The Effect of Environmental Preferences on Investor Responses to ESG Disclosure *

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May 24, 2023

Abstract

We study the effect of environmental preferences on portfolio allocation around the implementation of the European Sustainable Finance Disclosure Regulation (SFDR). In a model of asset allocation with heterogeneous environmental preferences, we show that the introduction of disclosure regulation leads to an increase in flows to ESG funds, in particular when investors have stronger environmental preferences. We also show that it can be optimal for some funds to misreport their greenness. We test these results by combining unique security-level data on the holdings of European mutual fund shares with survey data on country preferences for protecting the environment. We find that ESG funds experienced higher flows after the regulation, and that the development of these funds was largest in countries with stronger environmental preferences. Institutional investors appear to be more responsive to the disclosure rules than households, and funds with higher initial uncertainty about their true sustainability benefited most from the disclosure.

*Preliminary and incomplete, please do not distribute. The views expressed do not necessarily represent the views of the National Bank of Belgium. For comments and discussions, we thank Renée Adams, Estelle Cantillon, Lars Hansen, Zhiguo He, Emir Kamenica, Ralph Koijen, Mirabelle Muuls, Lubos Pastor, Lars Stole, Eric Zwick and seminar participants at the University of Chicago and the University of Luxembourg.

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I. Introduction

As financial regulators have become increasingly concerned about sustainability, disclosure has been one of their main areas of focus. While there have long been voluntary green classifications available to funds (for example, the Nordic Swan Ecolabel, which was developed in 1989), the European Sustainable Finance Disclosure Regulation (SFDR), which was passed in 2019 and came into effect in 2021, is the first regulation to mandate that mutual funds report the extent to which their investments are aligned with sustainability objectives. Other regulators such as the SEC (2022) have proposed similar rules, which are designed to combat greenwashing and promote sustainable investment. However, whether these regulations have the potential to impact the real economy depends on the response of investors.

In theoretical models of sustainable investing such as Pástor et al. (2020) or Berk and van Binsbergen (2021), heterogeneity in the environmental preferences of investors plays a key role in determining the market outcome. However, the empirical literature studying the effect of environmental labels, such as Hartzmark and Sussman (2019), has focused on average effects in a single market. In this paper, we bridge this gap by exploring how heterogeneous environmental preferences shape the way investors respond to the sustainability disclosures mandated by the SFDR.

The SFDR is an interesting setting to study the role of preferences and disclosure rules, for two reasons. First, the decision to regulate generally depends on the environmental preferences of the country. A country that has strong preferences to support the environment is more likely to introduce disclosure regulation, but its investors might be more likely to invest in sustainable assets even absent a disclosure rule. In our case however, the new regulation is the same for all members of the European Union, who hold a broad range of views on the importance of protecting the environment. This allows us to compare the response to disclosure rules for countries with strong and weak environmental preferences.

Such a design in turn raises a second challenge: it requires granular data on the portfolios of investors in multiple countries, covering a sufficiently large fraction of the financial system. We overcome this challenge by using the Securities Holdings Statistics (SHS). For 24 countries in the EU, we observe the security-level holdings by the main sectors of the financial system (e.g. banks, mutual funds, insurance companies or households). We focus our analysis on the holdings of UCITS investment fund shares (for "Undertakings for Collective Investment in Transferable Securities"), which are regulated mutual funds available to retail and institutional investors. Our data covers more than €8 trillion of assets and includes a broad range of investment fund categories such as bond funds, equity funds or allocation (mixed) funds. We complement the SHS data with fund characteristics from Morningstar, and we use data on the Eurobarometer survey to measure the environmental preferences of the countries in our sample.

Our analysis suggests that the SFDR had a sizeable impact on the mutual funds market in Europe. At the launch of the regulation, more than 46% of funds by assets chose to categorize themselves as ESG funds. In the quarters following the regulation, ESG funds experienced higher flows relative to their peers. The magnitudes are relatively large, with ESG funds experiencing 1.2% higher flows (as a share of total assets) relative to an average flow of 0.5% for all funds. When we consider the cross-country variation, we confirm that the market for ESG funds experienced the highest development in countries with stronger environmental preferences. We also find that institutional investors were most responsive to ESG labels and country preferences, consistent with regulatory or risk aversion motives.

