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Research article

Greening the portfolio: The role of environmental innovation, clean production, and controversy avoidance in sustainable SFDR fund selection

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Abstract: The Sustainable Finance Disclosure Regulation (SFDR) plays a key role in increasing transparency and reducing information asymmetry in the EU fund management industry. This study examined the impact of corporate environmental commitment and controversies on portfolio selection within the SFDR fund categories, particularly Article 8 and 9 funds. It explored whether sustainable fund managers prioritize companies with green innovation and cleaner production while avoiding controversial sectors and companies involved in ESG controversies. Using quantile estimation, this study finds mixed results in the factors that may explain variations (both positive and negative) in the frequency that corporations are included in EU sustainable fund categories. Our findings highlight the significance of resource use and the controversial sectors for Article 8 funds, and asymmetric relationships in the environmental innovation, resource use, and controversial sectors depending on the quantile analyzed for Article 9 funds. These mixed results demonstrate that the decision-making process of fund managers regarding the inclusion or exclusion of assets in EU sustainable fund portfolios involves not only variables related to Principal Adverse Impacts but also other factors, making the process significantly more complex.

Keywords: environmental, social, and governance (ESG) performance; environmental innovation; clean production; ESG controversies; mutual funds; sustainable funds; sustainable regulation; Sustainable Finance Disclosure Regulation (SFDR)

JEL Codes: G11, Q56, Q58

1. Introduction

The European Union has positioned itself at the forefront of sustainable finance regulation over the past decades, aiming to promote climate mitigation and achieve climate neutrality by 2050. The Sustainable Finance Disclosure Regulation (SFDR) is a key component of this broader European strategy and forms a critical part of the EU's 2018 Action Plan on Sustainable Finance, which included, among others, the EU Taxonomy Regulation, the creation of two climate benchmarks (the EU Climate Transition Benchmark (EU CTB) and the EU Paris-Aligned Benchmark (EU PAB)) and a proposal of an EU Green Bond Standard. The SFDR was implemented through the EU 2019/2088 SFDR on March 10, 2021, and harmonized rules for sustainability-related disclosures in financial services. The regulation seeks to improve information availability, reduce asymmetries for investors, and ultimately steer capital allocation toward sustainable investments. A key aspect of this regulation was the categorization of funds depending on their sustainability by the fund management companies. The two EU sustainable fund categories related to sustainable investment were Article 8 (which "promote(s) among other environmental and social characteristics (...)" and Article 9 (which "ha(s) sustainable investment as their objective (...)". In this context, understanding how fund managers interpret and apply these categories has become increasingly important, particularly in light of downgrades and reclassifications of funds from Article 9 to Article 8 of 307 funds reported by Morningstar in the 1Q23 SFDR Market Review. This phenomenon raises critical questions about the factors influencing such changes. In line with the environmental pillar of the Principal Adverse Impacts (PAI) applicable to investments in investee companies, which are at the core of SFDR to increase transparency and to make informed decisions, this article seeks to contribute by exploring what environmental or controversy avoidance factors could explain the shifts of corporate presence in sustainable funds.

From the demand side, investors are expressing a preference for green assets (Pástor et al., 2021); however, due to the asymmetric information investors receive, it is difficult to observe the genuine commitment of funds (Emiris et al., 2024), making it challenging to distinguish greenwashers from authentic investors (Liang et al., 2021). The absence of harmonized regulation regarding ESG disclosure has led to market distortions (Muñoz et al., 2021) and has raised concerns about potential cases of greenwashing. Research on this issue has been mixed up to today. Some academics have fund-supporting evidence of potential greenwashing in the fund industry (Brandon et al., 2022; Gangi & Varrone, 2018; Kim & Yoon, 2020; Leite & Céu Cortez, 2014; Liang et al., 2021; Utz & Wimmer, 2014) while others have observed true commitment of sustainable funds (Alda, 2020; Benson et al., 2006; Joliet & Titova, 2018; Kempf & Osthoff, 2007; Martinez-Meyers et al., 2024; Nitsche & Schröder, 2018). ESG disclosure has been associated with higher abnormal returns regardless of whether the disclosures were good or bad thanks to the increase in transparency (Williams & Apollonio, 2024). Regulation could improve the quality of disclosure (Muserra et al., 2020) and a more refined regulatory system could address the issue of greenwashing (Gatti et al., 2019; Seele & Gatti, 2017).

The EU has acknowledged this challenge and has been at the forefront of promoting sustainability with key legislative initiatives in the last decade. The EU Directive 95/2014 made it mandatory for corporations to disclose non-financial information. More recently, the EU introduced the Action Plan on Financing Sustainable Growth in March 2018 and the EU Green Deal in December 2019. Among these initiatives, the SFDR was introduced to address greenwashing concerns and promote higher transparency in the European fund sector. However, the application of the SFDR has raised some doubts and concerns about its impact on fund managers' portfolio allocation and decision-making.

What are the corporate drivers and barriers that EU sustainable funds managers consider when making portfolio allocation decisions? Is the commitment to addressing the climate change challenge and green innovation a priority for EU sustainable funds fund managers? Does the involvement in controversies or exposure to controversial sectors affect the level of corporate presence in sustainable funds?

There is a research gap regarding the relationship between ESG mandatory fund labels and portfolio selection. Our research questions address this gap by investigating potential drivers in the portfolio selection of EU sustainable fund categories. This paper focuses on whether corporations' commitment to green innovation and cleaner production is essential to attract sustainable fund managers' investments. We also want to test if, at the same time, these sustainable-labeled funds, according to the SFDR, have avoided companies with ESG controversies or, on the other hand, have exposed them to controversial sectors. The study will help us determine if SFDR incentivizes sustainable funds to choose environmentally committed companies ("good green corporations") and avoid controversial ones ("sinners"). In this respect, it is expected that the SFDR regulation has influenced the environmental preferences of sustainable-declared funds regarding their portfolio allocation, leading them to choose companies with higher innovation and cleaner production scores while reducing exposure to controversial sectors and companies.

This paper makes several significant contributions to the existing literature. First, it addresses an essential research gap for the current EU context by highlighting the need for more in-depth studies on portfolio selection in relation to the SFDR. Second, it adopts a dual approach to selection, integrating a positive strategy that focuses on identifying "best-in-class" environmentally friendly performers with a negative screening method aimed at excluding "sinful" and controversial companies. Additionally, this study adopts a dynamic approach by analyzing the factors that may explain variations (both positive and negative) in the frequency that corporations are selected by fund managers from the EU sustainable fund categories. Furthermore, it employs a quantile estimation methodology, which allows for an examination of the consistency of the identified drivers across the variations that companies may experience in sustainable funds. The results of this paper not only enhance our understanding of how sustainable fund managers make investment decisions but also provide insights into the broader implications of the SFDR for the financial market.

Our study is structured as follows: After this introductory section, Section 2 covers the literature review and hypothesis development. In Section 3, we will detail data collection, variable definition, and methodology. In Section 4, we will present our empirical results. In Section 5, we will discuss our findings, and finally, our main conclusions and future research ideas will be exposed in Section 6.

2. Theoretical framework

This section, first, includes an introduction to the SFDR, the interrelationships with other EU regulations, and its requirements. Second, it presents the studies related to SFDR as well as the hypothesis development.

2.1. Regulatory settings within the SFDR

As previously mentioned, the EU has developed a comprehensive sustainable finance framework to support and advance climate and sustainability objectives in the region. At the core of this framework are three key regulatory initiatives: the SFDR (disclosure when selling financial products),

CSRD (sustainable reporting initiative for corporations), and EU Taxonomy (a classification system to define what activities qualify as environmental and sustainable). These initiatives are interconnected and work together to promote sustainable fund flows by enhancing transparency and accountability, aiming to reduce potential cases of greenwashing. These initiatives are also the key regulations included in the new streamlining revision from the EU, known as the Omnibus Sustainable Regulation, which was introduced for debate in February 2025.

