCI.

Overall, total sample results reveal that a majority of analyzed ESG ETFs closely replicate the non-sustainable index, although they follow a sustainable strategy. Hence, a remarkable portion of ESG ETFs is comparable in risk and performance characteristics to the non-sustainable reference. This could be interesting for investors who support the transition to a sustainable economy by simultaneously

Table 4 Sharpe index model results (Period 2)

ETF	Alpha	t-Stat.	Beta	t-Stat.	F-Stat.	adj. R^2	Obs.	Spanning test H_0: ß=1 and α =0 F-Stat.
ETF 1	0.009	0.672	0.979***	84.853	7647.882	0.939	498	1.624
ETF 2	0.004	0.319	0.956***	71.995	9922.307	0.952	498	6.432***
ETF 3	−0.003	−0.226	1.038***	33.011	6973.041	0.933	498	0.740
ETF 4	−0.004	−0.153	0.989***	45.081	2802.207	0.849	498	0.132
ETF 5	−0.003	−0.124	1.002***	39.921	4200.100	0.894	498	0.010
ETF 6	0.013	1.064	0.912***	49.422	8568.146	0.945	498	12.019***
ETF 7	0.001	0.627	0.999***	205.369	60142.966	0.992	498	0.220
ETF 8	0.002	0.218	0.945***	70.987	12743.618	0.962	498	9.200***
ETF 9	0.003	0.230	0.947***	51.820	8310.352	0.944	498	4.452**
ETF 10	0.003	0.604	0.979***	64.556	18326.658	0.974	498	0.958
ETF 11	0.002	0.439	0.982***	97.526	37378.209	0.987	498	1.554
ETF 12	0.004	0.380	0.947***	56.687	9488.472	0.950	498	5.123***
ETF 13	−0.007	−0.732	1.045***	140.932	18726.602	0.974	498	18.158***
ETF 14	−0.005	−0.591	1.003***	72.214	7596.839	0.962	300	0.177
ETF 15	−0.054*	−1.959	1.006***	26.197	281.944	0.940	19	2.648*
ETF 16	0.003	0.778	0.984***	99.547	26333.701	0.981	498	1.343
ETF 17	0.003	0.967	0.976***	98.015	32768.371	0.985	498	2.902*
ETF 18	0.006	0.917	0.951***	66.986	25643.196	0.981	498	6.093***
ETF 19	−0.066**	−2.511	1.025***	29.759	1263.615	0.945	74	3.171**
ETF 20	0.002	0.419	1.005***	158.876	29866.246	0.985	444	0.602
ETF 21	−0.002	−0.236	0.991***	96.674	10961.165	0.961	444	0.579
ETF 22	−0.005	−0.380	0.769***	47.640	3790.119	0.890	469	104.072***
ETF 23	−0.007	−0.788	1.002***	58.260	7752.103	0.950	412	0.318
ETF 24	−0.007	−0.367	1.014***	47.058	2702.757	0.919	238	0.208
ETF 25	−0.014	−0.775	0.998***	40.664	2224.584	0.904	238	0.422
ETF 26	−0.012	−0.566	0.978***	37.928	1976.099	0.893	238	0.985
ETF 27	−0.005	−0.421	1.018***	60.676	4913.306	0.955	230	0.611
ETF 28	−0.013	−1.253	1.022***	111.445	7640.237	0.982	141	3.087**
ETF 30	−0.019	−1.026	1.026***	70.525	3634.854	0.963	139	1.639
ETF 31	−0.108***	−2.986	1.092***	30.196	867.835	0.945	51	8.504***

This table displays α- and β-values, associated t-statistics, F-statistics, significance levels, adjusted R^2, the number of observations, and a spanning test. Significance levels are 10% = *, 5% = **, and 1% = ***.

investing in portfolio characteristics that correspond to a well-diversified index such as the MSCI Europe. It is also interesting to observe that α coefficients are predominantly not different from zero.

After the Paris Agreement and before crisis periods, ESG ETFs tend to outperform their non-sustainable benchmark with slightly less risk. However, during the pandemic and especially during the Ukraine war, the risk of ESG ETFs increased relative to the benchmark together with slightly decreasing α coefficients. Periods 2 and 3 results may be explained by economic uncertainties as well as market and sector changes due to geopolitical uncertainties.

Time period results

Since markets continuously change over time, influenced by events such as geopolitical tensions, economic crises, and other global events, this section explores the effects of selected periods on the performance of ESG ETFs. The objective is to gain an understanding of how these ETFs react to varying market conditions compared to the MSCI Europe and whether specific periods consistently offer better or worse returns for the ETFs. Table 7 illustrates results based on regression specification (3). Since period 1 is omitted as the reference, C and MSCI coefficients relate to period 1.

The constant term represents the performance of ESG ETFs during period 1 relative to the MSCI Europe. With a coefficient value of 0.007 and a t-statistic of 4.091, a significant outperformance of ESG ETFs during period 1 can be observed relative to MSCI Europe. Corresponding to the index model results, the β_{Period_1} coefficient, which amounts to 0.980 is slightly below one, indicating a risk level of ESG ETFs slightly below the non-sustainable reference.

In period 2, dominated by the COVID-19 pandemic, ESG ETFs exhibited a significant underperformance of

Table 5 Sharpe index model results (Period 3)