In order to illustrate the mechanism through which environmental preferences shape investors' response to sustainability disclosures, we introduce a model with two key features. First, investors derive an individual-specific non-pecuniary benefit from holding green assets. Second, investors are not able to perfectly observe asset-level greenness. With the disclosure regulation, funds send a signal to investors which may or may not be their true greenness. Funds then choose which signal to report based on a trade-off between the benefits of attracting green investor capital and the costs associated with conforming to the requirements of the regulation.

We first show that it can be optimal for some funds to overstate their true greenness and for others to understate it. In particular, the preference of investors for green assets will generally lead fund managers to overstate their true greenness and "greenwash". If the costs of disclosure are too high however, managers can also choose to understate their greenness, a case which we label as "brownwashing".

We then highlight two channels through which disclosure affects asset allocation. The first one is the uncertainty channel: since the disclosure reduces the range of realized greenness of the funds, investors increase their holdings of shares in both ESG and non-ESG funds. The second one is the expectations channel: the newly-disclosed greenness will differ from the mean of the investors' prior. This leads to a reallocation of capital from funds revealed to be brown to those revealed to be green. The model also provides insights on the role of environmental preferences. In particular, it highlights that countries with stronger preferences will respond more to the disclosure rules. Given that institutional investors are arguably more sensitive to reputation or other sustainability risks, they are also more likely to respond to the disclosure rules.

We then use data on holdings of investment fund shares in Europe to test the predictions of the model. Our dataset covers more than 80% of the UCITS funds market from Q4 2018 to Q3 2022, with total holdings ranging from €8 to 10 trillion across quarters. Among domestic investors, the household sector is the largest holder of fund shares, accounting for around a third of the holdings. The ICPF and mutual fund sectors come second and third, with around 25% of the holdings each. Equity funds are the largest fund category (€2.5 trillion of assets), followed by fixed income funds (€1.8 trillion) and allocation funds (€1.2 trillion). We merge this data with the environmental preferences of countries compiled by the Eurobarometer survey, and we also complement the holdings data with fund characteristics from Morningstar.

The SFDR was adopted in 2019 by the Council and the Parliament of the European Union, and came into force in March 2021. The regulation requires financial intermediaries to publish data on the environmental risks of their investments. It defines in particular two types of ESG funds, falling either under article 8 or article 9. Article 8 funds make decisions based on ESG characteristics. They face additional disclosure requirements and must report how they meet the ESG characteristics. Article 9 funds have sustainability as an objective. They must indicate how their investments contribute to achieving the stated sustainability objective and how this differs from a traditional market objective. A common interpretation of these categories is that funds that e.g. apply ESG criteria to form their portfolio should choose to be article 8, while 'impact funds' that actively engage with the portfolio companies would opt for article 9 status.

At the launch of SFDR, article 8 funds accounted for the bulk of ESG funds, with €4.2 trillion of assets versus €0.3 trillion for article 9 funds. After the introduction of the SFDR, article 8 and

9 funds funds experienced higher transaction flows of €280 billion relative to €131 billion for other funds. Return flows were negative and similar for both categories of funds.

To test the model predictions about the determinants of fund choice under SFDR, we explore the relation between fund-level pre-SFDR investor preferences and SFDR classification choice. We find that, conditional on a fund's pre-SFDR Morningstar sustainability rating, funds with a greener investor base are more likely to choose articles 8 or 9. In the model, there are two potential interpretations of the cost to a fund of deviating from its true greenness. It could either represent the cost of adjusting its investments to conform to the regulation or the cost of potentially being penalized by the regulator. To explore this, we examine the path of portfolio carbon intensity for funds whose SFDR classification deviates from their pre-SFDR Morningstar sustainability rating. We find that funds with a high SFDR classification and low Morningstar sustainability rating lower their carbon intensity in the post-SFDR period relative to funds whose SFDR classification more closely aligns with their Morningstar sustainability rating. We interpret this as suggestive evidence that funds adjust their portfolios to conform to the requirements of SFDR.