The SFDR has been a regulation in evolution. The first implementation of the regulation has been called the Level 1 SFDR. One of the cornerstones of the regulation is the categorization of funds depending on their sustainability by the fund management companies. Table 1 displays the specifics of the various categories. For the purpose of this paper, we use the terms "EU sustainable fund categories" to refer to Article 8 (light green) and Article 9 (dark green). Investors are driven by "warm-glow preferences"—the satisfaction derived from owning investments labeled as sustainable (Bonnefon et al., 2025; Heeb et al., 2023). Hartzmark & Sussman (2019) found evidence that investors value sustainability in their fund selection, which is reflected in higher net inflows to SRI funds. By providing these labels, investors could reduce time and effort when researching SRI funds (Gutsche & Zwergel, 2020). Regulatory Technical Standards (RTS thereafter), also known as Level 2 of the SFDR, were introduced in January 2023. The categories remain in place, but in the update, the requirements to be categorized as Article 9 became stricter.

Table 1. SFDR categories.

Article number	Definition	Colloquial reference name
Article 6	Funds that do not take into account sustainability risks	Conventional non-ESG funds
Article 8	Funds that PROMOTE, among other environmental or social characteristics, provided the companies in which investments are made follow good governance practices	Light green
Article 9	Funds that have sustainable investment as their OBJECTIVE and comply with the "do no significant harm" principle to environmental or social objectives	Dark green

Source: Regulation (EU) 2019/2088

Since the start of the SFDR Level 1, the regulation has raised many concerns among practitioners. In the first quarter of the 2023 (1Q23) SFDR market review, Morningstar pointed out that there are still regulatory uncertainties and greenwashing concerns after two years. Morningstar observed the downgrade of 307 funds (a substantial share of passive and ETF funds) from Article 9 to Article 8 at the end of 2022 linked to the clarification provided by ESMA for RTS that Article 9 funds may only invest in sustainable investments except for cash and assets used for hedging purposes. In Figure 1, we can observe a significant increase in EU Sustainable Funds categories in recent years. By the end of the second quarter of 2024, they represented over 60% of the total assets under management in the EU fund universe.

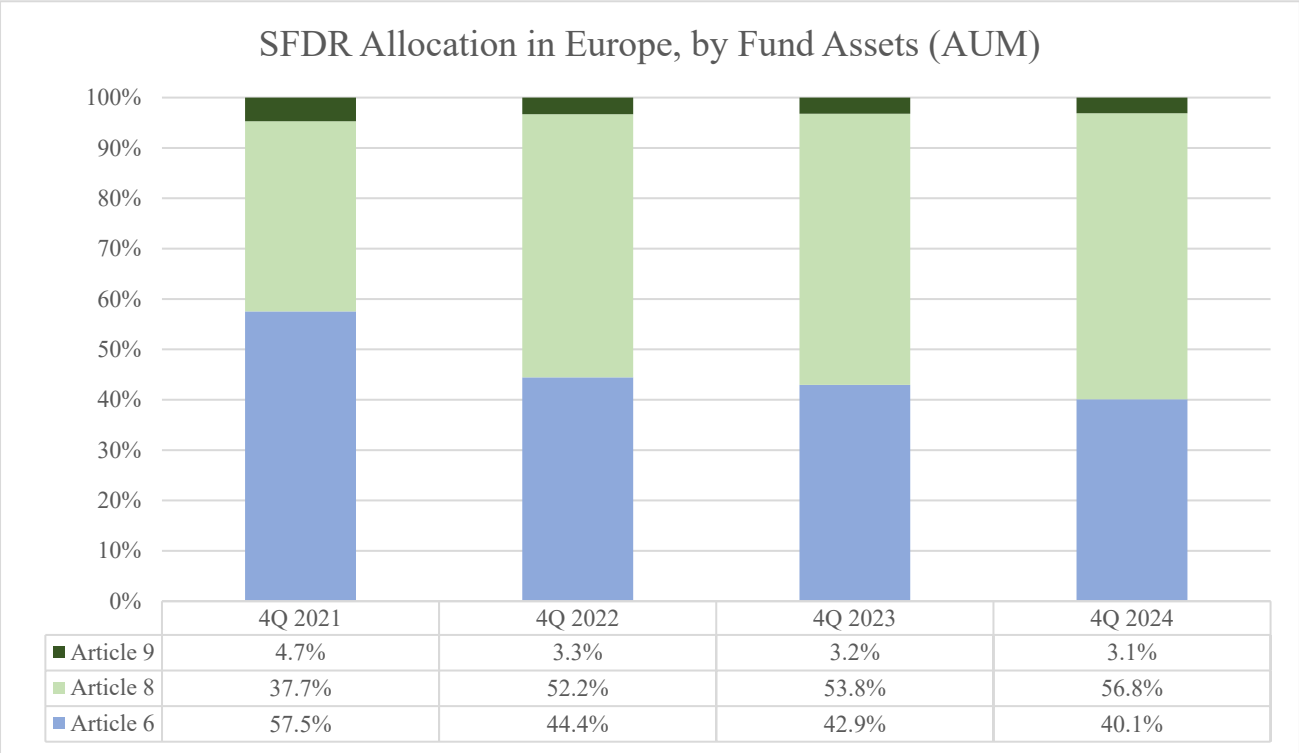

Figure 1. SFDR funds in Europe by Article (AUM) (Source: Morningstar.)

Level 2 of the SFDR and the Annex of 2022 included a list of the leading reference indicators (Principal Adverse Impacts, thereafter PAI) to include in the periodic pre-contractual and regular disclosure reports. The most used PAIs are those applicable to investments in investee companies, but there are also specific indicators applicable to investments in sovereigns, supranational, and real-estate assets. The final report on the draft of the Regulatory Technical Standards was released in December 2023 after a consultation process that included modifications and expansions of the PAI indicators. Table 2 shows the list of 14 mandatory indicators (9 for the environmental pillar and 5 for Social and Governance), which are complemented by 46 additional indicators.

The application of the SFDR requires investors to disclose these adverse impacts within their investment portfolios. As a result, fund managers will consider these indicators in their investment decisions, as they allow them to identify, manage, and mitigate sustainability risks. This paper focuses on five corporate variables linked to the 14 mandatory indicators (see Table 2 for the relationships), with the aim of analyzing whether companies that perform well in these variables, and thus minimize PAIs, have a greater presence in funds categorized as Article 8 and 9. These five corporate variables are: environmental innovation, emission reduction, environmental resource use, controversial sector, and corporate controversies.

Table 2. Description of the Principal Adverse Impacts (PAI) indicators on sustainability factors and their connection to the main variables.

List of the PAI applicable to investments in investee companies	Main variables under study
ENVIRONMENTAL PILLAR	
1. GHG emissions (Scope 1, Scope 2, Scope 3, and Total GHG emissions)	Environmental Innovation, Emission Reduction
2. Carbon footprint	Environmental Innovation, Emission Reduction
3. GHG intensity of investee companies	Environmental Innovation, Emission Reduction
4. Exposure to companies active in the fossil fuel sector	Controversial Sector
5. Share of non-renewable energy consumption and production	Environmental Innovation, Environmental Resource Use
6. Energy consumption intensity per high impact climate sector	Environmental Innovation, Emission Reduction, Environmental Resource Use
7. Activities negatively affecting biodiversity-sensitive areas	Environmental Innovation, Emission Reduction Environmental Resource Use
8. Emissions to water	Environmental Innovation, Emission Reduction
9. Hazardous waste and radioactive waste ratio	Environmental Innovation, Emission Reduction
SOCIAL AND GOVERNANCE PILLAR	
10. Violations of the UN Global Compact Principles and OECD guidelines for multinational enterprises	Corporate Controversies
11. Lack of compliance with UN Global Compact Principles and OECD guidelines	Corporate Controversies
12. Unadjusted gender pay gap	Corporate Controversies
13. Board gender diversity	Corporate Controversies
14. Exposure to controversial weapons	Controversial Sector

Source: Our own elaboration based on Regulation (EU) 2019/2088 on sustainability-related disclosures in the financial services sector and Commission Delegated Regulation (EU) 2022/1288 (RTS implementing SFDR).

