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To what extent do Article 8 funds demonstrate a superior sustainability performance compared to index funds, and is there evidence of greenwashing in the Article 8 fund market?

Master Thesis

by

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Supervisor: Paul Ehling

Abstract

This master's thesis examines the sustainability performance of Article 8 funds under the EU's Sustainable Finance Disclosure Regulation (SFDR). By analyzing a comprehensive dataset acquired from Morningstar's database from May 2020 to February 2023 and utilizing panel regression analysis, we scrutinize whether these funds outperform conventional index funds in sustainability metrics. The results reveal that Article 8 funds consistently yield superior sustainability ratings, underscoring the SFDR regulation's efficacy in enhancing transparency and mitigating potential greenwashing. This is in stark contrast to previous studies suggesting ambiguities in SFDR categories. Moreover, an emerging positive correlation between sustainability ratings and financial returns from December 2021 indicates that sustainable investing is increasingly rewarding. Our findings provide valuable insights into the sustainable finance landscape, demonstrating the pivotal role of SFDR in promoting sustainability and transparency in funds.

Master of Science in Business - Major in Sustainable Finance

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Contents

1. Introduction

Sustainable development has become a key priority for governments, businesses, and investors around the world. As the impacts of climate change, environmental degradation, social inequalities, and governance issues become increasingly evident, there is a growing recognition that we must transition to a low-carbon, resource-efficient, and equitable economy to protect the planet and ensure a prosperous future for all. One way the financial sector can support this transition is by providing funding for projects that contribute to environmental protection, social cohesion, and good governance practices. Sustainable investing, also known as socially responsible investing (SRI), has gained significant attention in recent years as more investors seek to align their investment decisions with their values. Many investors view sustainable investing as a holistic approach that addresses global challenges such as climate change, inequality, and responsible corporate behavior.

In this context, this master's thesis studies the sustainability performance of Article 8 funds, financial instruments designed by the European Union regulation to finance environmental, social and governance (ESG)-responsible projects, compared to general index funds. Our investigation relies on a comprehensive dataset of sustainability metrics and employs panel regression analysis and Wilcoxon test, amongst other statistical techniques, to compare these funds. Our primary research question is: "To what extent do Article 8 funds demonstrate superior sustainability performance compared to index funds, and is there evidence of greenwashing in the Article 8 fund market?" To answer this, we first investigate the factors that influence both fund types' sustainability ratings, then compare their relative performance over a specific period. The results of our study reveal that Article 8 funds consistently outperform index funds in terms of sustainability performance. Importantly, this finding remains significant after controlling for a range of influential factors. This outcome suggests that the SFDR regulation effectively promotes transparency in sustainability claims, thereby mitigating the risk of greenwashing. Furthermore, our research uncovers an emerging trend: a positive correlation between sustainability ratings and financial returns, particularly evident from December 2021 onwards. This finding indicates that sustainable investing is increasingly translating into financial rewards, reflecting a welcome shift from the previously observed disconnect between sustainability and financial performance. In conclusion, our research offers valuable insights into the effectiveness of Article 8 funds and the role of regulations like SFDR in sustainable finance. As the momentum for sustainable investment grows, our findings will be instrumental in guiding

this journey, assisting investors, policymakers, and regulators in their decisions.

1.1 Background and Context

The growing awareness of global challenges, such as climate change, environmental decline, social disparities, and governance issues has underscored the need for ESG-focused advancement. Both active and passive investors have demonstrated a strong interest in funds that adopt ESG-friendly investing strategies. This, in turn, has led to a substantial influx of capital into these funds, significantly increasing their cash inflows. This is evident in the research done by Becker et. al., where the results show that on the fund level, "the intervention (announcement of the SFDR) so far achieved its purpose of moving capital into more sustainable investments" (Becker et. al., 2022). The authors further elaborated on their findings, that "funds with classifications indicating a more advanced level sustainability integration experience significantly higher net fund flows after the public disclosure of fund labels". These findings have a direct impact on practitioners and investors. First, asset managers should increase their sustainability efforts due to investors investing more in Article 8 and Article 9 funds. Second, the risk of ESG overvaluation could be more prominent after introducing such labels.

On November 27th, 2019, the EU adopted the Sustainable Finance Disclosure Regulation as part of its broader efforts to promote sustainable finance and support the transition to a low-carbon, sustainable, and inclusive economy. The SFDR establishes a framework for disclosing information on the sustainability risks and impacts of financial products and the sustainability-related objectives of financial institutions and investment funds. The regulation aims to enhance transparency, enable investors to make informed decisions about the sustainability of financial products and encourage financial institutions and investment funds to integrate sustainability considerations into their investment processes.

The SFDR consists of 20 guiding articles, with Articles 6, 8, and 9 being particularly relevant to our study. Article 6 requires financial market participants to disclose how they consider sustainability risks in their investment decisions and provide information about the potential impacts of these risks on the returns of the financial products they offer. Article 8 refers to financial products that promote environmental, social, and governance causes, while Article 9 focuses on financial products that have sustainable investment as their primary objective. According to Article 6 of the SFDR, all funds are required to report some ESG information. However, Article 8 funds, also known as "light green" or general ESG funds, must provide more extensive ESG reporting, and Article 9 funds, or "dark green" funds, have an even higher level of

ESG reporting and commitment to sustainable investment objectives (The European Parliament And The Council Of The European Union, 2019).

In response to the significant increase in cash inflows to ESG-oriented funds, many general funds have undergone restructuring to align with the requirements of Article 8 funds, aiming to capitalize on the prevailing trend and attract additional capital by catering to the growing demand for sustainable investments. However, some critics argue that these funds may be more focused on generating financial returns than promoting comprehensive sustainable development. This raises concerns about potential greenwashing and the effectiveness of these funds as tools for driving sustainable growth.

Furthermore, we find it important to utilize available and relevant competence, in order to get a holistic view of our topic of interest. Accordingly, we were fortunate to get inspiration from Lars Qvigstad Sørensen, Senior Portfolio Manager at Storebrand Asset Management. After being in dialogue with Dr. Sørensen where we discussed possible topics for a master thesis, the level of sustainability of article 8 and 9 funds was brought up. Dr. Sørensens suggestion was to look at fund holdings for articles 8 and 9 funds, and then create a "portfolio" consisting of all funds in each category. Furthermore, one could equal-weight this portfolio and see what properties it had. He continues to state that to him, "It is obviously interesting to look at what articles 8 and 9 funds are investing in. SFDR categories drive flows, and it is important to prevent greenwashing; that funds call themselves article 9, but do not invest sustainably".

2. Literature Review

As concerns about the environmental and social impacts of the economy continue to intensify, it is crucial to understand the efficacy of various investment approaches in attaining their stated objectives. One relevant investment approach is Article 8 funds, which are expected to have a greener impact than for instance general indices without any sustainability objective. However, the existing research on these funds primarily focuses on their financial performance, rather than their ESG impact. Therefore, this literature review aims to bridge this gap by investigating the available literature on the ESG impact of Article 8 funds and their alignment with their intended objectives, in comparison to a control group without sustainability goals. Moreover, our review purpose is to contribute to the research on Article 8 funds by conducting new analyses. By examining the current state of knowledge on this topic, identifying gaps, and proposing areas for future research, this review seeks to enhance our understanding of the performance of Article 8 funds in achieving their sustainability and responsible investing goals. This study is

especially relevant given the growing demand for sustainable investments and the increasing importance of ESG considerations in investment decisions.

This literature review intends to provide a deeper understanding of the latter, by identifying relevant literature. It is based on systematic research of academic databases including the Web of Science, the Social Science Research Network (SSNR), and Google Scholar. We explored various combinations of keywords, such as "Article 8 funds," "SFDR," "Sustainability of SFDR funds," "ESG," "Sustainable Finance," and others. Our focus was on articles that incorporated one or more of these keywords, were published in 2019 or later, and specifically discussed the sustainability aspects of Article 8 funds rather than merely examining their financial performance in relation to their sustainable investment strategy. We primarily found three articles that satisfied our selection criteria.

The first article, titled "Sustainable Finance Disclosure Regulation (SFDR) effective in shaping sustainability objectives? An analysis of investment funds' behavior" (Cremasco et al., 2022), has the authors stating that their objective is to "analyse how European investment funds are incentivized to behave according to their sustainability claims." Their goal is to explore the extent to which European investment funds align their actions with their stated sustainability objectives. In their findings, they argue that despite the introduction of the SFDR, there is still confusion and uncertainty about the different categories of sustainable investment funds, namely Article 6 and Article 9 Funds. They conducted a study and found that both Article 6 and Article 9, which are supposed to represent different sustainability levels, do not differ much in terms of internal structures and incentives. Furthermore, they find that despite the apparent categorization, the managers of both funds prioritize portfolios with similar financial and sustainability performance, rendering the distinction between the two categories less meaningful, as financial performance takes priority over sustainability goals. Finally, the authors conclude that the financial market's ambiguity about sustainability categories raises concerns about greenwashing practices. They find that funds that add terms such as "sustainable", "esg", and etc. to their denominations, often behave similarly to for-profit funds, potentially masking their lack of sustainability achievement. This suggests that the SFDR may not effectively ensure transparency in sustainability claims, and it is our intention to investigate this issue further.

Titled "The Impact of Impact Funds - A Global Analysis of Funds With Impact-Claim", the second article by Scheitza et. al. (2022) explores the field of impact investing, which specifically aims to contribute to positive change. The authors investigate whether this impact claim is justified, by analyzing 185 impact funds using an established classification scheme that outlines the requirements for factual impact invest-

ing. The analysis draws on up-to-date data from Refinitiv's global fund database, employing a keyword search that includes the term "impact" while excluding funds where the term is interpreted financially. The funds analyzed are domiciled in Europe (65%) and North America (24%) and include public equity investments, fixed income, and private equity investments. The findings reveal that only one-third of the impact funds and Article 9 funds meet the outlined impact requirements (Scheitza et. al., 2022). These discrepancies raise concerns of potential greenwashing to some extent.

The third article by Rannou et. al. (2022), titled "How green are SRI labeled funds? Insights from a Machine Learning based clustering approach", differentiates European Socially Responsible Investment (SRI) labeled funds in terms of greenness. The authors employ a clustering approach based on a set of widely used environmental performance metrics to achieve this differentiation. Specifically, the paper examines the portfolios of European funds that hold the French SRI label at a stock level to evaluate their greenness. Their findings of the study indicate significant discrepancies between SFDR categories and their expected degree of greenness, raising concerns about greenwashing (Rannou et. al., 2022).

With respect to our research question, its relevance, and the recency of the matter, we expected to experience difficulties when conducting our literature review, mainly due to the limited amount of research conducted in the field. The aforementioned three articles have been especially relevant and valuable in informing our research on this subject. Nonetheless, our study will employ a distinct methodology, enabling us to explore the topic from a fresh and unique perspective.

We are well aware of the limitations of the research universe related to our subject. This is due to its originality and the limited amount of research done on the topic. Additionally, the existing research is relatively recent and has not yet been expanded upon or reproduced by other researchers. Nevertheless, as we are investigating a current trending issue in financial markets, the available findings align well with our expectations regarding the volume of research on the subject. Considering the constraints of the available literature and research, it is crucial that we apply a rigorous analytical approach when evaluating the information and establishing the foundation for our master's thesis. The importance of the transition to a sustainable economy cannot be stressed enough, and in order to contribute to the matter, transparent tools and regulations need to be in place. With this in mind, our goal is to provide an additional study that assesses the extent to which "green labeled" funds are truly green. In conclusion, our study seeks to contribute to the literature discussed in this review by examining the extent to which Article 8 funds differ in sustainability compared to general index funds. Through this investigation, we aim to offer perspective on the effectiveness of these types of investments in achieving their sustainability goals and contribute

to the ongoing discussion surrounding sustainable finance. The results of our study have the potential to inform investors, policymakers, and other relevant stakeholders, and advance the understanding of sustainable investment practices in the financial market.