ETF	Alpha	t-Stat.	Beta	t-Stat.	F-Stat.	adj. R^2	Obs.	Spanning test H_0: ß=1 and α =0 F-Stat.
ETF 1	0.000	0.091	1.024***	127.323	27124.838	0.976	668	4.372**
ETF 2	−0.001	−0.110	1.015***	57.300	8367.315	0.926	668	0.359
ETF 3	0.000	−0.084	1.017***	136.717	43254.788	0.985	668	2.683*
ETF 4	−0.028	−1.506	1.118***	38.496	2109.198	0.760	668	8.981***
ETF 5	0.014	1.580	0.865***	25.538	3964.584	0.856	668	8.080***
ETF 6	−0.008	−0.930	1.007***	57.554	8377.201	0.926	668	0.435
ETF 7	−0.002	−0.517	1.020***	157.809	28826.850	0.977	668	4.702***
ETF 8	0.005	0.782	1.018***	78.493	12305.058	0.949	668	1.449
ETF 9	0.000	0.004	1.020***	57.250	7862.141	0.922	668	0.666
ETF 10	0.002	0.668	1.024***	181.462	35976.885	0.982	668	9.717***
ETF 11	0.002	0.845	1.025***	169.498	45626.647	0.986	668	9.253***
ETF 12	−0.001	−0.118	1.017***	66.106	9253.324	0.933	668	0.614
ETF 13	−0.003	−0.355	1.122***	80.251	11024.222	0.943	668	37.893***
ETF 14	0.002	0.414	1.031***	118.558	15853.850	0.960	668	7.192***
ETF 15	−0.008	−0.936	1.023***	52.182	5693.452	0.895	668	0.870
ETF 16	−0.003	−0.775	1.025***	105.497	27371.991	0.976	668	3.336**
ETF 17	−0.002	−0.436	1.026***	109.491	27828.438	0.977	668	3.926**
ETF 18	0.000	0.029	1.036***	94.141	27103.805	0.976	668	5.570***
ETF 19	0.000	0.016	1.023***	56.377	5980.447	0.900	668	0.930
ETF 20	0.001	0.113	1.043***	71.990	15345.614	0.968	515	4.539**
ETF 21	0.002	0.244	1.006***	58.989	4622.829	0.922	394	0.083
ETF 22	−0.001	−0.112	0.846***	61.977	5039.547	0.883	668	75.520***
ETF 23	0.002	0.293	1.027***	70.172	10157.410	0.938	668	2.294
ETF 24	0.008	0.821	1.010***	59.863	6922.011	0.912	668	0.557
ETF 25	0.005	0.493	1.025***	57.343	6062.496	0.901	668	1.364
ETF 26	0.007	0.769	1.011***	52.636	6260.232	0.904	668	0.474
ETF 27	0.001	0.126	1.022***	68.957	11982.097	0.947	668	1.674
ETF 28	−0.003	−0.604	1.019***	69.053	12962.218	0.966	455	1.061
ETF 29	−0.002	−0.364	1.033***	78.128	13227.703	0.954	644	3.414**
ETF 30	0.001	0.136	1.028***	77.810	13848.896	0.954	668	3.447**
ETF 31	−0.005	−0.576	1.055***	48.177	7407.659	0.917	668	3.354**
ETF 32	−0.002	−0.307	1.039***	67.144	10518.864	0.941	660	3.309**
ETF 33	0.003	0.556	1.002***	68.191	9435.567	0.959	401	0.221
ETF 34	−0.002	−0.358	1.053***	72.054	4576.335	0.932	333	6.664***

This table displays α- and β-values, associated t-statistics, F-statistics, significance levels, adjusted R^2, the number of observations, and a spanning test. Significance levels are 10% = *, 5% = **, and 1% = ***.

-0.008 compared to period 1. These results align with the findings of Omura et al. (2021) and Pablova and Boyrie (2022), alongside the work of Folger-Laronde et al. (2022). Period 2 interaction term results reveal that risk in period 2 does not significantly deviate from risk in period 1.

In period 3, characterized by the Russian invasion and geopolitical tensions, ESG ETFs recorded a significant underperformance of −0.007 compared to period 1. Additionally, the period 3 interaction term shows a highly significant increased sensitivity of 0.039 compared to the reference.

Therefore, times without economic and geopolitical turmoil as prevailing in period 1 proved to be highly attractive in terms of risk and performance characteristics for ESG ETFs. Furthermore, the performance of ETFs appears to be contingent on the prevailing market conditions. In times of geopolitical unrest, the performance and risk of ESG ETFs deteriorate. To address investor's perspectives in more detail, we further examine ESG strategies.

ESG strategy results

This chapter examines the correlation of ESG strategies with risk and performance. The derivation of an ESG index product from a non-sustainable mother index requires a clear strategy such as negative screening (N), best-in-class (BIC),

Table 6 Sharpe index model results (total sample)

ETF	Alpha	t-Stat.	Beta	t-Stat.	F-Stat.	adj. R^2	Obs.	Spanning test H_0: ß=1 and α =0 F-Stat.
ETF 1	0.004	0.754	1.004	85.738	32082.357	0.935	2235	0.409
ETF 2	0.005	1.154	0.979	112.673	42525.323	0.950	2235	3.107**
ETF 3	0.000	−0.170	1.022	64.944	45606.785	0.957	2035	0.955
ETF 4	−0.007	−0.727	1.007	53.836	8589.630	0.808	2038	0.359
ETF 5	0.005	0.675	0.946	26.943	12380.494	0.871	1828	1.203
ETF 6	0.006	1.075	0.947	52.760	25891.546	0.940	1643	4.312**
ETF 7	0.000	0.353	1.007	334.775	179155.875	0.988	2235	3.670**
ETF 8	0.008	1.503	0.968	109.010	35674.313	0.957	1622	7.112***
ETF 9	0.006	1.067	0.972	74.765	22539.748	0.938	1500	2.403*
ETF 10	0.002	0.884	0.997	112.907	53342.809	0.972	1510	0.469
ETF 11	0.002	1.160	0.998	146.014	100612.459	0.985	1510	0.705
ETF 12	0.006	0.995	0.972	67.224	24828.536	0.946	1425	1.971
ETF 13	−0.003	−0.553	1.066	101.872	36375.970	0.962	1446	20.258***
ETF 14	0.000	−0.102	1.023	140.055	23330.689	0.960	968	5.059***
ETF 15	−0.009	−1.097	1.023	54.128	5962.956	0.897	687	1.030
ETF 16	0.001	0.367	0.996	138.528	69400.965	0.980	1389	0.181
ETF 17	0.001	0.416	0.995	122.028	76093.722	0.982	1379	0.220
ETF 18	0.005	1.393	0.981	58.917	60965.456	0.978	1349	1.220
ETF 19	−0.007	−0.770	1.024	63.904	7139.349	0.906	742	1.218
ETF 20	0.001	0.260	1.025	118.900	38017.815	0.975	959	4.393**
ETF 21	0.000	−0.016	0.998	102.174	13348.341	0.941	838	0.019
ETF 22	−0.003	−0.411	0.809	70.836	8679.872	0.884	1137	144.054***
ETF 23	−0.002	−0.306	1.017	87.056	17711.487	0.943	1080	1.079
ETF 24	0.004	0.511	1.011	69.604	9610.801	0.914	906	0.496
ETF 25	0.000	−0.028	1.018	69.199	8277.106	0.901	906	0.823
ETF 26	0.002	0.232	1.003	63.230	8233.952	0.901	906	0.051
ETF 27	−0.001	−0.102	1.021	85.418	16795.738	0.949	898	2.032
ETF 28	−0.005	−1.252	1.020	87.498	18939.858	0.970	596	2.209
ETF 29	−0.002	−0.364	1.033	78.128	13227.703	0.954	644	3.414**
ETF 30	−0.002	−0.359	1.028	92.505	17422.106	0.956	807	3.814**
ETF 31	−0.013	−1.336	1.060	52.946	8236.967	0.920	719	4.470**
ETF 32	−0.002	−0.307	1.039	67.144	10518.864	0.941	660	3.309**
ETF 33	0.003	0.556	1.002	68.191	9435.567	0.959	401	0.221
ETF 34	−0.002	−0.358	1.053	72.054	4576.335	0.932	333	6.664***