2.2. Studies related to the SFDR

The publication and entry into force of the SFDR are relatively recent; however, its application has attracted interest from academic researchers and practitioners. Previous literature has centered mainly on the effect of the SFDR on investment fund flows. Becker et al. (2022) observed that in the SFDR, the European funds experienced a higher increase in fund net inflows and in ESG scores vs. the matched USA funds. Ferriani (2022) studied the link between two sustainability labels and fund flows. The research observed that Morningstar (2023) sustainability ratings were more relevant for investors than the EU regulation labels. According to Emiris et al. (2024), the SFDR significantly impacted flows to ESG funds, with countries exhibiting stronger environmental preferences being more responsive to ESG labels.

Bengo et al. (2022) presented a conceptual paper focusing on social impact measurement practices and procedures linked to the SFDR. They associated Article 8 funds with proactive ESG performance approaches and Article 9 with a stronger commitment to promote change that they define as "ESG to Value". This aligns with Oehmke and Opp (2024), who proposed that socially responsible

funds need a mandate that allows the fund to trade off financial performance for social impact and emphasize the need for impact-oriented efforts metrics. Inderst and Opp (2025) highlighted the need of a clear taxonomy for sustainable investment products to prevent greenwashing and ensure the impact of sustainable finance.

Is the SFDR fulfilling its intended role as a clear sustainable investment taxonomy? Several recent papers on this topic raise concerns about the usefulness of the SFDR for sustainable investors. Fund managers are using SFDR sustainable categories to send a green signal to investors. However, the signal may not accurately reflect their true commitment to sustainability. Cremasco & Boni (2022) compared SFDR Article 9 funds vs. Article 6 and found, surprisingly, that both categories behaved similarly from a financial and sustainability perspective. Additionally, Scheitza and Busch (2024) analyzed the ambition level of SFDR Article 9 funds and found no significant differences in ESG scores between ESG-related and impact-related funds. Similarly, Lambillon and Chesney (2023) highlighted that the implementation of the SFDR Article 9 could lead to greenwashing risks due to discrepancies between the sustainability criteria of Article 9 funds and their actual investment practices. Recently, Abouarab et al. (2025) evaluated, through the use of a Greenwashing Index, whether the SFDR mitigates greenwashing among EU funds. They observed progress along with challenges and different behavior between the two categories of EU sustainable funds.

2.3. Hypothesis development

2.3.1. Environmental innovation as a driver

Due to the urgency of the climate change challenge, environmental management has become crucial. Governments and corporations are responding to the challenge of the climate transition. Companies are proactively responding to the challenge of climate transition as it has been linked positively to economic and operational performance (Augusto de Oliveira et al., 2019). Improved company reputation and appeal for job seekers have also been linked to environmental innovation (Liao & Cheng, 2020). Cortez et al. in 2022 observed that a green portfolio of energy stocks created using Eikon environmental theme scores, including environmental innovation, outperformed the market and its non-green counterparts from January 2008 to November 2020. Environmental actions have been linked to the signaling theory (Grinblatt & Hwang, 1989). Truong et al. (2021) observed that substantive actions improve the relative reputation of the company versus its peers. This helps demonstrate a genuine commitment to the cause as opposed to mere symbolic actions.

Rennings (2000, p. 322) defined environmental innovation or eco-innovations as “all measures of relevant actors (firms, politicians, unions, associations, churches, private households) which develop new ideas, behavior, products, and processes, apply or introduce them and contribute to a reduction of environmental burdens or to ecologically specified sustainability targets”. The author points out that environmental innovation helps balance the burden of environmental regulations. Hong et al. (2020) observed that mandatory environmental regulations can promote green innovation. Environmental innovation is also linked to the circular economy, a critical transition pillar toward a net-zero economy (Vieira & Radonjič, 2020).

Based on the previous arguments, we want to test if environmental innovation can act as a driver for fund managers with the following hypothesis:

HYPOTHESIS 1: Environmental innovation of corporations will positively affect their inclusion in the portfolios of Sustainable SFDR fund categories.

2.3.2. Cleaner production as a driver

Cleaner production (CP) encompasses a set of practices aimed at reducing emissions and maximizing resource use, where companies focus on reducing consumption and emissions to diminish negative externalities. Cleaner production refers to methods, practices, and tools that aim to improve industrial processes and reduce waste (Severo et al., 2017). CP is a proactive strategy that can result in long-term better performance, create a competitive advantage (Amores-Salvadó et al., 2014), enhance reputation (Matos et al., 2018), and reduce liability risk (Awewomom et al., 2024).

Matozza et al. (2019) observed that polluting industries, after experiencing reputation damage, achieve a higher environmental performance in the search to repair their environmental reputation. Companies have a moral responsibility to generate value for all stakeholders, as they have a moral claim on the company (Freeman, 1984; Freeman & Dmytriyev, 2020). Stakeholders favor CP practices because these proactive strategies can help advance the conversation about environmental commitment.

Therefore, based on the previous arguments, we propose to test the effect of cleaner production in terms of emission reduction and resource use as additional drivers for portfolio selection of sustainable European categories.

HYPOTHESIS 2: Emission reduction of corporations will positively affect their inclusion in the portfolios of Sustainable SFDR fund categories.

HYPOTHESIS 3: Corporations' use of environmental resources will positively affect their inclusion in the portfolios of Sustainable SFDR fund categories.

2.3.3. Exposure to the controversial sector as a barrier to investment

The legitimacy theory (Suchman, 1995) suggests that corporations may comply with norms to maintain legitimacy and reduce social pressure. Concerns about corporate legitimacy drive Corporate Social Responsibility (CSR) disclosure (Cho et al., 2015). Therefore, the company may use disclosure as a tactic or strategy, and understanding the motivations behind disclosure may be complex (Luft Mobus, 2005).

Investors are now more aware of the significance and influence of ESG criteria on performance. ESG scores, which evaluate the performance of reported information across the three pillars, have become standard practice for investors despite their limitations, divergences (Berg, Kölbel, & Rigobon, 2022), and biases. Additionally, investors recognize the significance of non-reported sustainability related information, commonly referred to as ESG controversies. ESG controversies, also called negative CSR events, have been linked to strong adverse market reactions (Hummel et al., 2019), translate into financial risk and increased investor uncertainty regarding the firm value, and can be seen as a proxy for potential threats to corporate legitimacy (Schiemann & Tietmeyer, 2022). SFDR regulation can be viewed as a tool for fund management companies to claim legitimacy after accusations and concerns about greenwashing in the fund industry. Our study analyzes whether fund managers of sustainable European categories avoid companies with controversies in their portfolios.

We will test both perspectives: 1) exposure to controversial sectors and 2) companies involved in controversies measured through an ESG controversy score.

Certain sectors are linked to controversies from the perspective of a sustainable investor. The origins of ethical finance were linked traditionally to "negative screening." In this approach, some sectors were excluded based on ethical considerations. Historically, these sectors have been called "sin sectors" and include alcohol, tobacco, gambling, and controversial weapons. We argue that sustainable SFDR fund categories will have a lower presence in their portfolios of the "sin sectors" due to regulation and the principle of "do no significant harm" (DNSH).