3. Data and Methodology

In our master's thesis, we sought to comprehensively explore the drivers of sustainability ratings and the performance of Article 8 and 9 funds, as well as index funds. We divided our methodology into two parts, employing diverse statistical techniques for in-depth analysis.

In part one, our data comprised around 4500 Article 8 and 9 funds and 72 index funds, sourced from Morningstar's database through BI Norwegian Business School's access. By gathering data from a well-respected and widely used database such as Morningstar, we aimed to ensure the reliability and credibility of our data sources. This broad spectrum allowed us to understand what drives sustainability ratings in these funds. We selected key metrics, including Portfolio Environmental, Social, and Governance Scores, Carbon Intensity, Emission Scopes 1 and 2, Percent of Female Executives and Directors representation, and Water Withdrawal Intensity Average. Using linear regression analysis, we explored the correlation between these metrics and the sustainability ratings. Further, we checked for multicollinearity through VIF analysis and inspected residual plots to ensure the robustness of our findings. In the case of index funds, our focus was on Exchange-Traded Funds (ETFs) as they replicate the performance of underlying indexes. We deliberately excluded ESG-focused ETFs to maintain the focus on general index funds. We extracted relevant metrics from Morningstar for these ETFs, applying the same analytical process as for Article 8 and 9 funds. This methodology consistency enabled us to perform a comprehensive comparison of sustainability performance across fund types. Finally, we compared the sustainability ratings of Article 8 and 9 funds with index funds using summary statistics and the Wilcoxon rank-sum test. This non-parametric test allowed for robust comparison given our large sample size for Article 8 and 9 funds and smaller sample for index funds. Visualization of the data was achieved through box plots, emphasizing the disparities in sustainability performance between the groups. Our methodology provided a solid foundation for our investigation, ensuring that the conclusions drawn were well-supported by the evidence.

Our subsequent analysis focused on a time series examination of sustainability ratings for Article 8 and index funds, constituting our primary research focus. We placed particular emphasis on Article 8 funds

due to their tendency to adopt the ”sustainable” label, a potential pitfall for misleading investors. The broader nature of Article 8 funds may allow for a wider range of interpretations and potentially ambiguous claims. Relative to Article 9 funds, Article 8 funds have less stringent reporting requirements, a factor that could potentially obscure the true sustainability performance of these funds. With data from April 2020 to January 2023, we aimed to scrutinize the sustainability rating development for these funds. We used a sample of 97 Article 8 funds and 72 index funds for our analysis. We utilized panel regression in our analysis to study the relationship between the sustainability ratings of Article 8 and index funds over time. We employed a Linear Mixed-Effects Model (LMM) to handle both fixed and random effects, accounting for variations between individual funds and over different time periods. By treating *Date* as a fixed effect, we accounted for time-specific, unobserved factors. Descriptive statistics were calculated to offer a snapshot of sustainability ratings for both types of funds, which aided in evaluating our hypothesis that Article 8 funds are potentially more sustainable than index funds.

Several control variables were incorporated into our model to account for potential influencing factors on sustainability ratings, like average market cap, fund size, historical drawdown, monthly return, price-to-book (P/B) ratio, and return on equity (ROE). We ensured no multicollinearity among these variables before including them in our model. Addressing the challenge of autocorrelation, we used three strategies: incorporating Time as a Fixed Effect, including a Lagged Variable, and a combination of both. After applying these methods, we identified the most suitable model by performing a residual analysis.

We refined our study period from December 2021 to February 2023, which showed a stabilization in the negative trend of sustainability ratings.

The refined analysis confirmed a statistically significant performance difference between Article 8 and index funds in terms of sustainability ratings, even after controlling for other variables and managing autocorrelation.

We also used visualizations like box plots, line graphs, and residual plots to better understand the differences in sustainability ratings between the two types of funds. Ultimately, our meticulous approach allowed us to effectively examine the performance of Article 8 and index funds in terms of sustainability, underscoring the importance of considering sustainability ratings in investment decisions and regulatory oversight.

3.1 Understanding Morningstar

The Morningstar Sustainability rating is determined through a five-step process. It begins by identifying portfolio holdings exposed to ESG risks and assessing them based on corporate or sovereign risk ratings frameworks. Next, scores are derived for corporate and sovereign sustainability within the trailing 12 months, leading to historical scores. Ratings are assigned based on these historical scores relative to the Morningstar Global Category. The final Morningstar Sustainability rating is obtained by combining the Corporate and Sovereign Ratings proportionally and rounding to the nearest whole number. Our focus relies in step two with the Portfolio Corporate Sustainability Score, which is an asset-weighted average of Sustainalytics' company-level ESG Risk Rating. The scores are rendered on an open-ended scale, where lower scores are better and display a lower ESG-risk (see Figure 1 below).

Figure 1

(Source: sustainalytics.com/esg-data)

At least 67% of assets in the portfolio holdings identified as corporate ESG risk need to have company ESG Risk Ratings in order to calculate the Portfolio Corporate Sustainability Score (Morningstar Sustainability Rating Methodology, 2021).

To retrieve the necessary data for this study, we created a customized "investment list" using Morningstar's database. The list was filtered based on specific criteria to match our requirements for obtaining data on Article 8 funds, ETF indexes, and their corresponding metrics. To ensure a random selection of funds, we exported the search results to Excel and performed a randomized selection process. In addition, we manually excluded ETF funds containing "ESG" or "SRI" to obtain a representative sample of general indexes without any focus on sustainability. After creating a universe of both Article 8 funds and indexes, relevant metrics were added to the search. Due to limitations in data extraction related to the frequency of observations, data handling, and processing were initially performed in Excel before importing it into R for further analysis. The definitions of the metrics used are retrieved directly from the Morningstar database through BI Norwegian Business School's access and are defined in the appendix 1.

4. Results

Following the foundation of background context, literature review, and methodology, we now transition to the crucial stage of our study—data analysis and interpretation. In this section, we will highlight our primary findings, integrating them with our previous discussions and examining their implications for various stakeholders. Our core objective is to distinguish the sustainability performance of Article 8 funds from index funds. By integrating these components with our empirical findings, we aim to present a comprehensive and insightful assessment of sustainability performance within the investment fund landscape.

4.1 Drivers Behind Sustainability Ratings

Part one of our analysis seeks to scrutinize the underlying determinants of sustainability ratings. We aim to unravel what factors primarily drive these ratings and how each factor's influence quantitatively contributes to the overall rating. This inspection ultimately grants us a more comprehensive overview of the interplay of these factors and their cumulative impact on the sustainability ratings. The first step in this process is to examine the correlations among various sustainability metrics. This examination not only enables us to comprehend the dynamics between these variables but also aids in ensuring the validity of our upcoming regression analysis, since multicollinearity can lead to inflated standard errors of the coefficient estimates, causing instability in the model.

Table 1: Correlation Matrix

	PSS	PES	PSSoc	PGS	CI	ES1	ES2	PFED	WWIA
PSS	1.00	0.42	0.32	0.21	0.33	0.23	0.14	-0.60	0.04
PES	0.42	1.00	0.22	0.28	0.32	0.50	0.26	-0.15	0.28
PSSoc	0.32	0.22	1.00	0.82	0.01	0.18	0.38	-0.18	-0.02
PGS	0.21	0.28	0.82	1.00	0.02	0.20	0.53	-0.33	-0.07
CI	0.33	0.33	0.01	0.02	1.00	0.32	0.14	-0.18	0.17
ES1	0.23	0.50	0.18	0.20	0.32	1.00	0.48	0.08	0.16
ES2	0.14	0.26	0.38	0.53	0.14	0.48	1.00	-0.29	0.01
PFED	-0.60	-0.15	-0.18	-0.33	-0.18	0.08	-0.29	1.00	0.05
WWIA	0.04	0.28	-0.02	-0.07	0.17	0.16	0.01	0.05	1.00

The positive correlation between Portfolio Environmental Score (PES) and both Carbon Intensity (CI), and Emissions Scope 1 (ES1) and Emissions Scope 2 (ES2) implies that funds taking on more environ-

mental risk may also be exposed to increased carbon-related risks. This is an important aspect to keep in mind as such risks may impact the funds' overall sustainability performance. The strong positive correlation between the Portfolio Social Score (PSSoc) and the Portfolio Governance Score (PGS) suggests that higher social risks often come with increased governance risks. This can indicate an interconnected nature of social and governance factors in contributing to the overall risk profile of the funds. Interestingly, the negative correlation between the PGS and the Percent of Female Executives and Directors (PFED) suggests that funds with higher governance risks tend to have fewer female executives and directors. This might prompt further inquiry into the role of gender diversity in mitigating governance risks. These findings could be a significant signal for investors and society as a whole, implying that greater gender diversity at executive and board levels may not only enhance representation and equity, but also contribute to better governance and potentially improved fund performance. Lastly, the low correlation between the Water Withdrawal Intensity Average (WWIA) and other metrics suggests that water-related risks might not be strongly tied to other risk dimensions in these funds. These insights help establish a clearer understanding of how different sustainability risks interact in the context of Article 8 and 9 funds, which will be valuable in interpreting the results of our upcoming regression analysis (see appendix for validation of the model 2).

Table 2: Regression Model Article 8 and 9

$$\textit{Portfolio Sustainability Score} = \beta_0 + \beta_1 \cdot \textit{Portfolio Environmental Score} + \beta_2 \cdot \textit{Portfolio Social Score} + \beta_3 \cdot \textit{Portfolio Governance Score} + \beta_4 \cdot \textit{Carbon Intensity} + \beta_5 \cdot \textit{Emissions Scope 1} + \beta_6 \cdot \textit{Emissions Scope 2} + \beta_7 \cdot \textit{Percent of Female Executives and Directors} + \beta_8 \cdot \textit{Water Withdrawal Intensity Average}$$

Table 3: Regression Results

Variable	**Coefficient**	**Standard Error**	**T-value**	**Significance**
Intercept	2.623×10^{1}	2.463×10^{-1}	106.501	$2 \times 10^{-16***}$
Portfolio Environmental Risk Score	5.172×10^{-1}	2.471×10^{-2}	20.934	$2 \times 10^{-16***}$
Portfolio Social Risk Score	1.040	2.951×10^{-2}	35.240	$2 \times 10^{-16***}$
Portfolio Governance Risk Score	-1.219	4.494×10^{-2}	-27.127	$2 \times 10^{-16***}$
Carbon Intensity	1.365×10^{-3}	1.517×10^{-4}	8.997	$2 \times 10^{-16***}$
Emissions Scope 1	2.308×10^{-7}	1.424×10^{-8}	16.208	$2 \times 10^{-16***}$
Emissions Scope 2	-7.303×10^{-7}	5.191×10^{-8}	-14.068	$2 \times 10^{-16***}$
Percent of Female Executives and Directors	-2.560×10^{-1}	4.313×10^{-3}	-59.358	$2 \times 10^{-16***}$
Water Withdrawal Intensity Average	-1.475×10^{-5}	2.027×10^{-6}	-7.277	$4.12 \times 10^{-13***}$
Adjusted R-squared				0.6428

The employed linear regression model showcases robust predictive capacity. The Multiple R-squared value is 0.6435 and the Adjusted R-squared value is 0.6428, indicating that about 64% of the variation in the Portfolio Sustainability Score can be explained by the independent variables included in the model.