This table displays α- and β-values, associated t-statistics, F-statistics, significance levels, adjusted R^2, the number of observations, and a spanning test. Significance levels are 10% = *, 5% = **, and 1% = ***.

Table 7 Time period results

	Coeff.	t-Stat.
C	0.007	4.091***
MSCI	0.980	229.784***
Period 2	−0.008	−2.854***
Period 3	−0.007	−3.417***
MSCI*Period 2	−0.005	−0.765
MSCI*Period 3	0.039	7.108***
adj. R2	0.94	
Obs.	41591	

This table displays coefficient results, associated t-statistics, F-statistics, significance levels, adjustedR^2, the number of observations, and a spanning test. Significance levels are 10% = *, 5% = **, and 1% = ***.

positive tilt (PT), thematic (THEM) and Paris aligned (PA). Combinations of different strategies are also possible. Overall, we observe 12 different strategies (combinations) for the analyzed ESG ETFs.

Table 8 illustrates strategy results for periods 1 to 3 and for the total sample. Results are based on regression specification (4). Since negative screening is omitted as the reference, α coefficients can be interpreted as performance results of this strategy type. For all periods, performance does not significantly differ from zero. MSCI β coefficients are highly significant and close to one during all periods. For the strategy coefficients, we observe only two (weakly)

Table 8 Strategy results

	Period 1		Period 2		Period 3		Total Sample	
	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.
C	0.002	0.491	0.003	0.439	0.000	0.074	0.002	0.670
MSCI	1.010***	65.223	1.009***	53.743	1.020***	160.735	1.012***	104.323
N + BIC	0.007	1.097	−0.002	−0.169	0.000	0.007	0.002	0.407
N + BIC + PA	0.011	1.433	−0.004	−0.306	−0.009	−1.590	−0.003	−0.543
N + BIC + THEM	0.014**	2.256	−0.007	−0.717	0.003	−0.843	0.002	−0.395
N + BIC + PT			−0.008	−0.741	0.002	0.345	−0.002	−0.465
N + BIC + PT + THEM			−0.016	−1.266	−0.003	−0.647	−0.007	−1.433
N + THEM	0.001	0.245	−0.002	−0.303	0.000	−0.149	−0.001	−0.285
N + THEM + PA			−0.029	−1.636	−0.002	−0.384	−0.008	−1.284
N + PT + THEM	0.000	−0.033	−0.006	−0.283	0.014	1.517	0.003	0.405
N + PT	0.014*	1.923	0.001	0.117	0.000	0.062	0.001	0.411
THEM			−0.008	−0.518	−0.001	−0.234	−0.004	−0.746
THEM + PA			−0.022	−1.073	0.000	0.013	−0.003	−0.635
MSCI * N + BIC	−0.029	−1.644	−0.042*	−1.956	−0.011	−0.724	−0.028**	−2.316
MSCI * N + BIC + PA	−0.067***	−3.208	−0.056**	−2.388	0.018	1.483	−0.027**	−2.036
MSCI * N + BIC + THEM	−0.033*	−1.811	−0.027	−1.203	0.013	1.381	−0.008	−0.671
MSCI * N + BIC + PT			−0.006	−0.240	0.011	0.965	0.011	0.892
MSCI * N + BIC + PT + THEM			0.014	0.654	−0.001	−0.068	0.008	0.540
MSCI * N + THEM	−0.010	−0.630	−0.023	−1.203	0.004	0.526	−0.011	−1.103
MSCI * N + THEM + PA			0.030	1.173	0.018	1.192	0.027	1.762
MSCI * N + PT + THEM	−0.079**	−2.102	−0.006	−0.167	−0.156***	−4.644	−0.066**	−2.093
MSCI * N + PT	−0.040**	−2.353	−0.040*	−1.656	0.019*	1.733	−0.016	−0.972
MSCI * THEM			−0.239***	−9.710	−0.074***	−4.470	−0.120**	−6.816
MSCI * THEM + PA			0.018	0.735	0.008	0.702	0.016	1.261
Adjusted R-squared	0.945		0.949		0.931		0.940	
Included observations:	8,737		11,416		21,438		41,591	

This table presents the findings from a detailed regression analysis of ESG ETFs for the defined periods, incorporating Paris Aligned (PA) strategies. The analysis evaluates the relationship of performance with different ESG strategies, including Negative Screening (NEG), Best in Class (BIC), Positive Tilt (PT), Thematic (THEM), and their combinations with PA. The table provides coefficients, t-statistics, probabilities for these strategies, and their interactions with the MSCI Europe Index. Significance levels are 10% = *, 5% = **, and 1% = ***.

significant coefficient values. This indicates that the strategy of issuers to construct an ESG product does not lead to significant performance differences between products. Strategy coefficient gaps in period 1 are due to a lower amount of ETFs. Since Paris alignment is probably the most severe way of ESG product construction, we further analyze the relation with the PA strategy in appendix B.

Interaction terms reveal that the strategy can significantly be related with the risk of an ESG ETF. Thematic investment, for example, has a significant negative relationship with the sensitivity coefficient during different periods. This shows that thematic investments are significantly negatively correlated with the risk relative to the reference. Significant negative signs can be also observed for strategy combinations where thematic investing is included.