With time, controversial sectors have expanded to include high-polluting sectors. As mentioned earlier, as part of the effort to promote sustainability, the EU established a Green Taxonomy, which is a list of activities that contribute to at least one environmental objective and do not significantly harm any others. The EU Taxonomy does not explicitly exclude any sectors or industries. However, in the annex, the regulation states, "An activity is considered to do significant harm to climate change mitigation if it leads to significant greenhouse gas (GHG) emissions". Therefore, we adopt an expanded definition of controversial sectors, encompassing fossil fuels (oil and coal). We do not exclude activities in the nuclear and gas sectors as they were subject to a complementary delegated act proposed by the European Commission in February 2022. Therefore, we propose to test the following hypothesis:

HYPOTHESIS 4: Corporations that belong to controversial sectors will negatively affect their inclusion in the portfolios of Sustainable SFDR categories.

2.3.4. Involvement in controversies as a barrier

The ESG (Environmental, Social, and Governance) controversies score is a metric used to assess the performance and behavior of companies in relation to sustainability and responsible business practices. It measures the extent to which a company is involved in or associated with controversies that could impact its ESG score. The controversies score considers factors such as environmental violations, labor disputes (strikes), product recalls, human rights issues, executive compensation, and board diversity, among others. ESG controversy scores are typically negative due to their negative impact and lower the company's overall ESG score. Controversies have been observed to have a negative relationship with firm performance (Elamer & Boulhaga, 2024) and future results (Passos & Campos-Rasera, 2023).

We argue that sustainable categories of SFDR funds will consider these factors and the guidance of "do not significant harm," and will choose companies with lower ESG controversy scores.

HYPOTHESIS 5: Corporations with high involvement in controversies will negatively affect their inclusion in the portfolios of Sustainable SFDR categories.

3. Materials and methods

3.1. Data collection

To analyze the effect of this regulation of the SFDR in portfolio construction, we have used the Eurostoxx 600. The EURO STOXX 600 is a stock index that represents the performance of 600 large, mid-, and small-cap companies across 18 European countries. It is designed to provide a

comprehensive measure of the European stock market. The index is maintained and calculated by STOXX Ltd., which is a global index provider owned by Deutsche Börse Group. The EURO STOXX 600 is often used as a benchmark to track the performance of European equities. We used Bloomberg to find the composition of the Euro Stoxx 600 at the time of the first collection of data. The sample includes data from March 2023 to March 2024. Finally, this study uses four quarters from May 2023 to March 2024 since data from March 2023 is used to calculate the first-time variations in the dependent variables. ESG data is published annually based on companies' sustainability reports. Consequently, the ESG scores used correspond to the 2022 fiscal year for all quarters of 2023 and to the 2023 fiscal year for the data reported in March 2024.

3.2. Quantile regression

Linear regression is one of the most used techniques to test relationships between corporate performance and corporate drivers and barriers. Ordinary linear regression predicts the mean; for this reason, the estimated coefficients are informative in the central part of the conditional distribution of the outcome variables; however, it does not allow one to estimate the dissimilar locations of the conditional distribution (Carfora et al., 2022). With the aim of overcoming this limitation and showing a complete picture of the relationship between dependent and independent variables (Muhammad and Migliori, 2022), this study uses a quantile regression technique (Koenker and Bassett, 1978). In addition, quantile regression does not need to comply with strict assumptions such as normality, homoscedasticity, or outliners (Johnston and Di Nardo, 2007)[1].

Based on the previous research and the development of hypotheses, this study tests the following quantile regression model:

$$\begin{aligned} \mathrm{Q}\left(\frac{Variation\ in\ Sustainable\ SFDR\ funds_i}{x_i}\right) &= \alpha + \beta_1 \cdot Innovation_i + \beta_2 \cdot Emissions_i + \beta_3 \cdot Resource\ use_i + \beta_4 \\ &\cdot Contro\ sectors_i + \beta_5 \cdot Controversies_i + \beta_6 \cdot Mkt\ Cap_i + \beta_7 \cdot PE_i + \beta_8 \\ &\cdot Px\ to\ Sales_i + \beta_9 \cdot Px\ to\ Book_i + \beta_{10} \cdot Px\ to\ cash\ flow_i + \sum_{K=1}^{10} \beta_{11,K} \cdot Sector_i \\ &+ \varepsilon_i \end{aligned}$$

where $\mathrm{Q}\left(\frac{Variation\ in\ Sustainable\ SFDR\ funds_i}{x_i}\right)$ denotes the conditional quantile function for the θth quantile, where $0 < \theta < 1$. The estimates have been made using simultaneous quantile estimation. The variables used are described in Section 3.

3.3. Description of variables

We created our sample by gathering information from two different databases: Bloomberg and LSEG Eikon. Our dependent variable is the quarterly variation in the frequency that corporations are selected by fund managers from European sustainable fund categories. By utilizing Bloomberg functions within the Bloomberg Database, we can determine the frequency at which each company in

[1] For a detailed list of advantages of quantile regression over simple linear regressions, see Gallego-Álvarez and Ortas, (2017).

the Eurostoxx 600 was included in the portfolio of SFDR funds for both Article 8 and Article 9 sustainable categories. Thus, we build two proxies (variation Article 8 and variation Article 9) of the dependent variable to capture changes in fund manager preferences over time in sustainable fund selection.

Our environmental innovation (Innovation) and clean production scores (Emissions and Resource use) are obtained from LSEG Eikon. For hypotheses 1, 2, and 3, we used the independent variables included in the breakdown of the environmental score from Eikon, which include Innovation, Emissions, and Resource use (LSEG, 2024). The scores from Eikon are calculated on a scale from 0 to 100 and represent the relative performance of ESG factors compared to the company's sector. According to LSEG (2024), the innovation category includes product innovation and green revenues/R&D/capex; the emissions reduction score considers indicators regarding emissions, environmental management systems, waste, and biodiversity; and the resource use category takes into account the following themes: water, energy, sustainable packaging, and environmental supply chain. Quintana-García et al. (2022) used these variables in their model and argued that resource efficiency, emission reduction, and innovation encompass comprehensive environmental practices. The validity of this database is supported by previous research (Cortez et al., 2022; Quintana-García et al., 2022).

We compiled a database of companies and their respective sectors and industries to create a dummy variable "Contro sectors" to measure whether companies belong to controversial sectors. First, we considered, as controversial sectors, the traditional ones such as alcohol (including breweries and distilleries), tobacco manufacturing, gambling, and companies involved in the production of controversial weapons and fossil fuels. These companies are often referred to as "sin stocks," "shunned stocks," or "vice stocks" because they generate profits from human vices (Blitz & Fabozzi, 2017). We use MSCI's "business involvement screens" to identify whether a company was affected by the four aforementioned screens. MSCI's screens are based on reported or estimated revenue. Second, we also considered controversial sectors from an environmental point of view, such as petroleum refineries, petroleum bulk stations and terminals, and coal mining.

To test hypothesis 5, we used the Eikon ESG controversy score to measure corporations' involvement in controversies (Controversies). The score is based on 23 ESG controversy topics, is calculated in relation to the industry peers, and addresses the market cap bias of large caps attracting more media attention. The higher the controversy score, the higher the grade and the lower the negative impact in the final Eikon ESG combined score. In Eikon, a score of 100% is linked to a grade of A+, which implies no controversies. To mitigate market cap bias, severity weights are applied, ensuring fair comparison between large- and small-cap companies (LSEG, 2024). The use of the Eikon ESG controversies score as a variable has been previously supported in academic research (Passos & Campos-Rasera, 2023; Giráldez-Puig et al., 2024).

The study includes several control variables. We include the variable Market Capitalization as a proxy for the company's size. We also include several control variables linked to valuation: Price Earnings Ratio, Price to Sales, Price to Book Value, and Price to Cash Flow. The data for the control variables were obtained for each period of the sample using LSEG Eikon. The Global Industry Classification Standard (GICS) was used to identify the main industry group that a company belongs to and create industry-specific dummy variables. Note that in this case, we have omitted the industrials category.