The model's high R-squared values reflect its robust fit, capturing a significant part of the data's inherent information. It showcases a strong explanatory power for the variation in Portfolio Sustainability Score, offering insightful understanding of the score's influencing factors.

An increase in the Portfolio Environmental Score leads to an increase in the Portfolio Sustainability Score, suggesting that funds with higher environmental risk tend to exhibit greater overall sustainability risk. Simultaneously, the model highlights a direct relationship between the Portfolio Social Score and the Portfolio Sustainability Score. Higher social risk within funds corresponds to increased sustainability risk, which signifies that social risk factors play a significant role in the overall sustainability risk. An intriguing finding is the negative relationship between the Portfolio Governance Score and the Portfolio Sustainability Score. This suggests that funds with elevated governance risk might have other compensating factors that help in mitigating overall sustainability risk. The model also emphasizes the critical role of carbon emissions in assessing sustainability risk. Higher values for Carbon Intensity, Emissions Scope 1 correspond to increased sustainability risk. The relationship between gender diversity, represented by the Percentage of Female Executives and Directors, and sustainability risk is noteworthy. An increase in the proportion of female leadership within a fund is associated with a decrease in sustainability risk, hinting at the potential beneficial effect of gender diversity in reducing sustainability risk. Lastly, the model indicates that a higher Average Water Withdrawal Intensity is associated with a lower sustainability risk. These findings form a complex yet insightful overview of the factors that contribute to sustainability risk within Article 8 and 9 funds and underscore the robustness of Morningstar's sustainability ratings. They demonstrate that these ratings, by incorporating a multitude of impactful factors, provide a well-rounded and reliable measure of the sustainability risk within Article 8 and 9 funds. However, it is important to note that these results show statistical associations and should not be interpreted as causative relationships. Further research is necessary to understand the underlying mechanisms driving these relationships.

For our analysis of index funds, we have adopted the same method as with Article 8 and 9 funds. However, we have excluded Portfolio Environmental Risk Score due to high multicollinearity, which can complicate interpretation and violate key linear regression assumptions. We have retained the Portfolio Carbon Risk Score and Water Withdrawal Intensity Average as representative of environmental factors, ensuring our model's robustness, interpretability, and the clear comparison across fund types (see appendix for validation of the model 3).

Table 4: Correlation Matrix

	PCSS	PSRS	PGRS	WWIA	PCRS	PFED
PCSS	1.00	0.62	0.51	0.04	0.86	-0.55
PSRS	0.62	1.00	0.79	-0.10	0.33	-0.32
PGRS	0.51	0.79	1.00	-0.15	0.25	-0.55
WWIA	0.04	-0.10	-0.15	1.00	0.002	0.03
PCRS	0.86	0.33	0.25	0.002	1.00	-0.24
PFED	-0.55	-0.32	-0.55	0.03	-0.24	1.00

The Portfolio Corporate Sustainability Score (PCSS) of the index funds shares a strong positive correlation with the Portfolio Social Risk Score (PSRS) and Portfolio Carbon Risk Score (PCRS), similar to what we observed in Article 8 and 9 funds. These correlations indicate that funds with higher corporate sustainability scores are likely to have higher social and carbon risks, suggesting that these dimensions of sustainability risks are often interconnected in these investment vehicles. Interestingly, the PCSS and the Percent of Female Executives and Directors (PFED) are negatively correlated. This pattern aligns with what we noticed in the Article 8 and 9 funds, suggesting that index funds with a greater proportion of Female Executives and Directors often demonstrate lower corporate sustainability risks. This observation further strengthens the case that gender diversity may play a significant role in mitigating both governance and broader corporate sustainability risks across different types of funds. The Water Withdrawal Intensity Average (WWIA) in index funds, much like in Article 8 and 9 funds, presents a very low correlation with the PCSS and other risk factors. This indicates that water-related risks might operate independently of other sustainability measures in these funds.

The regression analysis of index funds, excluding the Portfolio Environmental Risk Score, still reveals notable influences from several factors on the Corporate Sustainability Score (see Table 5). Both the Portfolio Social Risk Score and Portfolio Carbon Risk Score exert a positive influence on the sustainability score, indicating that higher social and carbon risks are associated with higher sustainability scores. Conversely, the Portfolio Governance Risk Score and the Percent of Female Executives and Directors exhibit a significant negative influence, echoing the pattern observed in Article 8 and 9 funds. This suggests that lower governance risks and greater female representation in leadership roles are tied to improved sustainability performance in these funds. Despite the exclusion of the Environmental Risk Score, the

Table 5: Regression Model: Index Funds

Portfolio Corporate Sustainability Score $= \beta_0 + \beta_1 \cdot$ *Portfolio Carbon Risk Score* $+ \beta_2 \cdot$ *Portfolio Social Risk Score* $+ \beta_3 \cdot$ *Portfolio Governance Risk Score* $+ \beta_4 \cdot$ *Water Withdrawal Intensity Average* $+ \beta_5 \cdot$ *Percent of Female Executives and Directors*

Table 6: Regression Results

Variable	**Coefficient**	**Standard Error**	**T-value**	**Significance**
Intercept	1.757×10^{1}	1.428	12.310	$2 \times 10^{-16***}$
Portfolio Carbon Risk Score	4.369×10^{-1}	1.976×10^{-2}	22.108	$2 \times 10^{-16***}$
Portfolio Social Risk Score	1.198	1.403×10^{-1}	8.539	$3.64 \times 10^{-12***}$
Portfolio Governance Risk Score	-7.121×10^{-1}	2.227×10^{-1}	-3.197	0.002^{**}
Water Withdrawal Intensity Average	3.272×10^{-5}	1.553×10^{-5}	2.106	0.039^{*}
Percent of Female Executives and Directors	-1.764×10^{-1}	1.778×10^{-2}	-9.921	$1.44 \times 10^{-14***}$
Adjusted R-squared				0.9443

Water Withdrawal Intensity Average, representing environmental aspects, maintains a minor but significant positive impact on the sustainability score. This underscores the nuanced role environmental factors play in shaping fund sustainability ratings.

Our model for index funds exhibits a remarkably high Adjusted R-squared value of 0.9443, indicating that our model explains nearly 94.43% of the variance in the Portfolio Corporate Sustainability Score. While this suggests a strong model fit, it is important to interpret this with caution and consider some essential points.

Although Morningstar has already provided clear explanations for the construction of these ratings, our regression analysis offers a distinctive and simpler mathematical approach, showcasing the relative weights and significance of different contributing factors in a numerical format. Our findings, while providing insight, are specific to our unique dataset and timeframe. Changes in the data could produce different results, highlighting the contextual nature of our interpretation. It is important to note that our analysis does not encapsulate all potential factors influencing sustainability ratings. Interpreting these results requires care. While we have identified significant relationships, we emphasize that correlation does not imply causation. It is crucial to avoid over-generalizing these findings and remain cognizant that they are specific to the particular set of data we analyzed. Lastly, we aim to present our findings objectively, striving to avoid bias and let the data speak for itself. Our interpretations are based solely on our results, without favoring any preconceived outcomes.

Bearing these points in mind, we now turn to examining the summary statistics for the Corporate Sustainability Score across both Article 8 and 9 funds, and index funds. This enables us to understand the

distribution of sustainability scores and assess the overall performance across these fund types.

Table 7: Summary Statistics for Article 8 and 9 Funds

Min	**Q1**	**Median**	**Mean**	**Q3**	**Max**
10.71	19.00	20.33	20.77	22.22	37.28

Table 8: Summary Statistics for Index Funds

Min	**Q1**	**Median**	**Mean**	**Q3**	**Max**
17.76	20.89	23.19	24.59	26.43	46.98

For Article 8 and 9 funds, the mean Corporate Sustainability Score is 20.77, indicating a considerable level of sustainability. The median score is slightly lower at 20.33, suggesting a somewhat skewed distribution with a small number of funds achieving particularly high scores. The minimum score is 10.71, while the maximum peaks at 37.28. Index funds show a slightly different picture. The mean Corporate Sustainability Score is 24.59, higher than that of the Article 8 and 9 funds, indicating a generally higher sustainability risk. The median score is 23.19, again revealing a skewed distribution. The range of scores is also wider in index funds, spanning from 17.76 to 46.98.

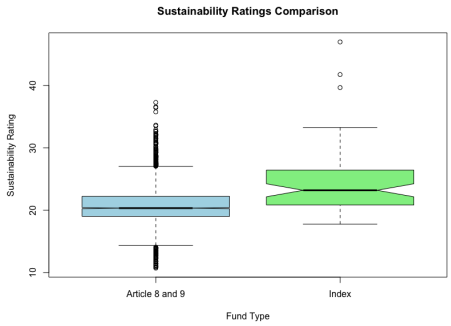

Figure 2

As we continue our analysis, we turn to statistical testing to ascertain whether there are significant differences between the sustainability ratings of Article 8 and 9 funds and index funds. Specifically, we apply the Wilcoxon rank sum test, a non-parametric test that assesses whether one sample's distributions differ from another.

The result from the Wilcoxon Rank Sum Test suggests a statistically significant difference (see Table 9) in the sustainability ratings between the two types of funds. This result implies that the differences we observed earlier in the mean and median scores are not merely due to random variation, but instead reflect a meaningful divergence in sustainability performance.

Table 9: Wilcoxon Rank Sum Test with Continuity Correction

Test Statistic (W)	72637
p-value	7.794e-12

To summarize, in this first part of our analysis, we've explored what drives sustainability ratings for Article 8 and 9 funds, as well as index funds. We examined the correlation between various sustainability risk factors and conducted a regression analysis to uncover the relationship between these factors and the overall sustainability score. We also presented a statistical comparison of the sustainability scores between the two categories of funds. This foundational understanding paves the way for the next part of our analysis, where we will investigate the sustainability ratings over time and introduce additional control variables to deepen our understanding of the drivers of these ratings. By integrating both cross-sectional and temporal perspectives, we aim to provide a comprehensive assessment of sustainability performance in these funds, contributing valuable insights to the ongoing discourse on sustainable investment.

4.2 Sustainability Ratings and Performance of the Funds

Before we delve into the detailed panel regression analysis, it is crucial to establish the foundational assumptions that guide our interpretation of the results. We base our analysis on the premise that Morningstar's rating system is both accurate and effectively represents the multifaceted reality of corporate sustainability. Furthermore, our findings assume that companies report their sustainability data truthfully and accurately, an assumption that needs to be taken into account particularly when addressing greenwashing risk. While our results contribute valuable insights, we encourage future research to delve deeper into potential nuances in reporting and measurement practices. For the scope of our current study, we acknowledge these potential complexities but do not explore them further. Any conclusions suggesting a reduction in greenwashing risk should be interpreted with caution, as companies might potentially report skewed data to cultivate a greener image.

Having established these assumptions, we turn to a broad overview of the sustainability ratings over the past three years. Visualizing this data provides a high-level understanding of patterns and trends in sustainability performance across Article 8 and index funds. By plotting the sustainability ratings over time, we gain insights into key trends, fluctuations, and periods of particular interest (median plot in appendix 4). This process helps us identify whether Article 8 funds consistently outperform index funds in terms of sustainability, and if there are notable shifts in these ratings over the given period. Understanding

these broader patterns provides valuable context for our subsequent, more detailed regression analysis. Our focus remains on what the reported data can reveal about the sustainability performance of Article 8 versus index funds.