In summary, the analysis indicates that the choice of ESG strategy does not have a significant correlation with the performance of the examined ETFs. The non-significant values have only minor economic implications. While this work does not identify a significant correlation of ESG strategies with performance, it nevertheless demonstrates that the chosen ESG strategies such as “thematic investment” can be significantly correlated with the sensitivity of ETFs to market fluctuations.

As illustrated in appendix B, results indicate that Paris-aligned strategies seem to be slightly more exposed to economic and geopolitical conditions in conditions of risk and performance.

Results of Fama and French (2015) five-factor model

Table 9 encompasses the results of the Fama and French (2015) five-factor model. To check for robustness, we also apply the Fama French (1993) three- factor model and the

Table 9 Fama and French five-factor model

Style	ETF	Alpha	t-Stat.	MKT	t-Stat.	SMB	t-Stat.	HML	t-Stat.	RMW	t-Stat.	CMA	t-Stat.	adj. R^2	Obs
	MSCI	0.000	−0.108	0.965***	30.672	−0.187***	−9.943	0.087	1.103	0.107**	2.243	−0.027	−0.241	0.955	3235
N	ETF 3	−0.005	−0.986	1.018***	42.039	−0.128***	−2.890	0.058	1.222	0.056	1.599	0.006	0.083	0.948	2035
	ETF 1	0.004	0.929	1.023***	32.308	0.064**	2.555	0.040	0.515	0.034	0.688	−0.193*	−1.751	0.911	3235
N + BIC	ETF 2	0.003	0.692	0.956***	29.952	−0.187***	−7.965	−0.007	−0.082	0.176***	3.617	−0.044	−0.381	0.902	3208
	ETF 21	−0.002	−0.333	1.003***	69.212	−0.217***	−10.363	−0.066**	−2.206	0.114***	4.318	0.139***	3.040	0.934	838
N + BIC + PA	ETF 19	0.008	1.067	1.009***	77.903	−0.085**	−2.126	−0.206***	−6.781	0.135***	4.473	0.119***	2.860	0.915	742
	ETF 15	0.000	0.002	1.044***	54.898	0.050	1.040	−0.246***	−6.333	−0.056	−1.285	0.203***	3.652	0.901	687
	ETF 4	−0.009	−1.606	1.132***	38.442	0.618***	17.795	−0.004	−0.089	−0.321***	−8.731	−0.356***	−4.974	0.885	2038
	ETF 9	0.006	1.251	0.989***	70.310	−0.104***	−3.317	−0.158***	−4.955	0.149***	6.355	0.081*	1.676	0.939	1500
	ETF 6	0.006	1.465	0.975***	51.921	−0.062**	−2.404	−0.200***	−8.552	0.040	1.473	0.146***	4.001	0.939	1643
N + BIC + THEM	ETF 13	−0.003	−0.676	1.083***	75.413	−0.066***	−3.153	−0.069***	−3.169	0.011	0.546	0.038	1.402	0.958	1446
	ETF 24	0.013**	2.186	1.002***	87.404	−0.138***	−4.039	−0.247***	−9.513	0.128***	5.479	0.202***	6.911	0.929	906
	ETF 25	0.008	1.194	1.000***	81.661	−0.159***	−4.709	−0.223***	−8.254	0.163***	6.274	0.166***	5.016	0.915	906
	ETF 26	0.011*	1.706	0.978***	79.243	−0.145***	−4.091	−0.195***	−6.284	0.149***	5.291	0.117***	3.142	0.915	906
	ETF 12	0.006	1.248	0.985***	73.949	−0.124***	−5.592	−0.168***	−6.801	0.141***	7.033	0.094**	2.357	0.949	1425
	ETF 8	0.007*	1.653	0.979***	62.770	−0.145***	−7.587	−0.177***	−8.133	0.087***	4.366	0.178***	6.084	0.947	1622
N + BIC+ PT	ETF 14	0.001	0.326	1.015***	103.851	−0.199***	−7.993	−0.048**	−2.131	0.145***	7.501	0.094***	3.075	0.947	968
N + BIC + PT + THEM	ETF 28	−0.003	−0.507	1.011***	61.150	−0.176***	−6.445	−0.063**	−2.569	0.091***	3.729	0.122***	3.322	0.956	596
N + THEM	ETF 7	0.000	−0.128	0.972***	31.165	−0.192***	−9.793	0.073	0.941	0.113**	2.407	−0.026	−0.238	0.949	3235
	ETF 23	0.003	0.787	1.034***	86.121	−0.104***	−5.119	−0.173***	−8.070	0.091***	4.471	0.158***	4.890	0.944	1080
	ETF 16	0.000	0.181	1.002***	72.112	−0.142***	−7.350	−0.061***	−3.436	0.029	1.553	0.127***	5.922	0.967	1389
	ETF 17	0.001	0.222	1.003***	66.695	−0.141***	−7.369	−0.068***	−3.940	0.035**	2.126	0.139***	5.907	0.970	1379
	ETF 10	0.001	0.414	0.998***	71.420	−0.169***	−9.358	−0.041**	−2.474	0.067***	4.066	0.100***	4.339	0.965	1510
	ETF 11	0.001	0.418	1.002***	87.220	−0.153***	−8.155	−0.046***	−3.091	0.060***	4.048	0.110***	4.950	0.973	1510
N + THEM + PA	ETF 27	0.008*	1.933	1.024***	88.590	−0.065**	−2.409	−0.196***	−8.153	0.057***	3.101	0.164***	4.865	0.949	898
	ETF 31	0.007	1.107	1.060***	71.234	0.068**	2.297	−0.254***	−9.084	0.038	1.458	0.104***	2.724	0.939	719
N + PT	ETF 18	0.005*	1.874	0.987***	45.328	−0.163***	−8.528	−0.127***	−5.836	0.072***	3.744	0.158***	6.185	0.967	1349
	ETF 20	0.001	0.443	1.045***	116.415	−0.165***	−6.879	−0.106***	−4.364	0.066***	3.239	0.187***	5.564	0.965	959
N + PT + THEM	ETF 5	0.004	0.542	0.956***	48.625	−0.145***	−5.578	0.075**	2.095	−0.083***	−2.596	0.241***	6.055	0.871	1828
THEM	ETF 34	0.009	1.331	1.053***	63.308	−0.180***	−7.436	−0.120***	−3.244	0.130***	4.833	0.165***	4.221	0.916	333
	ETF 29	0.005	1.089	1.043***	83.675	−0.047*	−1.942	−0.225***	−8.690	0.032	1.347	0.211***	6.226	0.953	644
	ETF 22	0.000	−0.013	0.843***	64.200	−0.164***	−5.912	−0.247***	−11.003	0.122***	3.938	0.302***	8.852	0.901	1137
THEM + PA	ETF 30	0.008*	1.843	1.036***	89.124	−0.054**	−2.197	−0.198***	−7.818	0.041**	2.186	0.182***	5.183	0.955	807
	ETF 32	0.006	1.100	1.034***	76.548	−0.064**	−2.244	−0.230***	−8.596	0.038	1.523	0.198***	5.544	0.944	660
	ETF 33	0.008	0.887	1.011***	51.934	−0.097***	−3.699	−0.049	−1.335	0.068**	2.529	0.090**	2.258	0.943	401