4. Results

4.1. Descriptive analysis

Table 3 displays the descriptive statistics for both the dependent and independent variables. Focusing on the dependent variables, this study highlights the differences between Articles 9 and 8 in terms of the variation of companies selected by fund managers. With respect to the sample of the study, given that Article 8 represents the majority of the UE Sustainable Fund Market, the companies have increased their presence in Article 8 funds substantially in comparison with Article 9 funds. Focusing on quantiles, it is observed that a substantial part of the sample has decreased their presence in funds categorized as Articles 8 (more than 10% of the sample) and 9 (more than 25% of the sample). Regarding the independent variables, the companies analyzed present a high commitment and effectiveness toward reducing environmental emissions (76.41 points out of 100, on average) and the use of resources (76.25 points out of 100, on average), and show a higher dispersion in terms of environmental innovation efforts (50.32 points out of 100, on average). Out of the sample, only 5% of the sectors are considered controversial. Additionally, over 50% of the companies have not been featured in any media reports regarding controversies, as they have received the highest scores in this area (100). Please be aware that Eikon takes into account the number of controversies and various types of controversies when determining the penalty for the score.

Table 3. Descriptive statistics of dependent and independent variables.

	Mean	S.D.	10th P.	25th P.	50th P.	75th P.	90th P.
VAR_ART_9	1.50	7.28	−6.00	−2.00	1.00	4.00	9.00
VAR_ART_8	55.34	116.91	−30	10	50	98	152
INNOVATION	50.32	33.19	0.00	20.54	52.34	80.34	93.54
EMISSIONS	76.41	20.04	48.19	64.99	81.87	92.46	97.46
RESOURCE USE	76.25	22.26	43.17	64.09	83.73	94.43	97.81
CONTRO_SECTORS	5	21.80	0.00	0.00	0.00	0.00	0.00
CONTROVERSIES	76.75	32.32	20.54	51.56	100.00	100.00	100.00

Table 4. Sector analysis of the sample vs. Eurostoxx.

	Weight in Article 9	Weight in Article 8	Weight by CAP Eurostoxx
COMUNICATION	5.6%	5.90%	2.60%
CONSUMER DISCRETIONARY	10.5%	11.70%	9.20%
CONSUMER STAPLES	7.9%	8.80%	7.20%
ENERGY	1.0%	2.40%	5.40%
FINANCIALS	16.6%	19.00%	32.30%
HEALTHCARE	10.4%	10.20%	14.10%
INDUSTRIALS	22.0%	18.50%	16.80%
INFORMATION TECHNOLOGY	6.5%	5.30%	4.00%
MATERIAL	9.5%	8.90%	4.80%
REAL ESTATE	4.1%	4.10%	1.20%
UTILITIES	5.8%	5.20%	2.40%

From an exploratory approach, this study performs a sector analysis to compare the frequency of companies in that sector that appear in Article 9 funds versus Article 8 versus their unadjusted weight using a total market cap of Eurostoxx 600. In Table 4, we observe that Article 9 funds are overweight

in the Industrial, Materials, Technology, and Utilities sectors while underweight in Energy and Financials at the start of our sample collection. This sector alignment could be linked to the guidelines given for this category and the link to sectors eligible under the Green Taxonomy. Article 8 funds show a different sector exposure with a higher relative weight in Communications, Consumer Discretionary, and Staples and Real Estate. Given these differences, depending on the industry, this study has included industry-specific dummy variables to control these effects.

4.2. Multivariable analysis

Tables 5 and 6 display the estimates of the ordinary least squares (OLS) and quantile regressions. Figures 2 and 3 show the estimation results and the patterns of the coefficients of the independent variables across quantile levels.

Table 5. Estimated coefficients for OLS and quantile regressions. Dependent variables: VAR_ART_9.

Variables	OLS	10^{th} P.	25^{th} P.	50^{th} P.	75^{th} P.	90^{th} P.
INNOVATION	0.0037	−0.0152**	−0.0047	−0.0006	0.0099**	0.0218**
	(0.0053)	(0.0062)	(0.0047)	(0.0037)	(0.0043)	(0.0094)
EMISSIONS	0.0023	−0.0028	−0.0021	−0.0038	0.0009	0.0252*
	(0.0088)	(0.0149)	(0.0093)	(0.0081)	(0.0115)	(0.0142)
RESOURCE USE	0.0131	−0.0295**	−0.0139*	0.0093	0.0256***	0.0236
	(0.0083)	(0.0116)	(0.0071)	(0.0066)	(0.0094)	(0.0211)
CONTRO_SECTORS	−0.0063	0.0300***	0.0163***	−0.0053	−0.0181**	−0.0339***
	(0.054)	(0.0075)	(0.0048)	(0.0036)	(0.0073)	(0.0087)
CONTROVERSIES	0.0021	−0.0020	0.0081	0.0009	−0.0006	0.0073
	(0.0057)	(0.0080)	(0.0058)	(0.0052)	(0.0077)	(0.0136)
MKT_CAP	1.7347***	0.4745	0.3536	1.1557***	2.2086***	4.0094***
	(0.3035)	(0.4632)	(0.2878)	(0.2369)	(0.3867)	(0.6026)
PE_RATIO	−0.0000	−0.0000	0.0000	−0.0000	−0.0000	−0.0000
	(0.0000)	(0.0016)	(0.0013)	(0.0019)	(0.0014)	(0.0022)
PX_TO_SALES RATIO	0.1497***	0.0636	0.0851*	0.1043***	0.1207	0.3197**
	(0.0531)	(0.0637)	(0.0439)	(0.0349)	(0.0760)	(0.1544)
PX_TO_BOOK_RATIO	0.0457*	0.0357	0.0175	0.0036	0.0301	0.0680
	(0.0266)	(0.0485)	(0.0287)	(0.0303)	(0.0312)	(0.0431)
PX_TO_CASH_FLOW	0.0005	0.0014	−0.0002	−0.0032	0.0083	0.0099
	(0.0045)	(0.0048)	(0.0031)	(0.0084)	(0.0097)	(0.0093)
INDUSTRY DUMMIES	Included	Included	Included	Included	Included	Included
CONSTANT	−7.7789***	−4.7001**	−2.5226*	−4.5733***	−8.1019***	−14.0960***
	(1.5865)	(2.2235)	(1.3866)	(1.2002)	(2.3356)	(3.1762)

Including 1938 observations. Statistically significant at 1% (***), 5% (**), and 10% (*).

The impact of environmental innovation leads to a heterogeneous and asymmetric increase in the number of funds categorized as Articles 8 and 9. In fact, hypothesis 1 is only supported in the highest quantiles. Contrary to what was expected, focusing on Article 9, the impact of environmental innovation is statistically significant and negative at the lowest quantiles. One possible reason for this outcome is that the score assesses the ability to minimize environmental costs and increase green revenues, research and development, and capital expenditures, while the SFDR's Performance Adverse Indicators (PAI) prioritize environmental outcomes and impacts (refer to Table 2 for the list of PAI). For this reason, fund managers may have been attempting to manage reputational risks by adopting a conservative approach. This could involve reducing their exposure or reevaluating companies in their Article 9 fund

portfolios even though they were highly invested in green investments and innovation but exhibited a low impact in environmental outcomes and performance as measured in the SFDR disclosures.

Table 6. Estimated coefficients for OLS and quantile regressions. Dependent variables: VAR_ART_8.