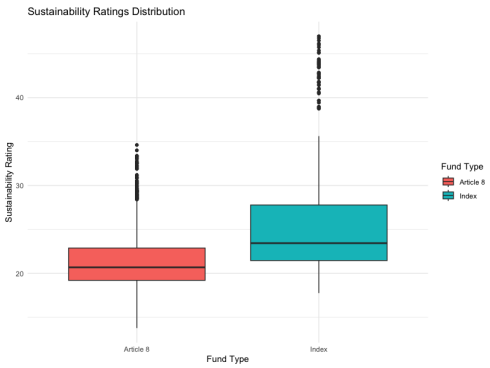

Figure 3: Sustainability Ratings Distribution

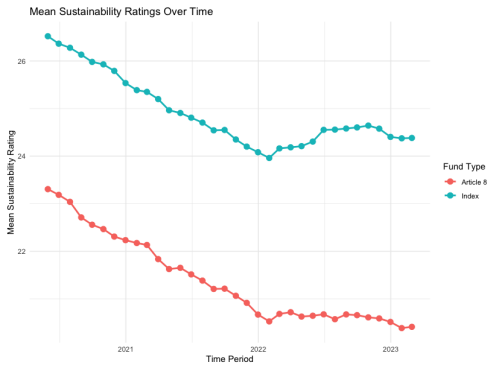

Figure 4: Mean Sustainability Ratings Over Time

Table 10: Regression Model: Mixed_Effects

$$\text{Sustainability rating} = \beta_0 + \beta_1 \cdot \text{Fund\_Type\_Numeric} + (1|\text{Fund\_ID}) + (1|\text{Date})$$

This regression model is a type of mixed-effects model, more specifically a linear mixed-effects model, which is used when there is some sort of clustering in the data. In our case, it is clustering by fund ID and date. The formula to the model can be read as follows:

Sustainability rating $\sim$ This is a dependent variable or outcome of interest. We are trying to investigate the *sustainability rating* of funds.

Fund_Type_Numeric $\sim$ This is an independent variable or predictor. It is what we think will influence the *sustainability rating*. It represents whether a fund is an *Article 8* fund or an *Index* fund.

$(1|Fund\_ID) \sim$ This term models the random effects of *Fund_ID*. It assumes that there are random differences between the intercepts (baseline *sustainability ratings*) for each fund that are not captured by the other variables in the model. This is used to account for the non-independence of observations within the same fund.

$(1|Date) \sim$ This term models the random effects of *Date*. Like the random effects of *Fund_ID*, it assumes there are random differences between the intercepts for each date that are not captured by the other variables. It takes into account the non-independence of observations taken on the same date.

The fixed effect is *Fund_Type_Numeric*, and these are the effects (or influences) we are interested in

studying. Here, *Fund_Type_Numeric* represents the type of fund we are investigating (Article 8 or Index). The coefficient for this predictor tells how much the *sustainability rating* changes, on average, for *Article 8* funds compared to *Index* funds, while controlling for the random effects.

Random effects are used to account for variation or differences across levels of these variables that are not directly related to the predictors of interest. The $(1|Fund\_ID)$ and $(1|Date)$ parts of the formula indicate that the model allows for different intercepts for each level of these variables – in other words, each fund and each date can have its own baseline *sustainability rating*. By including *Fund_ID* as a random effect, the model acknowledges that observations for the same fund are likely to be more similar to each other than to observations for different funds. Similarly, by including *Date* as a random effect, the model accounts for potential similarities in observations taken on the same date. This structure of the model allows us to draw more valid and generalizable conclusions about the effect of fund type on sustainability rating, by properly accounting for the clustered structure of the data.

Table 11: Mixed Effects 5

Random Effects:	Groups	Name	Variance	Std.Dev.
	Fund_ID	Intercept	15.8662	3.9832
	Date	Intercept	0.5827	0.7633
	Residual		0.6765	0.8225

Table 12: Fixed Effects

Fixed Effects	Estimate	Std. Error	df	t value	Significance
Intercept	25.0196	0.4877	182.4338	51.306	$2 \times 10^{-16***}$
Fund_Type_Numeric	-3.5060	0.6273	161.8827	-5.589	$9.48 \times 10^{-8***}$

Table 13: Correlation of Fixed Effects

Correlation of Fixed Effects:	(Intr)
Fund_Type_Nmr	-0.721

Fixed effects: The coefficient for *Fund_Type_Numeric* is -3.5060. Given that lower sustainability ratings indicate better sustainability, this negative coefficient suggests that Article 8 funds (coded as 1) have a lower (i.e., better) sustainability rating compared to Index funds (coded as 0), and is statistically significant at conventional levels.

Random effects: In this model, both *Fund_ID* and *Date* are treated as random effects, accounting for the fact that observations within the same fund (i.e., different dates for the same fund) are likely to be more similar to each other than observations from different funds. The standard deviation for *Fund_ID*, which is 3.9832, tells us that, on average, the sustainability rating for a specific fund is about 3.9832 units away from the average sustainability rating across all funds. These estimates are derived from our sample data and are intended to generalize to the population of all such funds.

Similarly, the model accounts for the fact that observations at the same date (i.e., sustainability ratings of different funds at the same date) are likely to be more similar to each other than observations from different dates. The standard deviation for *Date*, which is 0.7633, conveys that the average sustainability rating for a specific date is about 0.7633 units away from the average sustainability rating across all dates. As with *Fund_ID* these estimates are based on our sample and are meant to represent the general trend across all such dates. The model also adjusts for any differences between funds and fund types.

Correlation of Fixed Effects: The model shows a strong negative correlation of -0.721 between the intercept (baseline sustainability rating when predictors are zero) and *Fund_Type_Numeric*. This implies that different fund types have different baseline sustainability ratings, with higher *Fund_Type_Numeric* values correlating with lower baseline ratings. A unit change in fund type, from Index to Article 8 fund, decreases the sustainability rating by about 0.721 units, all else being equal. This reflects the model's interpretation and may not reflect the true population relationship.

In summary, the model suggests that Article 8 funds outperform Index funds in sustainability, controlling for differences between funds and over time. Other factors not included in the model and potential biases must be considered in these results.

We are also interested in running a model with *Date* as a fixed effect and comparing the results with the *mixed_effects* model where *Date* is a random effect. This comparison will allow us to see the impact of treating time as a fixed versus a random effect. Having *Date* as a fixed effect lets us control for time-constant, date-specific factors like macroeconomic influences, potentially reducing omitted variable bias at the cost of estimating more parameters, thus possibly reducing degrees of freedom. Treating time as a random effect offers a simpler model but assumes that time effects are random and not correlated with the model's predictors.

Table 14: Regression Model: Fixed Effects

$$\textit{Sustainability rating} = \beta_0 + \beta_1 \cdot \textit{Fund\_Type\_Numeric} + \beta_2 \cdot \textit{Date}$$

Table 15: Regression Results: Fixed Effects

Variable	**Coefficient**	**Std. Error**	**T-value**	**Significance**
Intercept	7.053×10^{1}	3.614	19.52	$2 \times 10^{-16***}$
Fund_Type_Numeric	-3.523	1.141×10^{-1}	-30.89	$2 \times 10^{-16***}$
Date	-2.791×10^{-8}	2.210×10^{-9}	-12.63	$2 \times 10^{-16***}$
Adjusted R-squared		0.1834		

In the linear model treating Date as a fixed effect, both *Fund_Type_Numeric* and *Date* are significant predictors of *Sustainability rating*, mirroring the *random_effects model*. The coefficient for *Fund_Type_Numeric* is -3.523, indicating a significant negative correlation between fund type and sustainability rating. This aligns with the *mixed_effects* model, despite minor differences in the coefficient value. The coefficient for *Date*, though small (-2.791e-08), signifies a slight negative trend over time, implying incremental improvements in sustainability ratings. However, this model explains about 18.37% of the variation in sustainability rating, as suggested by the R-squared value of 0.1837. The residual standard error of 4.022 indicates a slightly worse fit compared to the *mixed_effects* model. It is important to note that R-squared is not directly comparable between *fixed_effects* and *mixed_effects* models, but it gives some sense of the relative amount of variance explained in each.

The linear model with fixed effects yields similar conclusions to the *mixed_effects* model regarding the relationship between fund type and sustainability rating. However, treating *Date* as a fixed effect yields a smaller coefficient and a fairly low R-squared, suggesting the *mixed_effects* model is more fitting, given the assumption of uncorrelated time effects. Also, it is worth noting that potential violations of model assumptions, such as homoscedasticity and independence of errors, could make the linear model more sensitive.

Both from visual plots and from running a regression with time as a fixed effect, we observe a negative trend in sustainability ratings over a certain period, suggesting that generally, funds are becoming more sustainable. This observation is significant for our analysis because it allows us to account for autocorrelation or serial correlation in further analyses. However, it is important to note that this trend does not definitively establish a cause-effect relationship, but merely an association over time.

The table below provides a comprehensive statistical comparison of the sustainability ratings between two categories of funds - Article 8 and index funds. It is interesting to observe the distinctions in sustain-

ability performance, thus offering us valuable insights into our analysis.

Table 16: Statistical Comparison of Sustainability Ratings

Fund Type	**Mean Sustainability**	**Median Sustainability**	**Min. Sustainability**	**Max. Sustainability**
Article 8	21.3	20.7	13.8	34.6
Index	24.9	23.4	17.8	47.0

Article 8 funds display a superior sustainability performance compared to index funds, demonstrated by both average and median ratings of 21.3 and 20.7 respectively, against 24.9 and 23.4 for index funds. The extreme values confirm this pattern; the most sustainable Article 8 fund boasts a rating of 13.8, outdoing the index fund's 17.8, and even the least sustainable Article 8 fund, with a rating of 34.6, outperforms the least sustainable index fund which holds a rating of 47. This data underlines the consistent trend of Article 8 funds showing better sustainability performance across the board.

We are now progressing to include additional variables in our model that could potentially influence the sustainability ratings and help us to control for various factors.

Table 17: Regression Model: Mixed_Effects_All

$$\text{Sustainability rating} = \beta_0 + \beta_1 \cdot \text{Fund\_Type\_Numeric} + \beta_2 \cdot \text{Avr.m.cap} + \beta_3 \cdot \text{Fund\_size} + \beta_4 \cdot \text{Monthly.Ret} + \beta_5 \cdot \text{PB} + \beta_6 \cdot \text{ROE} + \beta_7 \cdot \text{Draw\_down} + (1|\text{Fund\_ID}) + (1|\text{Date})$$

Adding control variables to a regression model is important in order to control for the influence of other factors that may affect sustainability ratings. By controlling for these variables, we can isolate the effect of our main independent variable (*Fund_Type_Numeric*) on the dependent variable. The control variables we have included are average market cap (*Avr.m.cap*), the fund size (*Fund_size*), monthly returns (*Monthly.Ret*), price to book ratio (*PB*), return on equity (*ROE*), and drawdown (*Draw_down*). All these factors could conceivably influence a fund's sustainability rating.

When including control variables, the coefficient for *Fund_Type_Numeric* is more accurately capturing the isolated effect of fund type on the sustainability rating. Otherwise, it is possible that the effect we are attributing to fund type could actually be due to one of these other variables. By adding these control variables and treating time (*Date*) as a random effect, we are now accounting for variability in the sustainability ratings that may be due to fluctuations over time. It is good to account for time in our analysis when our data is collected over different time periods since many financial variables can exhibit trends or cycles over time.

This model is more complex than our initial *mixed_effects* model, but it also provides a more nuanced and controlled analysis of the factors affecting sustainability ratings. Correlation table of fixed effects is located in the appendix.