This table shows the results of the Fama and French (2015) five-factor regression of ESG ETFs and the parent index MSCI Europe on a daily basis. The table provides daily alphas, all estimated coefficients of the five Fama and French (2015) factors, t-statistics for the factors as well as adj. R^2 and number of observations. To correct for heteroscedasticity and autocorrelation, Newey and West (1987) is applied. Significance levels are 10% = *, 5% = **, and 1% = ***.

Carhart (1997) four-factor model. The results are provided in Annex C, Tables 12 and 13.

Except from single outliers, mostly found in the category N+BIC+THEM, we observe insignificant alphas. These results align with previous findings regarding research question 1, indicating no performance differences between benchmark index and ETFs. Therefore, the results also suggest no underperformance for investors when choosing such sustainable investment strategies. As expected, all beta values are close to 1. Additionally, most funds exhibit similar characteristics, which we summarize below.

The SMB factor by and large consistently negative and significant across all funds, indicating a general preference for large-cap investments, which is typical for such index ETFs. The coefficients of the HML variable are predominantly significant and negative across all funds, suggesting a tendency to invest in growth companies—an expected outcome for modern sustainable investment strategies. Regarding RMW, we observe mostly significant and positive coefficients, indicating a preference for robust and well-performing companies. Lastly, CMA is mostly significant and positive across all funds, implying a focus on conservative, well-established sustainable companies, which also aligns with our observed fund management strategies.

However, two ETFs reveal notably findings. First, ETF 4 exhibits a high and significant beta value (1.132) as well as positively and highly significant SMB coefficient. This suggests that the ETF's performance is primarily driven by smaller companies, reflecting its investment strategy. Regression results for the RMW and CMA variables are both negative and significant. One possible explanation is that investing in these small caps, which have high capital expenditures (i.e., a negative CMA value) and are therefore more growth-oriented, is associated with lower profitability (i.e., a negative RMW value).

Second, ETF 22 has a significant but relatively low positive beta coefficient (0.843), reflecting a conservative investment policy which is in line with its volatility-optimized strategy. Both the SMB and HML coefficients are negative and significant, indicating that the ETF's performance is correlated with investments in large-cap and value stocks, further supporting its conservative investment strategy (positive CMA value). Overall, the ETF's performance is correlated with firms exhibiting robust profitability (as seen in the positive RMW coefficient) and carries lower risk, as implied by its beta.

All in all, another key finding of these regressions is that different approaches to sustainability can be implemented using comparable strategies. In particular, the fund's investment style alone does not provide clear insights into the specific sustainable orientation being pursued. Thus, the ETF styles are very comparable and, in the sense of research question 3, do not have a fundamentally negative (or positive) effect on ETF performance. It is interesting to note that the product strategies of ESG ETFs appear to vary greatly, yet the fund style (Table 9) and performance of the strategies (Table 8) are very similar.

Conclusion

In this study, we examine the financial performance of 34 ESG ETFs in Europe from 2015 to 2024 and additionally consider far-reaching socio-economic and geopolitical events. Since the EU decided to become the leader in the transition to a sustainable economy and following Le Sourd und Safaee (2021), we analyze Europe's index market, represented by the leading index MSCI Europe. The ETF selection process relies on two main criteria: first, the MSCI Europe represents the parent index, and second, products are traded on XETRA, Europe's leading electronic trading platform. Performance is measured by the Sharpe (1963) index model and the Fama and French (2015) five-factor model. Additionally, we investigate the linkage of socio-economic and geopolitical crises, as well as the choice of ESG strategy, with ETF returns. The three research questions are addressed in the following.

Research question 1 Are there significant performance differences between ESG ETFs and their non-sustainable benchmark indices for the total sample?

For the total sample, the analysis of the Sharpe (1963) index model reveals, that ESG ETFs provide no significant performance differences relative to the MSCI Europe. Generally, ESG ETFs closely replicate their parent index, as spanning-test results show. The results of the Fama and French (2015) five-factor model also qualitatively confirm this finding, as they indicate no significant negative performance between the European benchmark index and ETFs. However, some isolated ETFs even exhibit a positive and slightly significant alpha value. Consequently, both results suggest that investors do not face major performance disadvantages when choosing sustainable investment strategies.

Research question 2 Does the performance of ESG ETFs differ during crisis events such as the COVID-19 pandemic

or the Ukrainian war in comparison to their non-sustainable parent index?

To address research question 2, we split the analysis into different time-periods. period 1, starting from the Paris Climate Agreement until the declaration of the pandemic in March 2020, only positive alpha coefficients can be observed for ESG ETFs. Altogether, 7 out of 16 ESG ETFs show a significant outperformance relative to the MSCI Europe. Unlike Nofsinger and Varma (2014), who observe an outperformance for sustainable mutual funds in times of geopolitical crisis, ESG ETFs tend to underperform the non-sustainable benchmark during the COVID-19 pandemic (period 2). Also time period results (Table 7) show a significant underperformance during period 2. Results qualitatively confirm by individual ESG ETF results (Table 4), where considerably decreasing alpha coefficients can be observed. In times of geopolitical unrest, particularly during the Russian-Ukrainian war in period 3, an underperformance of ESG ETFs is further intensified. Regarding the sensitivity of ESG ETFs, sustainable products seem to be riskier than the MSCI Europe during period 3. Time period results as illustrated in Table 7 qualitatively confirm individual ESG ETF results (Table 5). Overall, a significant underperformance is observed for period 2 and 3, together with a highly significant increase in risk during period 3.