Variables	OLS	10th P.	25th P.	50th P.	75th P.	90th P.
INNOVATION	−0.0018	−0.0408	−0.0376	0.0633	0.1260	0.2653*
	(0.0714)	(0.1158)	(0.0722)	(0.0647)	(0.0768)	(0.1485)
EMISSIONS	0.0205	−0.3233*	−0.1415	−0.1108	0.0490	0.3856*
	(0.1153)	(0.1845)	(0.0965)	(0.0685)	(0.1229)	(0.1982)
RESOURCE USE	0.3912***	0.2419	0.2566**	0.4503***	0.4915***	0.3784
	(0.1175)	(0.1747)	(0.1214)	(0.0785)	(0.1268)	(0.2620)
CONTRO_SECTORS	−0.3399***	−0.1223	−0.2808***	−0.2519**	−0.3074***	−0.7108***
	(0.0825)	(0.1672)	(0.0973)	(0.0995)	(0.1170)	(0.2075)
CONTROVERSIES	−0.1444*	−0.0691	−0.1009**	−0.0968*	−0.2503***	−0.1515
	(0.0802)	(0.1091)	(0.0453)	(0.0502)	(0.0643)	(0.1457)
MKT_CAP	26.6732***	−0.9056	15.5263***	25.8699***	31.6282***	49.8142***
	(3.7686)	(5.7290)	(4.0302)	(3.3130)	(3.5735)	(6.0764)
PE_RATIO	−0.0000	−0.0001	−0.0002	−0.0002	0.0001	0.0001
	(0.0001)	(0.0180)	(0.0191)	(0.0072)	(0.0191)	(0.0351)
PX_TO_SALES RATIO	2.2194***	2.6600***	2.3938***	2.3780***	2.1300**	1.3490
	(0.6556)	(0.8793)	(0.4293)	(0.5287)	(0.9996)	(1.8881)
PX_TO_BOOK_RATIO	0.5598*	0.3961	0.0143	0.4802	0.4594	0.8411
	(0.2932)	(0.5669)	(0.2845)	(0.3142)	(0.6481)	(1.1233)
PX_TO_CASH_FLOW	−0.0041	0.0366	−0.0140	−0.0343	−0.0341	−0.0102
	(0.0573)	(0.0823)	(0.0409)	(0.0686)	(0.1230)	(0.1840)
INDUSTRY DUMMIES	Included	Included	Included	Included	Included	Included
CONSTANT	−80.7869***	−0.5963	−49.1262***	−82.4161***	−73.9972***	−73.4010**
	(19.8291)	(22.2878)	(14.8248)	(14.4166)	(17.9688)	(31.8233)

Including 1938 observations. Statistically significant at 1% (***), 5% (**), and 10% (*).

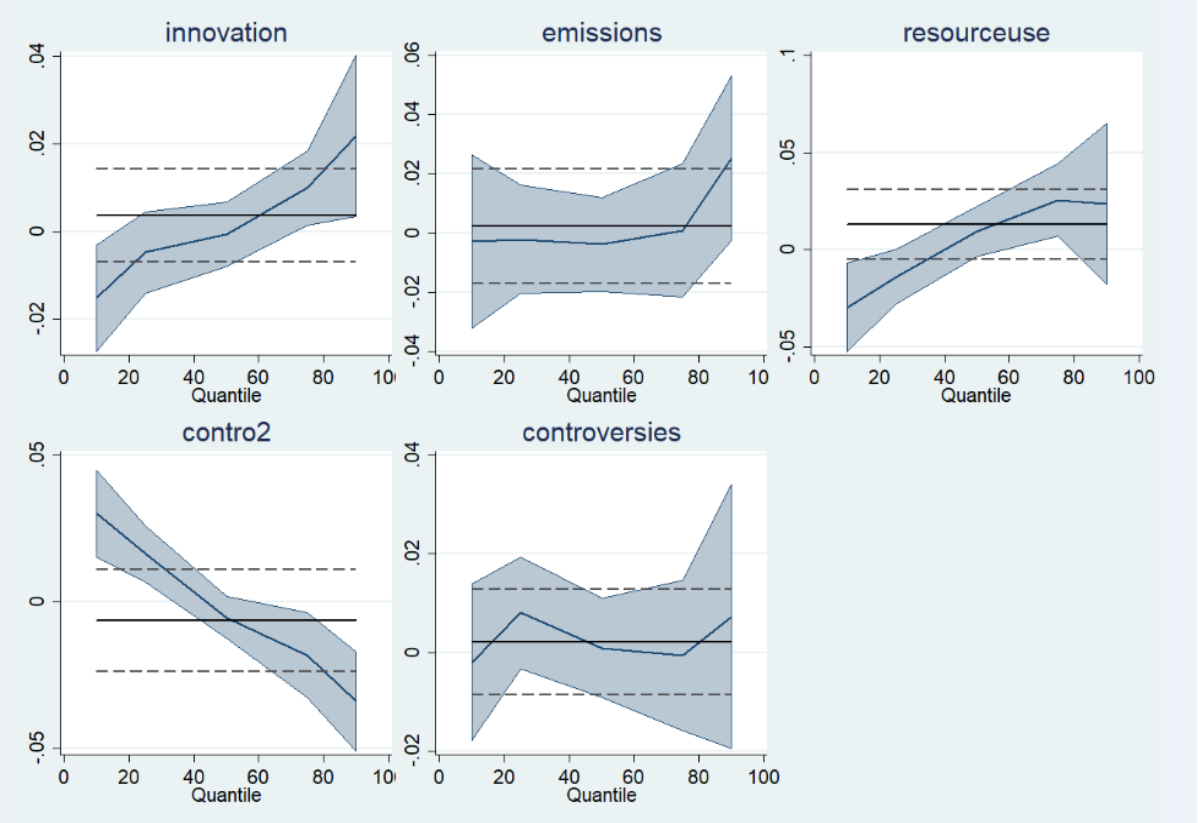

Figure 2. Quantile regression coefficients. Dependent variables: VAR_ART_9.

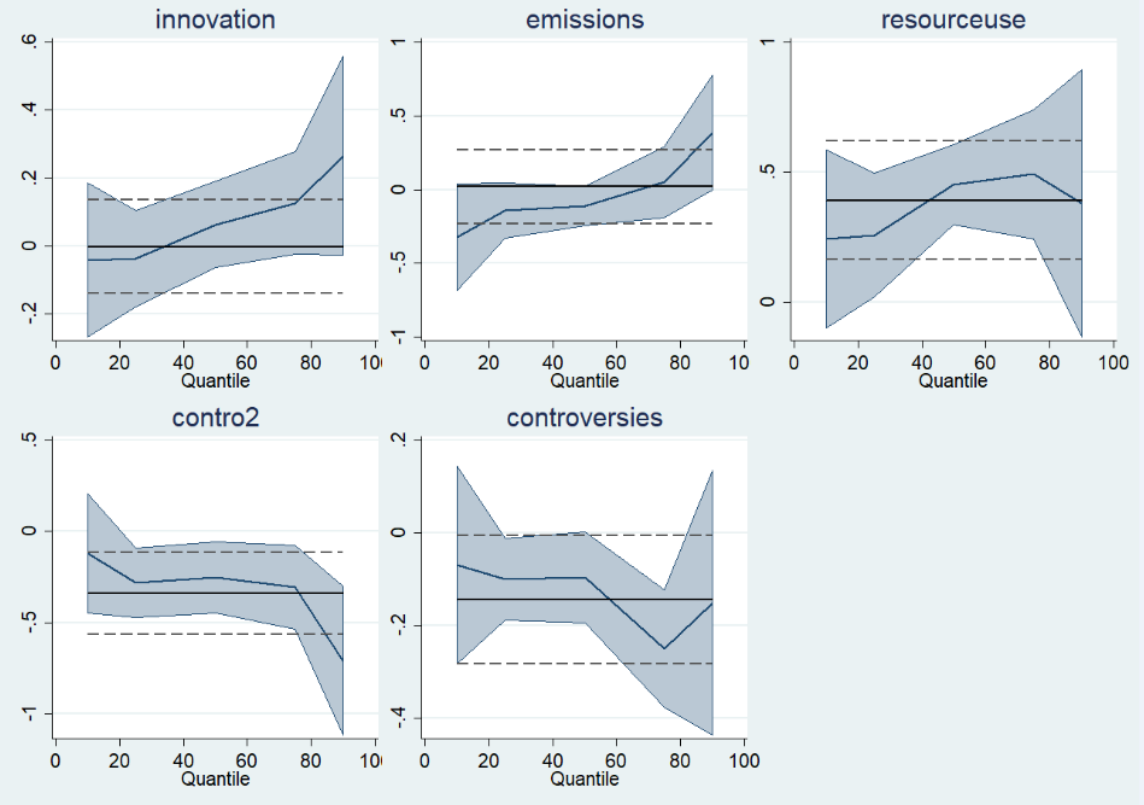

Figure 3. Quantile regression coefficients. Dependent variables: VAR_ART_9.