The results (see Table 18) demonstrate that *Fund_Type_Numeric*, *PB*, *ROE*, and *Draw_down* are statistically significant and thus influence Sustainability ratings. In particular, the model consistently suggests that Article 8 funds are tied to lower, and hence better sustainability ratings, even after controlling for other variables. However, *Avr.m.cap*, *Fund_size*, and *Monthly.Ret* are not statistically significant, indicating that they are not related to Sustainability rating when other variables are taken into account. Like the initial model, *mixed_effects_all* accounts for variations across different *Fund_ID* and *Date*, providing a robust depiction of the hierarchical nature of the data and its impact on sustainability ratings. As such, this model provides a more comprehensive analysis of the impact of *Fund_Type_Numeric* on sustainability ratings by considering a broader set of variables, making it superior to the previous model for the current investigation.

Table 18: Regression Results Mixed_Effects_All (Residuals in appendix 6)

Random Effects:	Groups	Name	Variance	Std.Dev.	
	Fund_ID	Intercept	15.4208	3.9269	
	Date	Intercept	0.2650	0.5148	
	Residual		0.2821	0.5311	
Fixed Effects:	Estimate	Std. Error	df	t value	Significance
Intercept	2.651e+01	7.994e-01	1.252e+02	33.167	$2e-16^{***}$
Fund_Type_Numeric	-4.393e+00	8.839e-01	1.112e+02	-4.970	$2.44e-06^{***}$
Avr.m.cap	1.177e-07	4.307e-07	8.436e+02	0.273	0.78475
Fund_Size	2.044e-10	1.497e-10	8.332e+02	1.366	0.17232
Monthly.Ret	-8.547e-03	5.099e-03	7.408e+02	-1.676	0.09413
PB	-2.051e-01	7.362e-02	8.069e+02	-2.786	0.00546^{**}
ROE	-1.914e-02	8.911e-03	6.559e+02	-2.148	0.03209^{*}
Draw_down	2.231e-02	4.354e-03	5.990e+02	5.125	$4.03e-07^{***}$

Fund Type (Fund_Type_Numeric): This variable remains significant, with a larger coefficient (-4.393) in absolute terms than in our previous *mixed_effects* model (-3.506). This indicates a more substantial difference between Article 8 and index funds in terms of sustainability rating than previously estimated. Even after controlling for additional factors, Article 8 funds, on average, attain better sustainability rat-

ings, i.e., lower scores, than index funds when all other variables are held constant.

Price-to-Book Ratio (PB): This significant variable has a negative coefficient, suggesting that higher PB ratios correspond to lower (improved) sustainability ratings when holding other factors constant. Therefore, it could be inferred that companies which prioritize sustainable practices and ESG compliance might have a higher market valuation relative to their book value. For investors, this correlation could suggest that companies demonstrating robust sustainability performance may command higher valuations, potentially offering a more attractive investment proposition in terms of both financial returns and positive ESG impact. However, further research is needed to confirm the precise nature of this relationship.

Return on Equity (ROE): This significant variable with a negative coefficient suggests that higher ROE often corresponds to better sustainability ratings. Essentially, funds with higher ROE, a sign of efficient management and financial health, tend to demonstrate improved sustainability. However, it is important to note this is a statistical correlation and does not necessarily indicate causation, as other unseen factors could be at play. For instance, high ROE might be due to increased financial leverage, which could entail long-term risk.

Drawdown (Draw_down): This variable is of high significance with a positive coefficient, suggesting that funds experiencing larger drawdowns tend to exhibit higher (i.e., worse) sustainability ratings, with other factors held constant. Drawdown, referring to a peak-to-trough decline during a particular period of an investment, fund, or commodity, is usually expressed as the percentage between the peak and the subsequent trough. Accordingly, funds with a history of substantial drawdowns—which could indicate higher risk and increased volatility—tend to have poorer sustainability ratings. This is intuitively sensible as funds subjected to significant drawdowns may adopt riskier investment strategies potentially misaligned with sustainable practices.

Average market cap *(Avr.m.cap)*, fund size *(Fund_size)*, and monthly return *(Monthly.Ret)* are statistically insignificant, implying they do not have a meaningful impact on sustainability rating in this model. The variances associated with *Fund_ID* and *Date* have reduced from our prior *mixed_effects* model, suggesting the added variables have accounted for some variability. Incorporating this variance through random effects allows the model to account for unexplained variation between funds, enhancing accuracy and generalizability of the fixed effects.

Table 19: Correlation Matrix

	Fund_Type_Numeric	Avr. m.cap	Fund Size	Monthly Ret.	PB	ROE	Drawdown
Fund_Type_Numeric	1.00	0.20	0.17	-0.33	0.44	0.25	-0.21
Avr. m.cap	0.20	1.00	0.20	-0.07	0.09	0.04	-0.02
Fund Size	0.17	0.20	1.00	-0.05	0.14	0.08	0.02
Monthly Ret.	-0.33	-0.07	-0.05	1.00	-0.04	-0.13	0.52
PB	0.44	0.09	0.14	-0.04	1.00	0.50	0.08
ROE	0.25	0.04	0.08	-0.13	0.50	1.00	-0.13
Drawdown	-0.21	-0.02	0.02	0.52	0.08	-0.13	1.00

Table 20: VIFs

Fund_Type_Numeric	Avr. m.cap	Fund Size	Monthly Ret.	PB	ROE	Drawdown
1.007094	1.081427	1.041531	1.170861	1.192976	1.078396	1.255501

The correlation matrix shows no strong correlations among variables, with the highest correlation (under 0.5) between PB and ROE. All Variance Inflation Factors (VIFs) are less than 5, indicating no significant multicollinearity. Hence, each variable provides unique information, enhancing the robustness of the regression results. Overall, the low multicollinearity suggests that our model provides distinct, useful information and demonstrates reliability and robustness to minor alterations.

Fit of the model:

AIC for *mixed_effects* : 13466.16

AIC for *mixed_effects_all* : 2232.37

BIC for *mixed_effects* : 13498.74

BIC for *mixed_effects_all* : 2285.03

The *mixed_effects_all* model has significantly lower Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values compared to the *mixed_effects* model. This suggests that the *mixed_effects_all* model, despite its complexity, provides a better fit to the data. The addition of extra predictors appears to have enhanced the model's performance.

Investigating autocorrelation in our model's residuals is crucial. If present, it suggests missing time-dependent explanatory information, leading to inefficient estimates and potentially under-estimated standard errors. The negative trend found in previous analyses implies an improvement in sustainability ratings over time and highlights the need to check for autocorrelation. If confirmed, we may need to adjust our model, for instance, by incorporating lagged variables or accounting for random slopes in our mixed model, to ensure our estimates and conclusions are reliable.

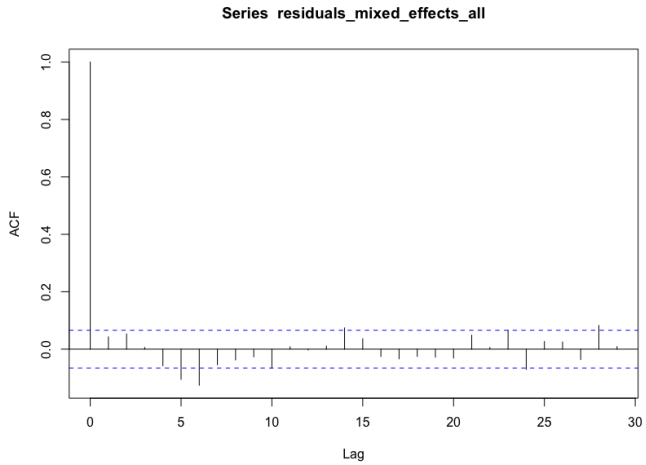

Figure 5

The Autocorrelation Function (ACF) plot indicates statistically significant yet relatively weak autocorrelation at specific lags. This suggests that our model's residuals exhibit some autocorrelation, implying that the sustainability rating in a given period might be somewhat influenced by past ratings. Consequently, the current model might not be fully capturing certain patterns in the data. This might be explained by the inherent autocorrelation in the data generation process, such as the gradual changes in sustainability ratings over time, leading to a degree of dependency between current and past ratings. Given the degree of autocorrelation detected in our *mixed_effects_all* model, we will tackle this issue with three distinct strategies:

Incorporating time as a fixed effect: This approach aims to control for any time-specific, unobserved characteristics that may be contributing to the autocorrelation of the residuals. By treating time as a fixed effect, we can account for these time-related influences that are not directly observable or measured.

Including a lagged variable: By incorporating a lagged dependent variable into our model, we directly use past information in our prediction. This strategy acknowledges that previous sustainability ratings might have an effect on current ratings, thus helping to manage the autocorrelation

Combining fixed time effects and a lagged variable: Lastly, we will run a model that simultaneously incorporates time as a fixed effect and includes a lagged variable. This combined approach aims to account for both time-specific effects and the influence of past sustainability ratings on the current ratings.

Incorporating time as a fixed effect:

Table 21: Regression Model: mixed_effects_fixed_date

$$\text{Sustainability rating} = \beta_0 + \beta_1 \cdot \textit{Fund\_Type\_Numeric} + \beta_2 \cdot \textit{Avr.m.cap} + \beta_3 \cdot \textit{Fund\_size} + \beta_4 \cdot \textit{Monthly.Ret} + \beta_5 \cdot \textit{PB} + \beta_6 \cdot \textit{ROE} + \beta_7 \cdot \textit{Draw\_down} + (1|\textit{Fund\_ID})$$

Treating time as a fixed effect in the *mixed_effects_fixed_date* model helps account for consistent, time-dependent trends influencing sustainability ratings. This approach is vital since systematic changes over time might not be captured by other variables. On the other hand, the *mixed_effects_all* model treats time as a random effect, addressing time-dependent variation without assuming a structured time influence. Comparing these models enables us to discern whether time influences sustainability ratings in a more systematic or random manner.

AIC for *mixed_effects_fixed_date*: 2327.33

BIC for *mixed_effects_fixed_date*: 2375.20

Figure 6

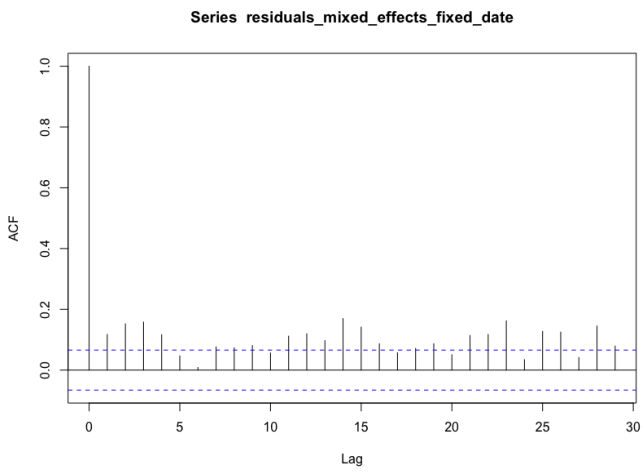

Table 22: Regression Result: Mixed Effects Fixed Date

Random Effects	Groups	Name	Variance	Std.Dev.	
	Fund_ID	Intercept	15.1446	3.8916	
	Residual		0.3562	0.5968	
Fixed Effects	Estimate	Std. Error	df	t value	Significance
Intercept	2.785e+01	7.823e-01	1.196e+02	35.595	2×10^{-16}***
Fund_Type_Numeric	-4.204e+00	8.761e-01	1.113e+02	-4.798	5×10^{-6}***
Avr.m.cap	3.794e-07	4.711e-07	8.690e+02	0.805	0.42081
Fund_Size	-6.946e-11	1.633e-10	8.756e+02	-0.425	0.67063
Monthly.Ret	-9.858e-03	3.721e-03	7.702e+02	-2.649	0.008 23**
PB	-2.458e-01	7.851e-02	8.467e+02	-3.132	0.001 80**
ROE	-9.099e-02	7.084e-03	7.898e+02	-12.843	2×10^{-16}***
Draw_down	3.146e-02	3.240e-03	7.970e+02	9.710	2×10^{-16}***

Incorporating time as a fixed effect resulted in higher AIC and BIC values, indicating a poorer fit compared to the model treating time as a random effect. The *mixed_effects_all* model also displayed less autocorrelation in the ACF plot. Even though more predictors were significant when treating time as a fixed effect, the diagnostic results suggest that the *mixed_effects_all* model, treating time-specific attributes as random effects, is more appropriate for our data. This affirms the importance of model fit and accuracy over mere significance of predictors for robust predictive modeling.