Research question 3 What impact does ESG strategy have on ETF performance?

To address research question 3, the relation of ESG strategies with performance and risk is captured for the total sample as well as for periods 1 to 3. For the total sample, it is interesting to observe, that different strategies provide no ongoing significant over- or underperformance. This finding is also strengthened by the Fama and French (2015) five-factor model regressions, which show the strategies are largely comparable from a performance perspective.

Regarding the various subperiods, we do not observe ongoing significant over- or underperformance for period 1 to 3 results from the Sharpe (1963) model. However, the sensitivity of ESG ETFs is considerably associated with the selected strategies. We find significantly lower sensitivities to market fluctuations for the strategies "Negative + Best in Class," "Negative + Best in Class + Paris," "Negative + Positive Tilt + Thematic," and "Thematic."

In summary, this study provides valuable insights for ethically oriented investors. However, there are also limitations to be noted. One is the is its explicit focus on European data. Furthermore, the question arises as to why one should invest in products that perform worse than their benchmark index. To address the first aspect, one could compare the performance of sustainable ETFs worldwide, but to the disadvantage of a different understanding of sustainability. The introduction of the Taxonomy Regulation provides a unique opportunity to conduct a comprehensive study of the European ETF market that complies with this strict definition, as we have chosen to focus exclusively on products that meet the criteria set out in Articles 8 and 9 of the SFDR. To answer the question of why one should invest in ESG products despite their potential underperformance, we refer to Pástor et al. (2021). Based on their equilibrium model, the authors conclude that the expected returns on green assets are low because "investors enjoy holding them". A second argument concerns hedging opportunities for climate risks. The observed lower performance therefore reflects a rational trade-off between return, hedging and sustainability preferences. However, the authors observe an outperformance of green assets in the event of positive shocks to the ESG factor. In line with this, we observe an outperformance of ESG ETFs during period 1, when enthusiasm for sustainability started.

In conclusion, this study offers valuable insights for ethical investors. Although the analyzed ESG ETFs predominantly mirror the performance of the non-sustainable benchmark, they tend to be more volatile in times of crisis events such as the Russian-Ukraine conflict. This is important information, especially for risk-averse investors. Also, the performance of ESG ETFs is negatively affected in times of geopolitical turmoil. Regarding the ESG strategies, no significant correlation with over- or underperformance can be observed. However, certain strategies such as "thematic investment" exhibit a lower market sensitivity relative to the benchmark, which might appeal to risk-averse investors. Overall, this study underscores the need for investors to carefully balance their ethical considerations with their risk tolerance and return expectations, especially in times of geopolitical turmoil.

Appendix A

See Table 10.

Table 10 Sharpe index model results (sample from 01.01.2012 to 14.12.2015)

ETF	Alpha	t-Stat.	Beta	t-Stat.	F-Stat.	adj. R^2	Obs.	Spanning test
								H_0: ß=1 and α =0
								F-Stat.
ETF 1	0.014**	2.244	0.953***	60.000	12332.578	0.925	1000	5.309***
ETF 2	0.004	0.502	0.984***	77.848	9590.489	0.908	973	0.903
ETF 7	0.000	−0.230	0.996***	255.415	82716.262	0.988	1000	0.497

This table displays α- and β-values, associated t-statistics, F-statistics, significance levels, adjusted R^2, the number of observations, and a spanning test. Significance levels are 10% = *, 5% = **, and 1% = ***.

Appendix B

A strategy denoted as "Paris-aligned" has to follow a clearly defined procedure for the reduction of greenhouse gas emissions. Since Paris alignment is probably the most severe way of ESG product construction, we further analyze the linkage of the PA strategy with risk and return characteristics, which is crucial for investors seeking to align their portfolios with climate goals. Hence, we examine whether strategies that include PA exhibit distinct performance characteristics compared to their non-Paris aligned counterparts. This is especially relevant in the context of increasing regulatory requirements and risk and performance characteristics of sustainable investments.

We apply a regression analysis, separating the ETFs into two groups based on their strategy inclusion of PA. The non-Paris aligned strategy serves as the reference category. The regression specification is employed as follows:

$$R_{i,t} = \alpha_{nonPA} + \beta_{nonPA} * R_{MSCI,t} + \beta_{1PA} * ESG\ Strategies_{PA} + \beta_{2PA} * R_{MSCI,t} * ESG\ Strategies_{PA} + \varepsilon_{i,t} \quad (8)$$

The constant term α_{nonPA} includes the performance of non-Paris-aligned strategies and β_{nonPA} the risk of non-Paris-aligned strategies. The performance of Paris-aligned strategies is captured by coefficient β_{1PA}, while the interaction term coefficient β_{2PA} captures the variable effect (risk) of Paris-aligned strategies. Coefficient $\epsilon_{i,t}$ represents error terms of ETF i at time t. To correct for heteroscedasticity and autocorrelation, Newey and West (1987) is applied.

Results are illustrated in Table 11. During period 1, the Paris-aligned strategies reveal a positive but insignificant outperformance relative to the reference. Interaction terms show that the risk is significantly below the reference. However, signs change to negative performance coefficients in times of economic turmoil. During period 3, a significant underperformance can be observed for strategies that include PA. Also, risk significantly increases relative to the reference in times of economic turmoil, as captured by the interaction term coefficient in period 3. Overall, the Paris-aligned strategies seem to be slightly more exposed to economic and geopolitical conditions in the context of risk and performance.

Table 11 Paris aligned strategies results

	Period 1		Period 2		Period 3		Total sample	
	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.	Coeff.	t-Stat.
C	0.005**	2.537	−0.001	−0.483	−0.003	−1.347	0.000	−0.113
MSCI	0.988***	191.426	0.978***	184.372	1.010***	208.567	0.990***	288.294
PA	0.007	1.026	−0.006	−0.611	−0.009**	−2.067	−0.005	−1.438
MSCI*PA	−0.045***	−3.107	−0.016	−1.154	0.026***	2.851	0.004	0.446
Adjusted R-squared	0.943		0.947		0.934		0.942	
Included observations:	8,737		11,416		12,799		32,952	

This table presents the results of the regression analysis conducted to evaluate the relationship of the Paris alignment strategies (PA) with the performance of ESG ETFs across three distinct periods and the total sample. For each period, the table includes coefficients, t-statistics, and probabilities for the constant (C), the MSCI Europe Index (MSCI), the Paris Alignment variable (PA), and the interaction of MSCI and Paris Alignment (MSCI*PA). The table also shows adjusted R-squared values and the number of included observations for each period. Significance levels are 10% = *, 5% = **, and 1% = ***.