We then estimate the impact of the SFDR on flows to mutual funds using three broad sets of empirical specifications. In the first set, we aggregate the flows and holdings at the fund level. While this removes the investor heterogeneity, it allows us to use the same specification as Hartzmark and Sussman (2019), focusing on the flows as a share of net assets after the introduction of the SFDR. The analysis confirms that article 8 and 9 funds experienced higher flows, in particular after controlling for the Morningstar sustainability rating. The magnitudes are relatively large, with article 8 and 9 funds experiencing 1.2% higher flows as a share of net assets relative to other funds.

In a second set of specifications, we explore the heterogeneity across investors at the country level, aggregating across financial sectors. To measure the development of SFDR in each country, we use combined flows, defined as the sum of the holdings at the introduction of the SFDR in 2021 Q1, and the transaction flows in the following quarters. We use this measure instead of the flows in order to take into account the choice of SFDR status by the fund, as the shift to article 8 and 9 could occur both at the launch of the SFDR and in the following quarters. We find that countries with stronger environmental preferences experienced higher flows into article 8 and 9 funds. The results are robust to a broad range of specifications, controlling for the Morningstar sustainability rating and including individual fund fixed effects. In this step, we also test the uncertainty channel by incorporating information about the historical volatility of a fund's sustainability rating. We find that the magnitude of the shift by green investors to article 8 and 9 funds is larger for funds with volatile sustainability ratings.

Finally, we use the full granularity of the data and the variation across investor countries and sectors. We find that institutional investors such as the ICPF and mutual fund sectors seem to respond more strongly in countries with strong environmental preferences, while the household sector is relatively less sensitive.

Overall, our results illustrate how investor preferences shape the impact of sustainability disclosure rules in financial markets. While prior work has focused on aggregate reaction of investors in a single market, the use of granular cross-country data on holdings of investment fund shares allows to confirm the importance of investor preferences. The different responses of financial sectors to the regulation is also a novel insight which we aim to further explore in the next iterations.

I.A. Related Literature

Our paper is related to four strands of the literature. First, our paper relates to research on product quality disclosure rules and certification, summarized by Dranove and Jin (2010). Within this literature, a number of authors have explored the impact of ESG disclosure policies on financial markets. Hartzmark and Sussman (2019) study the introduction of sustainability ratings by Morningstar in 2016. They show that funds with a higher rating have more capital inflows than low rated funds. Rzeźnik et al. (2021) and Ceccarelli et al. (2022) respectively use a change in the rating methodology of Morningstar and the adoption of the Principles for Responsible Investing (PRI) by funds to highlight the importance of sustainability ratings to investors. However, neither of these papers considers heterogeneity in the preferences of investors or differences in the type of investors (e.g. banks versus insurers). Similarly, existing studies of the SFDR such as Becker et al. (2022) and Ferriani (2022) also find that ESG funds under SFDR (article 8 and article 9 funds) experience higher flows than other funds under the new disclosure rules, but do not explore to what extent environmental preferences determine these flows.

A second set of papers has explored the interaction between social values and market outcomes. Gennaioli et al. (2022) study the role of trust on outcomes in the insurance market and show that the cost of insurance for households is higher in countries where trust is low. Aghion et al. (2023) show that the incentives to innovate are higher in markets with strong environmental preferences. A broader literature has also studied the interaction of culture and financial market outcomes (see e.g. Aghion et al. (2010) or Guiso et al. (2004)).

A third set of papers has considered the impact of investor preferences on asset prices (Koijen and Yogo 2019) and the specific role of environmental preferences (Pástor et al. 2020; Avramov et al. 2022). Giglio et al. (2023) conduct a survey on the ESG preferences of retail investors and their investment portfolios. They show that investors expect ESG investments to underperform the market and that ethics-driven investors have the highest ESG portfolio holdings. Bolton and Kacperczyk (2021) show that firms with high carbon emissions earn a higher return. Baz et al. (2022) and Engle et al. (2020) build measures of climate risks for firms and investors and Alekseev et al. (2022) use the reaction to climate risks to construct hedging portfolios.

Lastly, our focus on the development of the financial sector is related to seminal work by Rajan and Zingales (1998), with recent work using micro data to study the structure of the financial system (Maggiori et al. 2020; Beck et al. 2023) or the impact of central bank policies (Koijen et al. 2021; Papoutsi et al. 2021). Our focus on institutional and retail investors is also related to the work of Scharfstein (2018) who studies the role of pension systems in the development of the financial sector across countries.