Including a lagged variable:

Table 23: Regression Model: *mixed_effects_all_lagged*

$$\text{Sustainability rating} = \beta_0 + \beta_1 \cdot \textit{lagged\_Sustainability\_rating} + \beta_2 \cdot \textit{Fund\_Type\_Numeric} + \beta_3 \cdot \textit{Avr.m.cap} + \beta_4 \cdot \textit{Fund\_size} + \beta_5 \cdot \textit{Monthly.Ret} + \beta_6 \cdot \textit{PB} + \beta_7 \cdot \textit{ROE} + \beta_8 \cdot \textit{Draw\_down} + (1|\textit{Fund\_ID}) + (1|\textit{Date})$$

Figure 7

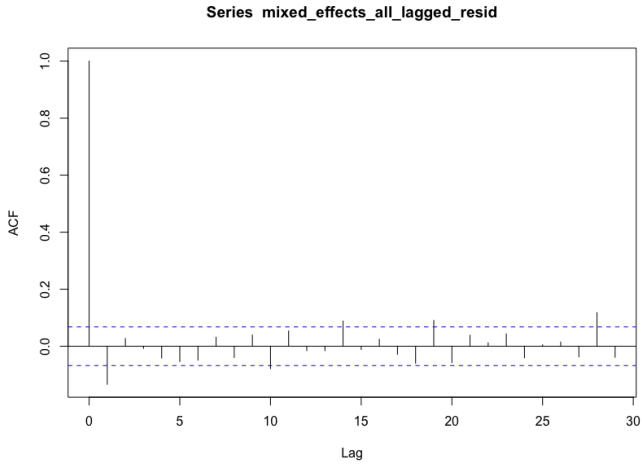

Table 24: Regression Result: Mixed Effects All Lagged

Random Effects	Groups	Name	Variance	Std.Dev.	
	Fund_ID	Intercept	15.05299	3.8798	
	Date	Intercept	0.07605	0.2758	
	Residual		0.26272	0.5126	
Fixed Effects	**Estimate**	**Std. Error**	**df**	**t value**	**Significance**
Intercept	1.916e+01	1.163e+00	3.752e+02	16.472	2×10^{-16}***
lagged_sustainability_rating	2.980e-01	3.299e-02	8.165e+02	9.032	2×10^{-16}***
Fund_Type_Numeric	-3.272e+00	8.910e-01	1.077e+02	-3.672	0.000 376***
Avr. m.cap	3.552e-07	4.414e-07	7.340e+02	0.805	0.421192
Fund_size	1.314e-10	1.510e-10	7.707e+02	0.870	0.384503
Monthly Ret.	-9.079e-03	4.773e-03	3.049e+02	-1.902	0.058066
PB	-2.372e-01	7.263e-02	7.560e+02	-3.266	0.001 141**
ROE	-1.946e-02	8.441e-03	4.130e+02	-2.305	0.021 666*
Draw_down	2.643e-02	3.942e-03	2.044e+02	6.703	1.94×10^{-10}***

AIC for *mixed_effects_all_lagged*: 2032.758

BIC for *mixed_effects_all_lagged*: 2089.502

Introducing a lagged dependent variable in the model has improved fit and predictive power and addressed autocorrelation partially. *Fund_ID* and *Date* random effects still significantly impact the model, and past sustainability ratings play a crucial role in predicting current ratings. Compared to the original *mixed_effects_all* model, this model has lower AIC and BIC scores, indicating a superior fit. Although the ACF plot still shows some autocorrelation, it is less systematic with fewer significant spikes, suggesting partial mitigation of autocorrelation. However, the remaining autocorrelation might need alternative model structures to address fully. Hence, the *mixed_effects_all_lagged* model shows noticeable improvement over the initial *mixed_effects_all* model.

Combining fixed time effects and a lagged variable:

Table 25: Regression Model: *mixed_effects_fixed_date_lagged*

$$\text{Sustainability rating} = \beta_0 + \beta_1 \cdot \textit{lagged\_Sustainability\_rating} + \beta_2 \cdot \textit{Fund\_Type\_Numeric} + \beta_3 \cdot \textit{Avr.m.cap} + \beta_4 \cdot \textit{Fund\_size} + \beta_5 \cdot \textit{Monthly.Ret} + \beta_6 \cdot \textit{PB} + \beta_7 \cdot \textit{ROE} + \beta_8 \cdot \textit{Draw\_down} + \beta_9 \cdot \textit{Date} + (1|\textit{Fund\_ID})$$

AIC for *mixed_effects_fixed_date_lagged*: 2050.734

BIC for *mixed_effects_fixed_date_lagged*: 2107.478

Table 26: Regression Result: Mixed Effects Fixed Date Lagged

Random Effects	Groups	Name	Variance	Std.Dev.	
	Fund_ID	Intercept	15.1342	3.8903	
	Residual		0.2744	0.5238	
Fixed Effects	Estimate	Std. Error	df	t value	Significance
Intercept	4.152e+01	3.856e+00	8.011e+02	10.770	2×10^{-16}***
lagged_sustainability_rating	3.146e-01	3.318e-02	8.202e+02	9.481	2×10^{-16}***
Fund_Type_Numeric	-3.078e+00	8.921e-01	1.070e+02	-3.451	0.000 802***
Avr. m.cap	1.978e-07	4.488e-07	7.870e+02	0.441	0.659522
Fund_size	3.552e-11	1.517e-10	8.131e+02	0.234	0.814917
Monthly Ret.	-5.252e-04	3.493e-03	7.265e+02	-0.150	0.880504
PB	-3.238e-01	7.146e-02	7.783e+02	-4.531	6.8×10^{-6}***
ROE	-1.971e-02	8.352e-03	7.555e+02	-2.360	0.018 541*
Draw_down	1.239e-02	3.572e-03	7.443e+02	3.468	0.000 554***
Date	-1.380e-08	2.116e-09	7.431e+02	-6.519	1.3×10^{-10}***

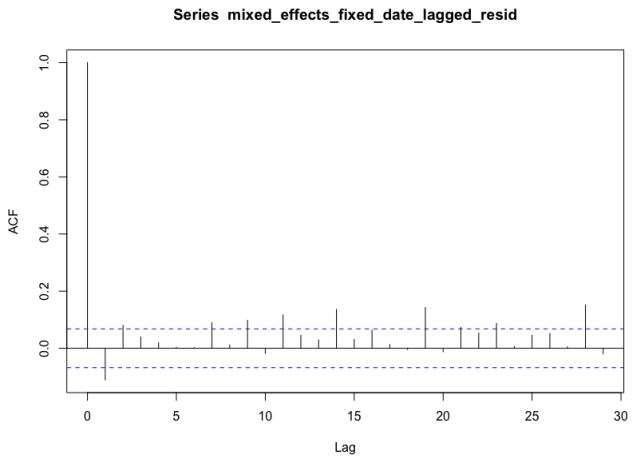

Figure 8

This model shows slightly larger AIC and BIC 2050.73 and 2107.47 respectively, than the *mixed_effects_all_lagged*. Additionally, the ACF of the residuals displays a wavier pattern and has more spikes, indicating that the autocorrelation issue is not entirely resolved and is somewhat worse than the *mixed_effects_all_lagged* model. Based on these results, the *mixed_effects_all_lagged* model - with a lagged dependent variable but without treating time as a fixed effect - provides the best balance in terms of model fit, handling of autocorrelation, and complexity.

Our analysis identifies the *mixed_effects_all_lagged* model as the best fit for our data, incorporating lagged sustainability ratings, *Fund_Type_Numeric*, and other control variables. A significant difference in sustainability ratings between Article 8 and index funds was found, with both types improving their sustainability performance from May 2020 to December 2021. The autocorrelation issue detected in our model necessitates further improvements. To address this, we propose reapplying the *mixed_effects_all_lagged* model to data from December 2021 to February 2023. This period, where no trend is detected in the sustainability ratings plot, appears to offer a phase of stability in the ratings. This change could provide a more accurate depiction of the performance difference between fund types. Even after controlling for additional variables, our findings consistently indicate superior sustainability performance of Article 8 funds.

Table 27: Regression Model: *mixed_effects_dec2021_onwards*

$$\text{Sustainability rating} = \beta_0 + \beta_1 \cdot \textit{lagged\_Sustainability\_rating} + \beta_2 \cdot \textit{Fund\_Type\_Numeric} + \beta_3 \cdot \textit{Avr.m.cap} + \beta_4 \cdot \textit{Fund\_size} + \beta_5 \cdot \textit{Monthly.Ret} + \beta_6 \cdot \textit{PB} + \beta_7 \cdot \textit{ROE} + \beta_8 \cdot \textit{Draw\_down} + (1|\textit{Fund\_ID}) + (1|\textit{Date})$$

Table 28: Regression Result: Mixed Effects Dec2021 Onwards

Random Effects	Groups	Name	Variance	Std.Dev.	
	Fund_ID	Intercept	15.22238	3.90159	
	Date	Intercept	0.00217	0.04658	
	Residual		0.16412	0.40512	
Fixed Effects	**Estimate**	**Std. Error**	**df**	**t value**	**Significance**
Intercept	2.369e+01	1.270e+00	3.845e+02	18.648	$2 \times 10^{-16***}$
lagged_sustainability_rating	9.393e-02	3.977e-02	5.720e+02	2.362	$0.0185*$
Fund_Type_Numeric	-3.907e+00	8.995e-01	1.093e+02	-4.343	$3.15 \times 10^{-5***}$
Avr. m.cap	4.723e-07	3.665e-07	5.148e+02	1.289	0.1981
Fund_size	1.536e-10	1.359e-10	5.351e+02	1.130	0.2588
Monthly Ret.	-8.980e-03	3.415e-03	9.231e+01	-2.629	$0.0100*$
PB	-4.283e-01	8.258e-02	5.073e+02	-5.187	$3.09 \times 10^{-7***}$
ROE	8.928e-03	1.134e-02	5.054e+02	0.787	0.4315
Draw_down	2.033e-02	3.471e-03	1.053e+02	5.855	$5.47 \times 10^{-8***}$

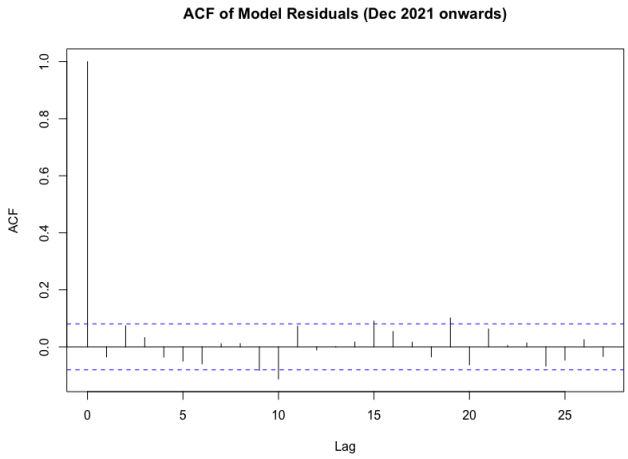

Figure 9

In our updated analysis using data from December 2021 onwards, we continue to gain key insights into the sustainability performance of Article 8 versus index funds. This model controls for fund-specific and market-level characteristics and includes time as a random effect. Our findings reveal that lagged sustainability rating remains a significant predictor of performance, suggesting consistent sustainability outcomes. If a fund had a better sustainability rating in the previous period, it likely maintains its strong performance. Notably, the fund type continues to significantly influence sustainability rating. Article 8 funds consistently outperform index funds in sustainability ratings, underlining their superior performance.