Appendix C

We apply the well-known three-factor regression model developed by Fama and French (1993), which comprises the three stock market factors excess market return $(R_{Mt} - R_{Ft})$, size (SMB), and book-to-market ratio (HML):

$$R_{it} - R_{Ft} = a_i + b_i\,(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + e_{it} \quad (9)$$

We also apply the well-known Carhart (1997) four-factor regression, which extends the Fama and French (1993) three-factor model by the one-year momentum (MOM):

$$R_{it} - R_{Ft} = a_i + b_i\,(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + m_i MOM_t + e_{it} \quad (10)$$

Tables 12 and 13 results qualitatively confirm a and b results of the Fama and French (2015) five-factor model as illustrated in Table 9.

Table 12 Fama and French (1993) three-factor model

Style	ETF	Alpha	t-Stat.	MKT	t-Stat.	SMB	t-Stat.	HML	t-Stat.	adj. R^2	Obs
	MSCI	0.000	−0.054	0.985***	41.364	−0.104***	−6.150	0.054***	6.223	0.953	3235
N	ETF 3	−0.005	−0.939	1.026***	51.625	−0.077***	−3.571	0.050***	4.965	0.947	2035
	ETF 1	0.005	0.940	1.028***	40.636	0.026	1.365	−0.076***	−6.072	0.909	3235
N + BIC	ETF 2	0.004	0.735	0.989***	39.582	−0.053**	−2.474	−0.055***	−4.123	0.897	3208
	ETF 21	−0.001	−0.109	0.999***	75.762	−0.085***	−4.444	−0.010	−0.985	0.927	838
N + BIC + PA	ETF 19	0.013	1.626	1.005***	77.975	0.058**	2.306	−0.152***	−10.886	0.908	742
	ETF 15	0.003	0.300	1.012***	64.409	0.066**	2.531	−0.124***	−6.162	0.898	687
	ETF 4	−0.010	−1.401	1.103***	41.244	0.264***	9.674	−0.167***	−5.013	0.845	2038
	ETF 9	0.007	1.365	0.998***	78.630	0.017	0.942	−0.122***	−9.717	0.933	1500
	ETF 6	0.007	1.484	0.970***	51.008	0.005	0.339	−0.118***	−9.086	0.936	1643
N + BIC + THEM	ETF 13	−0.003	−0.485	1.082***	87.596	−0.046**	−2.313	−0.052***	−4.598	0.958	1446
	ETF 24	0.018**	2.445	0.985***	88.906	0.022	1.027	−0.148***	−12.764	0.916	906
	ETF 25	0.014*	1.738	0.990***	74.664	0.017	0.679	−0.149***	−11.941	0.902	906
	ETF 26	0.016**	2.097	0.974***	77.848	0.005	0.215	−0.147***	−11.394	0.906	906
	ETF 12	0.007	1.252	0.992***	82.050	−0.001	−0.072	−0.127***	−12.337	0.943	1425
	ETF 8	0.008*	1.824	0.978***	63.102	−0.033*	−1.746	−0.085***	−7.885	0.941	1622
N + BIC+ PT	ETF 14	0.005	0.905	1.012***	92.593	−0.057***	−3.314	−0.016	−1.609	0.938	968
N + BIC + PT + THEM	ETF 28	0.003	0.513	1.004***	73.723	−0.061***	−2.723	−0.012	−1.098	0.951	596
N + THEM	ETF 7	0.000	−0.072	0.993***	42.280	−0.104***	−6.026	0.039***	4.267	0.946	3235
	ETF 23	0.004	0.813	1.022***	96.240	0.011	0.644	−0.096***	−10.168	0.937	1080
	ETF 16	0.000	0.144	0.996***	73.265	−0.085***	−4.493	0.003	0.245	0.965	1389
	ETF 17	0.001	0.161	0.998***	70.172	−0.077***	−4.887	0.003	0.303	0.967	1379
	ETF 10	0.002	0.590	0.999***	71.440	−0.091***	−4.990	0.004	0.409	0.962	1510
	ETF 11	0.002	0.522	1.001***	79.506	−0.078***	−4.605	0.007	0.769	0.970	1510
N + THEM + PA	ETF 27	0.012**	2.149	1.008***	90.702	0.028	1.607	−0.109***	−10.994	0.944	898
	ETF 31	0.010	1.428	1.048***	83.533	0.125***	5.585	−0.192***	−12.863	0.937	719
N + PT	ETF 18	0.005	1.461	0.984***	45.094	−0.067***	−3.316	−0.048***	−4.051	0.962	1349
	ETF 20	0.001	0.359	1.031***	122.021	−0.059***	−3.711	−0.012*	−1.756	0.958	959
N + PT + THEM	ETF 5	0.003	0.345	0.932***	53.818	−0.139***	−5.455	0.216***	9.462	0.868	1828
THEM	ETF 34	0.007	0.758	1.041***	55.015	−0.052*	−1.823	−0.015	−0.415	0.901	333
	ETF 29	0.010	1.549	1.019***	87.530	0.041**	2.289	−0.106***	−7.718	0.945	644
	ETF 22	−0.001	−0.096	0.820***	69.445	0.007	0.378	−0.088***	−7.356	0.874	1137
THEM + PA	ETF 30	0.012**	2.126	1.017***	94.682	0.034**	2.141	−0.099***	−9.315	0.950	807
	ETF 32	0.009	1.510	1.011***	75.786	0.024	1.024	−0.121***	−8.400	0.937	660
	ETF 33	0.008	1.272	1.003***	56.536	−0.023	−0.868	−0.003	−0.169	0.939	401

This table shows the results of the Fama and French (1993) three-factor regression of ESG ETFs and the parent index MSCI Europe on a daily basis. The table provides daily alphas, all estimated coefficients of the three Fama and French (1993) factors, t-statistics for the factors as well as adj. R^2 and number of observations. To correct for heteroscedasticity and autocorrelation, Newey and West (1987) is applied. Significance levels are 10% = *, 5% = **, and 1% = ***.