II. Model

II.A. Model Overview and Setup

To illustrate the mechanism through which an investor's response to the SFDR signal depends on his environmental preferences, we present a model with two key features. First, investors have a preference for green assets, as in Pástor et al. (2020). Second, due to asymmetric information, investors are unable to observe the true greenness of the funds and instead form a prior. This generates uncertainty about the fund greenness, as in Avramov et al. (2022). Disclosure then affects capital allocation by changing the prior of investors, as shown below.

There is a single period and F risky investment funds, indexed by $f = 1, ..., F$.[1] The $F \times 1$ vector of returns is $r \sim (\mu_r, \Sigma_r)$. While many studies have shown, both theoretically and empirically, that greenness and returns are related, in order to emphasize the direct impact of greenness itself on asset allocation, we assume that returns are exogenous and unaffected by greenness. Asset f's greenness is denoted g_f, with g representing the $F \times 1$ vector of greenness. $g_f > 0$ indicates that asset f has positive social impact, whereas $g_f < 0$ indicates the opposite. g_f is observed by managers, but not by investors. There are I investors, indexed by $i = 1, ..., I$ who trade the F risky assets and a riskless asset, which is in zero net supply. Investor i has initial wealth W_{0i} and chooses an $F \times 1$ vector of portfolio weights in the risky assets X_i.

II.B. Demand for Greenness

Investors have utility:

$$V(W_{1i}, X_i) = -e^{-A_i W_{1i} - d_i g' X_i}, \tag{1}$$

where A_i is investor i's absolute risk aversion, d_i is his environmental preference and $W_{1i} = W_{0i}(1 + r_f + X_i' r)$ is his wealth at time 1. Thus, investor i solves:

$$\max_{X_i} \quad \mathbb{E}_0 \left[-e^{-a_i(1+r_f+X_i'r) - d_i g' X_i} \right], \tag{2}$$

where $a_i \equiv A_i W_{0i}$ is his relative risk aversion.

Perfect information. If greenness is perfectly known to investors (or if investors believe that they have perfect information about greenness), the model is exactly as in Pástor et al. (2020) and portfolio weights are given by:[2]

$$X_i^* = \frac{1}{a_i} \Sigma_r^{-1} \left(\mu_r + \frac{d_i}{a_i} g \right) \tag{3}$$

[1]The model can be easily extended to the case where some assets are funds that are affected by the SFDR and others are stocks that are not.

[2]Note that this expression can be expressed: $X_{if}^*(g_f) = \frac{\mu_{r,f} + \frac{d_i}{a_i} g_f - a_i \sum_{f' \neq f} X_{i,f'} \sigma_{r,ff'}}{a_i \sigma_{r,f}^2}$, where X_{if}^* are the elements of X_i^*. This will be useful when we turn to the fund's problem.

All else equal, investors with a stronger environmental preference d_i allocate a higher fraction of their portfolio to green assets. The greenness of the asset complements the returns in the utility of investors and greener assets will trade at a premium.

Uncertainty. As noted by Avramov et al. (2022), investors generally do not have perfect information about asset greenness. Instead, they only know the distribution of the greenness of funds, $g^{prior} \sim \mathcal{N}(\mu_g, \Sigma_g)$, where μ_g is the greenness of the funds and Σ_g is the covariance matrix of greenness across funds.[3]

As derived in the Appendix A.A and as in Avramov et al. (2022), the solution to this maximization problem gives the following portfolio weights under uncertainty:

$$X_i^{*UNC} = \frac{1}{a_i}\left(\Sigma_r + \frac{d_i^2}{a_i^2}\Sigma_g + 2\frac{d_i}{a_i}\Sigma_{rg}\right)^{-1}\left(\mu_r + \frac{d_i}{a_i}\mu_g\right), \tag{4}$$

where Σ_{rg} is the cross-covariance between greenness and returns. For simplicity, in the analysis that follows, we will assume that Σ_g is a diagonal matrix and $\Sigma_{rg} = 0$.