Among the control variables, the monthly returns and Price-to-Book ratio have a significant relationship with sustainability ratings. A higher PB ratio is associated with better sustainability ratings, suggesting that a fund's valuation plays a role in assessing its sustainability performance. Our model also highlights a shift in the influence of monthly returns on sustainability ratings. In the previous model using the full dataset, monthly returns were not a significant predictor. However, in the updated model, higher monthly returns are now associated with better sustainability ratings. This indicates that the relationship between financial returns and sustainability ratings has strengthened since December 2021, possibly due to recent market conditions or changes in fund strategies, leading to a closer alignment between financial returns and sustainability. However, the impact of ROE on sustainability ratings is less pronounced over time, indicating a possible weakening in this relationship. The autocorrelation function plot reveals minor instances of autocorrelation at lags 10, 15, and 19, indicating residual autocorrelation within the model. This suggests that, while we have successfully mitigated autocorrelation by considering time as a random effect and including lagged sustainability rating, it has not been entirely eradicated. In conclusion, the updated analysis reaffirms that, after accounting for several influential factors and temporal effects,

Article 8 funds tend to perform better in terms of sustainability compared to index funds. This offers evidence against greenwashing in the Article 8 fund market.

4.3 Discussion of the Results

Our analysis of the sustainability ratings of Article 8 and index funds provides compelling insights for a diverse array of stakeholders, including institutional and private investors, households, and regulatory bodies such as the European Union. These findings hold particular relevance in the light of the EU's sustainable finance framework and the EU taxonomy, which aim to provide clear guidelines for defining and promoting environmentally sustainable economic activities.

For institutional and private investors, such as Lars Qvigstad Sørensen, Senior Portfolio Manager at Storebrand Asset Management, our findings offer insightful trends. We have uncovered a consistent superior sustainability performance by Article 8 funds compared to index funds. However, it is worth noting that our findings are generalized, and the performance of individual funds can vary significantly. Each fund's sustainability performance should be assessed individually to understand its unique position within these broader trends. Our study challenges the traditional belief of mutually exclusive financial returns and sustainability ratings. We have identified a strengthening relationship between the two, presenting a fresh perspective for investment professionals. This pattern suggests that a portfolio composed predominantly of Article 8 funds could offer an attractive combination of sustainable and financial returns. In addressing the concern of greenwashing, the empirical evidence from our research indicating the consistent outperformance of Article 8 funds compared to index funds in terms of sustainability may contribute to greater transparency and signal a potential shift towards reduced greenwashing practices. However, it is important to scrutinize the sustainability claims of each fund individually, despite the general positive trend observed among Article 8 funds. Finally, our approach towards analyzing funds is in line with the EU's initiative to foster sustainable economic activities. This, along with our insights, can potentially support investment professionals like Dr. Sørensen and other stakeholders as they collaborate towards a greener future.

For households, the implications of our findings are particularly pertinent. With modern financial technologies and platforms providing easier access to various financial instruments, households now have the opportunity to engage in private investment. In this context, our insights into the sustainability performance of Article 8 funds can guide their investment decisions. As households become increasingly aware of and concerned about the environmental impact of their investments, the demonstrated superiority of

Article 8 funds in sustainability ratings provides a compelling option. By investing in these funds, households can not only contribute to environmental conservation but also secure their financial futures. The long-term superior sustainability performance of Article 8 funds can potentially yield sustainable returns, reinforcing the appeal of these funds to environmentally conscious private investors. Notably, the relationship between financial returns and sustainability ratings has strengthened since December 2021. This alignment could be attributed to recent market conditions or changes in fund strategies, and can provide a fresh perspective to households, in that prioritizing sustainability need not compromise financial returns. Reflecting on the research of Rannou et al. (2022) and Cremasco et al. (2022), which previously highlighted potential discrepancies and ambiguity in sustainability classifications and greenwashing, our findings add a new dimension to this narrative. Our results suggest a possible shift over time in the effectiveness of the SFDR in differentiating sustainability claims. It shows that Article 8 funds consistently scored statistically significantly higher on sustainability compared to conventional index funds. This trend might indicate an evolution towards more transparency and a potential reduction in greenwashing practices, signaling a potential transformation in the sustainability landscape.

The implications of our findings extend to the broader discourse on sustainable finance and the initiatives of the European Union. The EU taxonomy aims to create a common language for defining "sustainable" and help scale up sustainable investments. It seeks to protect investors from greenwashing, promote climate-friendly practices in companies, and mitigate market fragmentation. In line with these objectives, our study demonstrates how quantitative analysis can help identify funds that genuinely prioritize sustainable practices. By doing so, we contribute to the prevention of greenwashing, a misleading tactic where funds claim to be "green" without substantial evidence of their environmental performance.

Furthermore, our study aligns with the EU's overarching conditions for defining environmentally sustainable economic activities. Our models account for time-dependent trends, fund-specific and market-level characteristics, and also include a lagged sustainability rating. By comprehensively considering these parameters, our approach mirrors the multifaceted nature of the EU's conditions and the six climate and environmental objectives established in the Taxonomy Regulation (EU taxonomy for sustainable activities, n.d.).

Implication for the Paris Agreement

The findings of our study hold relevance for the objectives outlined in the Paris Agreement. The demonstrated efficacy of the SFDR regulations in enhancing transparency and curbing potential greenwashing contributes to the global efforts towards meeting the transparency and accountability commitments of the

Paris Agreement. Furthermore, our findings directly align with the Paris Agreement's aim to hold the increase in the global average temperature to well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius. The higher sustainability performance of Article 8 funds indicate that they are likely to be investing in activities that contribute less to greenhouse gas emissions. The emerging positive correlation between sustainability ratings and financial returns implies that it is becoming increasingly financially viable to invest in funds that support the goal of limiting global warming to 1.5 degrees Celsius. This, in turn, encourages further investments in such funds, providing a tangible pathway towards achieving this crucial target of the Paris Agreement. Finally, the observed trend towards sustainable investing being associated with financial rewards strengthens the Paris Agreement's objective of making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. It suggests that, over time, a low-carbon economy can be both environmentally sustainable and financially rewarding, which is a promising prospect for the world's climate goals (Paris Agreement, 2015, United Nations).

In summary, our study's findings offer valuable insights for investors, households, and policymakers striving to align financial decisions with sustainability objectives. By underscoring the superior performance of Article 8 funds and highlighting the strengthening relationship between financial returns and sustainability, our research contributes to the understanding of sustainable finance in the context of the EU taxonomy. It supports the EU's agenda of scaling up sustainable investments and provides robust, quantitative evidence to guide investors, households, and regulators in their pursuit of sustainability.

5. Conclusion

Our analysis and comparison of sustainability ratings between Article 8 and index funds, from May 2020 to February 2023, offer valuable and insightful perspectives on sustainable finance. Through robust statistical methods, we accounted for influential factors and temporal effects. We also addressed autocorrelation inherent in time-series data, incorporating a lagged dependent variable and treating time as a random effect.

Our research consistently demonstrates the superior sustainability ratings of Article 8 funds over index funds. This is a promising sign that SFDR regulations have improved transparency and decreased potential greenwashing. Moreover, we observed an emerging correlation between sustainability ratings and financial returns, particularly from December 2021 onwards, indicating a trend towards sustainable in-

vesting yielding financial rewards. However, as is the case with any study, this research has potential areas of expansion and limitations. Notably, we identified residual autocorrelation in our chosen model, suggesting opportunities for future research to refine the model further. Additionally, although we found a significant average effect, it would be insightful to analyze variations among individual funds, shedding light on specific Article 8 funds that perform exceptionally well or poorly. Furthermore, qualitative research could also complement our quantitative analysis. Methods such as interviewing fund managers or analyzing fund reports could provide more detailed insights into the practices and strategies of Article 8 funds, offering a holistic perspective on their performance.

In conclusion, our research adds valuable insights to the sustainable finance dialogue, underlining the importance of regulations like SFDR and the potential benefits of sustainable investing strategies. As the momentum behind sustainable investing continues to grow, our findings can guide investors, fund managers, and regulators. Future research, both quantitative and qualitative, will further enhance our understanding and aid in the development of a robust and sustainable financial ecosystem.

6. References

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Appendix

1. Morningstar Metrics Definition

Portfolio Environmental Risk Score

The asset-weighted average of the Company Environmental Risk scores for the covered corporate holdings in a portfolio. Company Environmental Risk Scores from Sustainalytics measure the degree to which a company's economic value may be at risk driven by environmental factors. The environmental risk represents the unmanaged environmental risk exposure after taking into account a company's management of such risks. The Environmental Risk Scores are displayed as a number between 0 and 100, though most scores range between 0 and 25.

Portfolio Social Risk Score

The asset-weighted average of the Company Social Risk Scores for the covered corporate holdings in a portfolio. Company Social Risk Scores from Sustainalytics measure the degree to which a company's economic value may be at risk driven by social factors. The social risk represents the unmanaged social risk exposure after taking into account a company's management of such risks. The Social Risk Scores are displayed as a number between 0 and 100, though most scores range between 0 and 25.

Portfolio Governance Risk Score

The asset-weighted average of the company Governance Risk Scores for the covered corporate holdings in a portfolio. Company Governance Risk Scores from Sustainalytics measure the degree to which a company's economic value may be at risk driven by governance factors. The governance risk represents the unmanaged governance risk exposure after taking into account a company's management of such risks. The Governance Risk Scores are displayed as a number between 0 and 100, though most scores range between 0 and 25.

Carbon Intensity

CALCULATED DATA: [Year]_Total Emissions / [Year]_Revenue (Mil USD). In metric tonneCO2e per Mil USD Revenue.

Emissions Scope 1

The asset-weighted average of holdings with scope 1 emissions data from Sustainalytics in a fund. Scope 1 emissions include direct greenhouse gas emissions from sources that are owned or controlled by the companies held in the fund. Scope 1 can include emissions from fossil fuels burned on site, emissions from entity-owned or entity-leased vehicles, and other direct sources.

Emissions Scope 2

The asset-weighted average of holdings with scope 2 emissions data from Sustainalytics in a fund. Scope 2 emissions include greenhouse gas emissions from the generation of purchased electricity consumed by the companies held in the fund. Scope 2 emissions physically occur at the facility where electricity is generated.

Percent of Female Executives and Directors

The asset-weighted average of female officers and directors of the equities held in the portfolio that are within the scope of our research coverage (UK, US and Canada equities).