Regarding emissions reduction as a driver for the inclusion of corporations in the Sustainable SFDR fund categories, this study cannot accept the proposed hypothesis 2, except for the highest quantile. A possible explanation for this finding is that many companies within Eurostoxx 600 have demonstrated strong efforts and results in reducing emissions, exceeding the financial market's expectations. The results may also be influenced by the index's large-cap bias and the documented size bias of ESG scores. (Drempetic et al., 2020; Dobrick et al., 2023).

Regarding the variation of funds categorized as Article 8 to which a company belongs, hypothesis 3 cannot be rejected for the central quantiles (pgs. 25, 50, and 75), which also shows an increasing trend in the impact of resource use at different quantile levels. However, for the variation regarding Article 9, the results in the lower quantiles are counterintuitive. This result can be explained using the same arguments as those for hypothesis 1.

With respect to the variations of funds categorized as Article 8, this study finds evidence to support hypothesis 4. As expected, companies belonging to controversial sectors have less presence in the portfolios of Sustainable SFDR categories except for the lowest quantile of sustainable funds categorized by Article 8. This relationship is stronger as the dependent variable shows higher values. Focusing on Article 9, this finding is consistent with higher quantiles. In lower quantiles, the relationship is in the opposite direction, given the large proportion of companies that have reduced their presence in Article 9 funds and do not belong to controversial sectors.

Regarding hypothesis 5, the results are mixed. Focusing on the variation of the number of companies included in portfolios of funds categorized by Article 9, this study does not find a significant relationship with the involvement of corporations in controversies. However, with respect to the funds

categorized by Article 8, this study finds a positive (in Table 5, the sign is negative, but given the construction of the score, it represents a positive relationship) and significant relationship in the 25th, 50th, and 75th quantiles. This could be due to two reasons. The financial market might penalize corporate controversies over a shorter period. Second, companies involved in controversies make additional efforts to invest in sustainability to restore market trust (Matozza et al., 2019). Dorfleitner et al. (2020) observed mixed results in relation to the impact of the Eikon ESG controversy score on stock performance and found that the absence of ESG scandals normally escapes the investor's radar for small caps.

The results obtained from the ordinary least squares (OLS) estimation are consistent with those from the quantile regression analysis when the direction of the relationship remains stable across quantiles. This is the case of the variation in Article 8 with the variables *resource use*, *controversies*, and *controversial sectors*, where OLS results are aligned with those observed across different quantiles. However, when asymmetric relationships emerge depending on the quantile, OLS proves to be less effective in detecting significant variables in the relationship (e.g., variation Article 9). This highlights the added value of quantile regression in capturing the heterogeneity of effects that may not be adequately reflected through conventional OLS estimation.

5. Discussion

We have summarized our results for the discussion in Figures 4 and 5. The findings for the different hypotheses are visualized for each type of sustainable fund article. The colors used in the figures serves to visualize the relationship. Note that red is used to represent a negative relationship, while green is used to represent a positive relationship. The results broadly indicate that a significant increase in a company's presence in funds categorized under Article 8 or 9 can be explained by strong performance in environmental innovation, emissions reduction, and resource use, particularly within the upper quartiles (75th or 90th percentiles). However, a decrease in a company's presence in EU sustainability funds does not appear to be linked to poor performance in these areas (with the exception of the 25th percentile in Article 8 funds in the case of *resource use*). In some lower percentiles, there is even evidence of an inverse relationship: despite strong performance in environmental impact management, fund managers have chosen to reduce the company's allocation to sustainability funds. The relationship between the controversial sector variable is also asymmetrical when focusing on the variation in the presence of companies in Article 9 funds. Specifically, companies operating in controversial sectors tend to limit their increasing presence in Article 9 funds. Conversely, it is observed that these companies may experience fewer exits from Article 9 funds. However, in the case of Article 8 funds, belonging to a controversial sector appears to adversely affect the likelihood of achieving favorable growth in their presence in such funds. Surprisingly, being a company associated with ESG scandals does not significantly impact the variation in the number of Article 9 funds in which it is present. This finding contrasts sharply with the situation regarding Article 8 funds, where the observed results are contrary to expectations.

Focusing on the variation of companies in funds categorized as Article 8, the results of this study show that Resource Use is a significant variable for the central quartiles. Investors in the biggest sustainable fund category may be motivated by the increasing awareness of the circular economy and the higher clarity in the environmental pillar due to the EU taxonomy. Moreover, the SFDR indicators heavily emphasize environmental disclosure, with 9 out of 14 indicators being environmental KPIs.

The Eikon resource score emphasizes energy and water efficiency, the use of renewables, and the environmental supply chain. This is connected to three environmental Performance Assessment Indicators (PAI) detailed in Table 1: share of non-renewable energy consumption and production (PAI number 5), energy consumption intensity per high-impact climate sector (PAI number 6), and activities negatively affecting biodiversity-sensitive areas (PAI number 7).

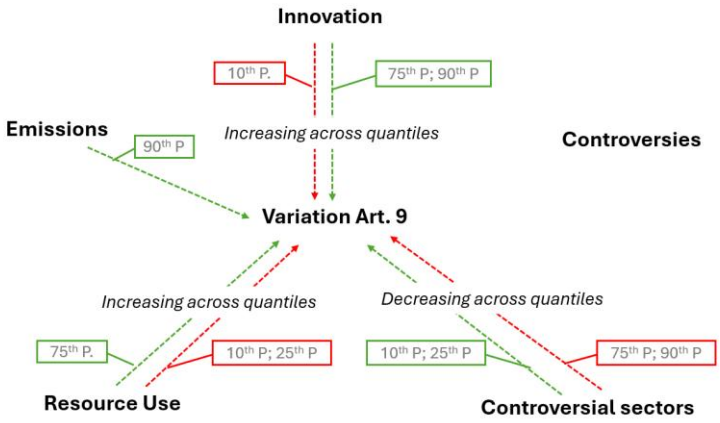

Figure 4. Summary of relationships. Dependent variables: VAR_ART_9. (Note: Green means positive statistically significant relationships and red means negative statistically significant relationships.)