Table 13 Carhart (1997) four-factor model

Style	ETF	Alpha	t-Stat.	MKT	t-Stat.	SMB	t-Stat.	HML	t-Stat.	MOM	t-Stat.	adj. R^2	Obs
	MSCI	−0.002	−0.434	0.984***	41.336	−0.138***	−7.395	0.054***	6.113	0.040***	8.077	0.954	3235
N	ETF 3	−0.006*	−1.731	1.028***	48.298	−0.100***	−5.482	0.050***	4.532	0.031***	4.434	0.948	2035
	ETF 1	0.005	0.970	1.028***	40.636	0.026	1.147	−0.076***	−5.729	0.001	0.056	0.909	3235
N + BIC	ETF 2	0.002	0.386	0.987***	39.576	−0.096***	−4.161	−0.054***	−3.848	0.052***	5.639	0.899	3208
	ETF 21	−0.003	−0.503	1.008***	72.154	−0.118***	−5.794	−0.009	−0.866	0.046***	4.677	0.929	838
N + BIC + PA	ETF 19	0.011	1.503	1.014***	79.614	0.031	1.177	−0.187***	−11.788	0.069***	4.586	0.911	742
	ETF 15	0.003	0.460	1.005***	71.408	0.076**	2.480	−0.099***	−4.389	−0.038**	−1.996	0.899	687
	ETF 4	−0.001	−0.218	1.088***	51.602	0.422***	12.947	−0.166***	−6.075	−0.219***	−10.329	0.872	2038
	ETF 9	0.006	1.139	1.001***	70.970	−0.001	−0.061	−0.121***	−8.375	0.027*	1.814	0.934	1500
	ETF 6	0.006	1.331	0.971***	48.459	−0.005	−0.280	−0.118***	−8.642	0.013	1.076	0.936	1643
N + BIC + THEM	ETF 13	−0.002	−0.293	1.078***	81.866	−0.025	−1.358	−0.054***	−5.045	−0.030***	−3.249	0.959	1446
	ETF 24	0.016***	2.611	0.988***	96.330	−0.007	−0.256	−0.179***	−11.716	0.067***	5.170	0.919	906
	ETF 25	0.012	1.492	0.993***	83.018	−0.014	−0.509	−0.183***	−12.933	0.073***	5.014	0.905	906
	ETF 26	0.014*	1.915	0.976***	81.783	−0.017	−0.673	−0.171***	−12.664	0.051***	3.679	0.907	906
	ETF 12	0.005	0.868	0.997***	71.616	−0.032*	−1.662	−0.125***	−9.940	0.043***	3.489	0.944	1425
	ETF 8	0.006	1.323	0.983***	56.719	−0.069***	−3.453	−0.083***	−6.680	0.051***	5.844	0.943	1622
N + BIC+ PT	ETF 14	0.003	0.662	1.015***	103.274	−0.089***	−4.002	−0.040***	−3.479	0.064***	5.763	0.941	968
N + BIC + PT + THEM	ETF 28	0.002	0.389	1.010***	71.106	−0.083***	−3.648	−0.039***	−3.181	0.054***	4.733	0.953	596
N + THEM	ETF 7	−0.002	−0.418	0.992***	42.100	−0.135***	−6.902	0.040***	4.080	0.038***	6.547	0.947	3235
	ETF 23	0.003	0.519	1.028***	93.635	−0.015	−0.837	−0.099***	−8.161	0.042***	3.825	0.939	1080
	ETF 16	0.000	−0.051	0.998***	72.049	−0.094***	−4.898	0.003	0.304	0.012*	1.799	0.965	1389
	ETF 17	0.000	−0.007	0.999***	68.075	−0.085***	−5.063	0.004	0.361	0.012	1.517	0.967	1379
	ETF 10	0.000	−0.140	1.005***	66.789	−0.120***	−6.555	0.006	0.586	0.043***	7.197	0.963	1510
	ETF 11	0.000	−0.042	1.006***	75.277	−0.105***	−6.531	0.008	0.916	0.039***	6.905	0.971	1510
N + THEM + PA	ETF 27	0.010**	2.176	1.010***	92.394	0.011	0.553	−0.129***	−10.251	0.042***	4.091	0.945	898
	ETF 31	0.010	1.330	1.047***	77.246	0.126***	5.521	−0.191***	−13.181	−0.003	−0.234	0.937	719
N + PT	ETF 18	0.003	0.927	0.988***	41.878	−0.096***	−5.000	−0.046***	−3.588	0.041***	5.016	0.963	1349
	ETF 20	0.000	0.067	1.037***	120.290	−0.076***	−4.262	−0.012	−1.481	0.026***	3.485	0.959	959
N + PT + THEM	ETF 5	0.005	0.711	0.928***	55.982	−0.093***	−3.816	0.215***	11.658	−0.063***	−4.531	0.870	1828
THEM	ETF 34	0.003	0.364	1.041***	51.014	−0.086***	−3.224	−0.063*	−1.939	0.124***	6.261	0.911	333
	ETF 29	0.009*	1.685	1.032***	90.278	0.029*	1.649	−0.148***	−9.306	0.058***	5.156	0.948	644
	ETF 22	−0.002	−0.309	0.829***	68.130	−0.022	−1.117	−0.086***	−7.309	0.041***	4.011	0.877	1137
THEM + PA	ETF 30	0.011**	2.103	1.021***	97.130	0.018	1.116	−0.118***	−9.382	0.039***	3.890	0.951	807
	ETF 32	0.008	1.499	1.023***	86.703	0.012	0.498	−0.160***	−9.248	0.056***	4.810	0.939	660
	ETF 33	0.007	1.062	1.001***	56.662	−0.041	−1.464	−0.025	−1.450	0.062***	3.714	0.941	401

This table shows the results of the Carhart (1997) four-factor regression of ESG ETFs and the parent index MSCI Europe on a daily basis. The table provides daily alphas, all estimated coefficients of the four Carhart (1997) factors, t-statistics for the factors as well as adj. R^2 and number of observations. To correct for heteroscedasticity and autocorrelation, Newey and West (1987) is applied. Significance levels are 10% = *, 5% = **, and 1% = ***.

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