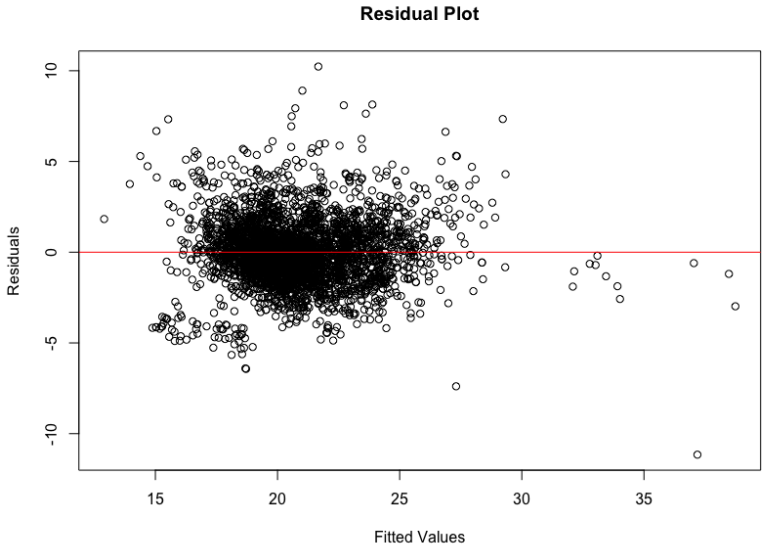
Water Withdrawal Intensity Average

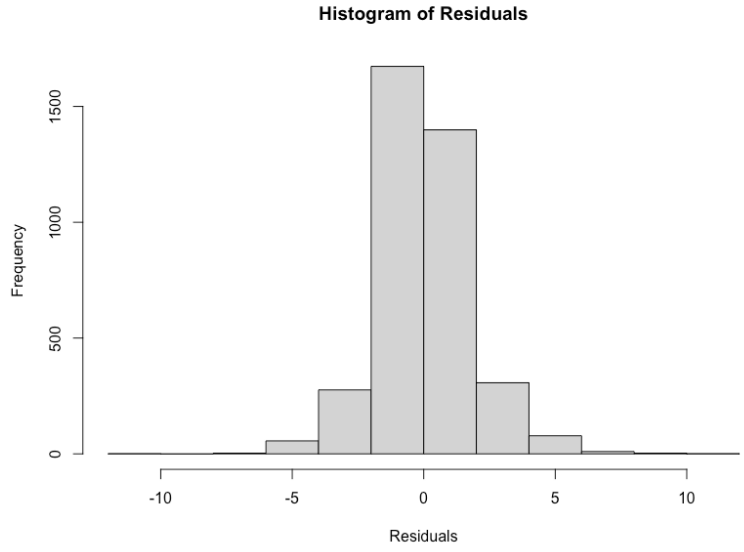
The weighted average of the covered holdings' water withdrawal intensity values. At the holding level, water withdrawal intensity represents the volume of water withdrawal per unit of revenue (million USD). Water withdrawal differs from water consumption or water usage, and is defined as the total volume (in cubic meters) of water withdrawn or diverted from various water sources, such as groundwater, lake, municipal supplies, etc. (including sea water).

Portfolio Carbon Risk Score

The asset-weighted average of the carbon risk scores for the portfolio's covered, corporate holdings. The carbon risk score indicates the overall material risk a company faces from the transition to a low-carbon economy. Carbon risk scores from Sustainalytics measure the degree to which a company's economic value may be at risk driven by carbon transition factors. The carbon risk score ranges from 0 to 100, with higher scores indicating higher carbon-related risks.

2. Validation of Article 8 & 9 model



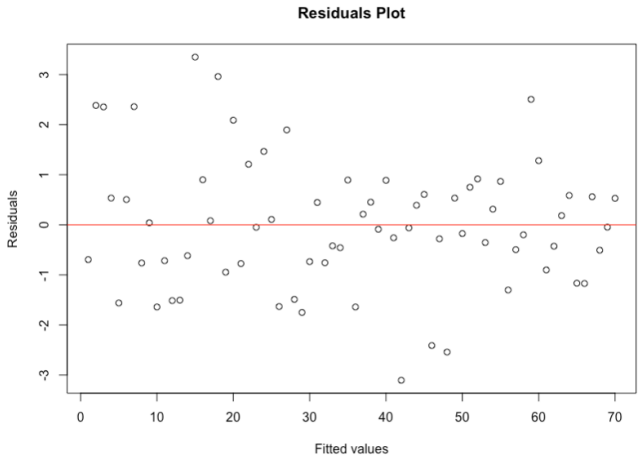


Histogram Residuals Article 8 & 9

VIFs Artcile 8 & 9

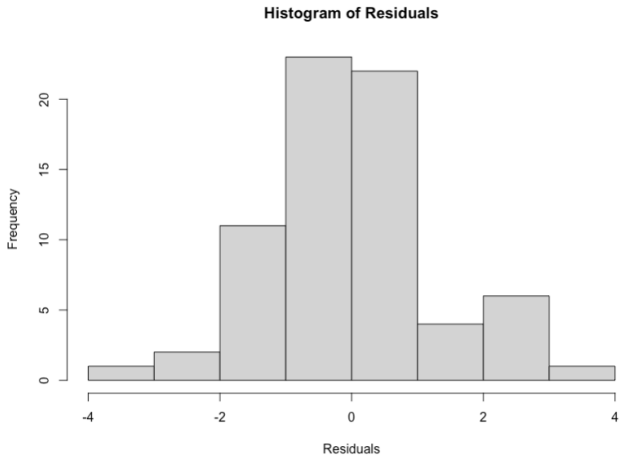
Variable	Value
Portfolio Environmental Score	1.619
Portfolio Social Score	3.209
Portfolio Governance Score	4.132
Carbon Intensity	1.239
Emissions Scope 1	1.942
Emissions Scope 2	1.910
Percent of Female Executives and Directors	1.361
Water Withdrawal Intensity Average	1.131

3. Validation of Index Model

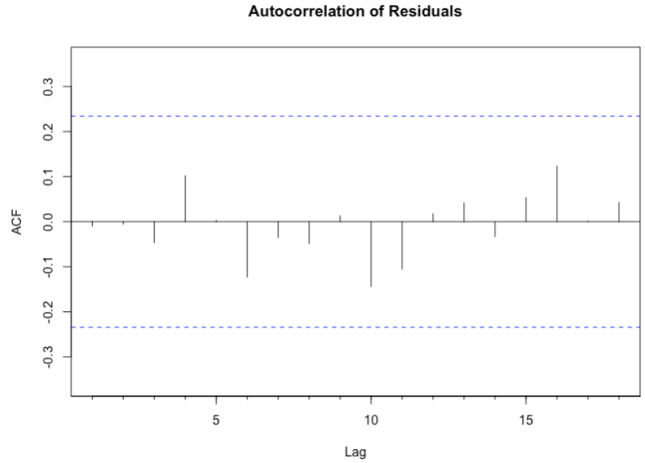


Durbin-Watson test

Data	**Durbin-Watson (DW)**	**p-value**
model_index_carbon_water	2.0126	0.5101



Autocorrelation Residuals Index



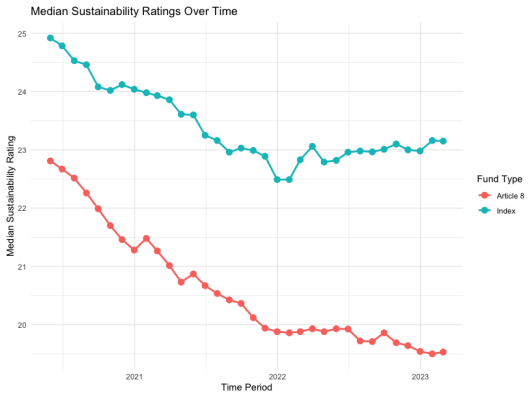
Shapiro-Wilk normality test

Data	W	p-value
residuals(model_index_carbon_water)	0.98289	0.455

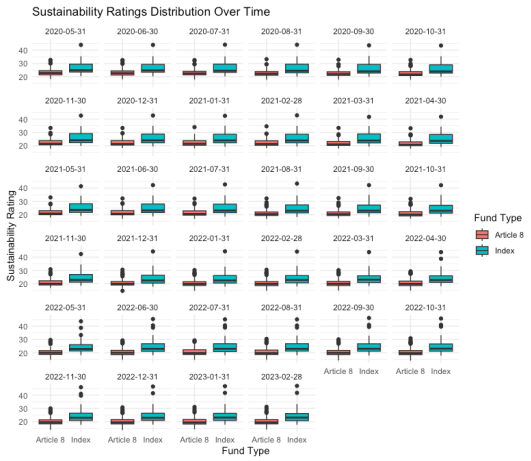
VIFs Index

Variable	VIF
Portfolio Carbon Risk Score	1.165
Portfolio Social Risk Score	3.026
Portfolio Governance Risk Score	3.702
Water Withdrawal Intensity Average	1.029
Percent of Female Executives and Directors	1.554

4. Median Sustainability Ratings Over Time

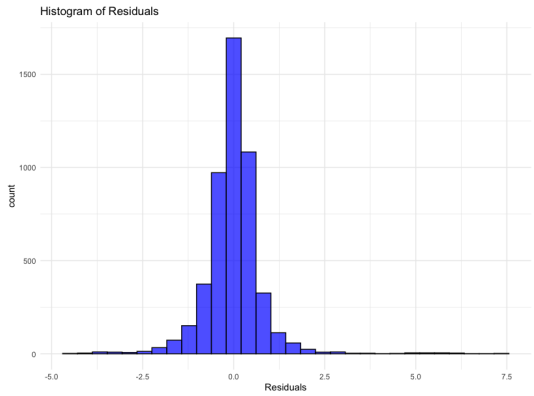


Median Sustainability Ratings Over Time

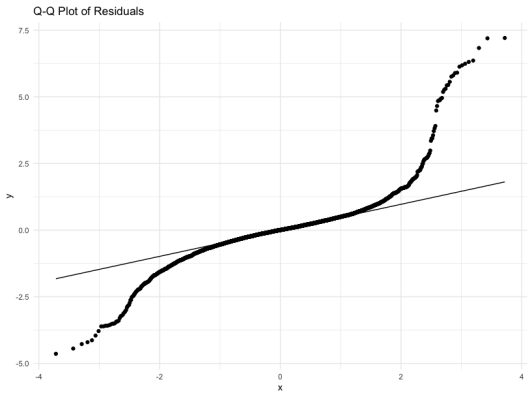


Sustainability Ratings Distribution Over Time Monthly Box Plot

5. Model Mixed_Effects Plots



(a) Histogram of Residuals

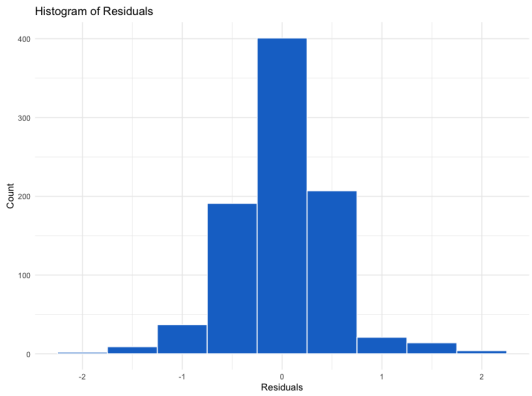


(b) Q-Q Plot of Residuals

6. Mixed_Effects_All

Correlation Fixed Effects

	Intercept	Fund_Type_Numeric	Avr.m.cap	Fund_Size	Monthly.Ret	PB	ROE
Fund_Type_Numeric	-0.028						
Avr.m.cap	0.032	-0.031					
Fund_Size	-0.048	-0.025	0.104				
Monthly.Ret	-0.045	0.003	-0.001	0.050			
PB	-0.132	-0.062	-0.219	-0.097	-0.010		
ROE	-0.147	0.003	-0.091	-0.009	0.100	-0.196	
Draw_down	0.089	0.017	0.058	-0.120	-0.368	-0.223	-0.051



Histogram of Residuals