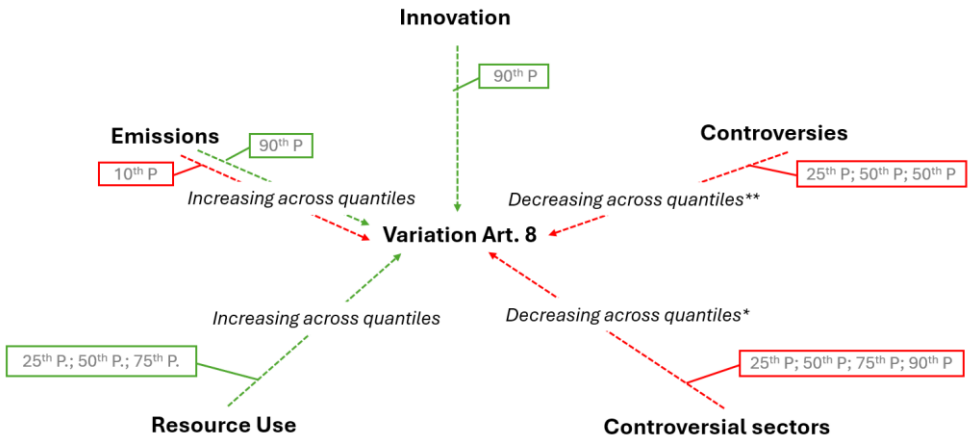

Figure 5. Summary of relationships. Dependent variables: VAR_ART_8. (Note: Green means positive statistically significant relationships and red means negative statistically significant relationships.)

These results are connected to Emiris' findings, which showed a higher increase in flows to ESG funds in countries with stronger environmental preferences. Fund managers might be tilting their portfolios toward companies with high resource scores because they are believed to perform better in the long run (Amores-Salvadó et al., 2014) and, therefore, could become a source of ESG alpha. This is also in line with the findings of Quintana-García et al. (2022), who observed higher effectiveness of corporate performance than environmental innovation in companies' reputations and linked to improving their firm's legitimacy. One could argue that selecting top performers in resource efficiency may serve as a legitimizing tool for sustainable fund categories in the EU, addressing criticisms received about greenwashing.

Due to increasing competition, resource scarcity, and climate challenges, companies are seeking ways to enhance resource use (Mohanty et al., 2021), and this choice may be rewarded by investors. Additionally, the current geopolitical and economic situation has led to a rise in Brent crude oil prices. The average price during our sample period was $77.98 per barrel, compared to an average of $41.70 in 2019. This increase in the last five years may have drawn the attention of fund managers to energy efficiency and renewable energy ratios, shifting it away from other environmental concerns such as emissions. Emissions have been addressed through longer-standing policies and regulations in the region, such as the EU ETS. Hengge (2023), who studied 2000 publicly quoted European companies from 2011 to 2021, found that investors have been pricing these transition risks linked to the shift toward a low-carbon economy.

The mixed and counterintuitive findings for Article 9 could be affected by the size and number of funds. As illustrated previously in Figure 1, Article 9 funds represent only 3.4% of the total funds by assets under management (thereafter, AUM) versus the dominant category, Article 8, which represents 57.6% by AUM of the total market. Additionally, to mitigate potential ESG-related criticism and protect their reputation, many fund management companies have reclassified or downgraded funds from Article 9 to Article 8. The percentage of these funds has decreased from 4.7% of AUM in the fourth quarter of 2021.

Regarding our hypotheses 4 and 5 linked to controversies, we see mixed results depending on the variable used to measure controversies and the SFDR fund category. For Article 8 funds, exposure to controversial sectors is a significant variable, except for the lowest quantile, and ESG controversies show a significant positive relationship in the 25th, 50th, and 75th quantiles. However, for Article 9, our results indicate that investors may not be using the input of Controversies scores in their portfolio selection. These results align with the finding that CSR disclosure is not positively valued by investors as disclosure may be linked to legitimacy concerns but not what investors value for analyzing firm value (Cho et al., 2015).

With respect to the variations of funds categorized as Article 8, this study finds evidence to support hypothesis 4. As expected, companies belonging to controversial sectors have less presence in the portfolios of Sustainable SFDR categories except for the lowest quantile of sustainable funds categorized by Article 8. Traditionally, one of the most used sustainable investment strategies used by fund managers has been the use of negative screening, which avoided controversial sectors. This approach has been associated with a restriction of the investment universe, a potential return sacrifice (Gasser et al., 2014; Trinks and Scholtens, 2017), and increasing costs associated with the screening and monitoring process (Cummings, 2000; Gregory et al., 1997).

However, exposure to controversial sectors shows different relationships depending on the quartile for Article 9 funds. These results could be linked to the fuzziness and lack of clarity in SFDR

categories (Cremasco & Boni, 2022). The SFDR may need adaptations and further clarifications on the articles to serve to truly differentiate between sustainable investment categories and avoid the subjectivity of socially responsible investment (SRI) asset managers (Quirici & Giurlani, 2023). The SFDR categories should evolve to effectively transmit the actual ESG risk of the investment fund (Ferriani, 2022). We recommend that EU policymakers adjust the SFDR to include and promote a standardized use of keywords and terminology such as "ESG" or "sustainability" (Kuzminaet al., 2023). This has been addressed partially by the report published in 2024 by ESMA, "Guidelines on fund´s names using ESG or sustainability-related terms". The regulation sets a minimum threshold of at least 80% of the investment that must align with ESG or sustainability objectives in order to use ESG or sustainability-related designations. For terms such as "environmental", "impact", and "sustainability", minimum safeguards are set in reference to the exclusion criteria for Paris-aligned Benchmarks (thereafter, PAB). However, for funds with terms such as "transition", "social", and "governance", the rules applicable are linked to the Climate Transition Benchmarks, which differ from PAB as they do not exclude corporations exposed to fossil fuels. Funds with terms in their names that align with sustainable investment objectives could potentially be categorized as SFDR Article 9. This categorization could help explain the mixed results observed for hypothesis 4 regarding controversial sectors.

6. Conclusions

The impact of mandatory sustainable disclosure and sustainable labels is a main area of focus for investors, regulators, and practitioners. In this paper, we studied how the environmental commitment of companies and exposure to controversies impact portfolio selection for the sustainable SFDR categories. The entry of force of the SFDR has been a major natural event to test the impact of fund managers reacting to these new disclosure and categorization requirements.

We built a model where we tested if corporate green innovation and cleaner production, the latest addressed by emission reduction and environmental resource use, are significant factors for EU sustainable fund managers. Our findings show that resource use is a significant variable for Article 8 funds, while emission reduction and environmental innovation only support the expected relationship in the highest quantiles. Overall, our results confirm the importance of resource and energy efficiency for fund managers in their decision-making, which is critical to address the climate change challenge, particularly amid the current energy inflationary context. We also tested if EU sustainable fund managers avoided controversial sectors and companies involved in controversies. Our work presents mixed results, with Article 8 actually exhibiting an avoidance of controversial sectors and ESG controversies while Article 9 displays a mixed behavior regarding controversial sectors and no statistical significance for ESG controversies. Our study opens future avenues of research on why fund managers are not giving relevance to ESG controversies scores and whether these scores are effectively measuring controversies in a way that investors find relevant. Furthermore, we could address further granularity in the study by diving deeper into whether the domicile of funds affected their commitment. Nonetheless, a limitation of the ESG data arises from their annual nature and the inherent reporting lag, as the data used is derived from sustainability reports. As a result, the ESG scores used in the analysis reflect one year past performance rather than real-time conditions. Future research could explore the impact of more frequent or real-time ESG data publication on the accuracy and relevance of such scores in the analyzed relationship. Another limitation of the data relates to the availability of

Eikon-related controversy data, as in many instances, data points are missing or incomplete. Additionally, the analysis covers a relatively short period, which may impact the robustness and generalizability of the findings. Future work could address these limitations by extending the analysis period and exploring other sources of information regarding data on ESG-related controversies. Research could also be expanded to test if fund managers in their effort to support investment in environmentally friendly companies, neglect governance and social considerations. Future studies could explore these dynamics further, offering valuable insights into the landscape based on the variations in the presence of corporations within the portfolio of the sustainable SFDR categories of funds.

Author contributions

All authors have participated in the Conceptualization, Investigation, Methodology, Formal analysis, Writing, Reviewing, and Editing of the research carried out.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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