There are two main ways in which X_i^{*UNC} deviates from the perfect information portfolio weights, X_i^*. First, aggregate investment into the fund industry is lower with imperfect information. Since utility is concave in greenness, the uncertainty reduces the total amount of investment as investors account for the higher risk of the assets.[4] Second, the uncertainty induces a misallocation of capital across green and brown funds. Since investors do not know the true values of g, they make their decisions based on μ_g, which could be higher than g for some funds and lower than g for others. This effect also leads portfolio weights to deviate from the perfect information benchmark for investors with any non-zero level of d_i.

II.C. *Supply of Greenness*

One important distinction between external sustainability ratings (such as Morningstar Globes) and SFDR classifications is that managers choose their own SFDR classifications. The introduction of the disclosure regulation thus not only reveals information to investors, but involves a

[3]In the simple case that we use as our baseline, the prior is constant across investors, but this assumption can be easily relaxed.

[4]In fact, d_i is the Arrow-Pratt coefficient of absolute risk aversion with respect to portfolio greenness, $g_i \equiv g' X_i$, so the intuition is as if investors with higher taste for greenness are also more risk averse with respect to the greenness of their portfolios.

signalling choice by the fund manager. Intuitively, choosing an SFDR classification involves a tradeoff between the benefit of attracting green investor capital and the cost of preparing the documentation for the regulators and restricting the investment opportunity set or risking a penalty from the regulator.

We can formalize this by considering the fund manager's problem. Each manager f is endowed with (exogenous) true greenness g_f, which is private information. This represents the greenness of the manager's unconstrained (by investor environmental preferences or regulation) portfolio. For instance, this could represent investment in renewable energy production or the internal investment processes of the fund such as due diligence or a set of skills with regard to assessing investments in certain firms/industries.

With the disclosure rule, the regulator requires the manager f to announce a stated greenness $\tilde{g}_f$. If the stated greenness is above a threshold $\overline{g}$, the fund is categorized as green (e.g. article 8 or 9) and will face increased scrutiny from the regulator.

Given true greenness g_f, we define the cost to manager f of reporting greenness $\tilde{g}_f$ as:

$$C(\tilde{g}_f, g_f) = \gamma \cdot \mathbb{1}\{\tilde{g}_f > \overline{g}\} + \phi(\tilde{g}_f - g_f)^2 \cdot \mathbb{1}\{\tilde{g}_f > g_f\}. \tag{5}$$

The cost function has a fixed and a variable component that aim to capture two features of SFDR: first, SFDR requires all funds (including article 6) to provide information on their greenness. This is modelled as funds reporting a continuous greenness level $\tilde{g}_f$. Second, SFDR creates different categories of funds (articles 6, 8 and 9) with each category implying a higher greenness and different reporting costs. This discrete feature of SFDR is captured by the threshold $\overline{g}$. In equation (5), the fixed cost $\gamma\mathbb{1}\{\tilde{g}_f > \overline{g}\}$ represents the cost of obtaining the green label from the regulator (and announcing $\tilde{g}_f > \overline{g}$). This cost is paid by all managers who choose the green label. The variable cost, $\phi(\tilde{g}_f - g_f)^2\mathbb{1}\{\tilde{g}_f > g_f\}$, could be interpreted in (at least) two ways. One interpretation is that it represents the cost of changing the fund's portfolio to conform to the stated greenness. The variable cost is only imposed on managers who overstate their true greenness and choose $\tilde{g}_f > g_f$ because those who choose a lower type are actually expanding their investment opportunity set. If the manager does not change the fund's portfolio to conform with his chosen $\tilde{g}_f$, an alternative interpretation of the variable cost is that it embeds the probability of being discovered by the regulator and the penalty for lying. These interpretations have very different implications for the investor problem. If managers "pay" the variable cost by changing their portfolio greenness to conform to the requirements of their stated greenness, then (a) investors should choose portfolio weights based on stated greenness, $\tilde{g}_f$ directly instead of using $\tilde{g}_f$ as a signal from which to infer true g_f and (b) the change in portfolio composition is likely to affect expected returns. We focus on the case where the underlying portfolio does not change and the variable cost reflects the possibility of being penalized for greenwashing. Accounting for point (a) yields almost identical model implications and intuition (see Appendix B.B and Figure 9). In order to cleanly illustrate the effects of green preferences on the development of sustainability labels, we abstract from the effects on expected returns mentioned in point (b).

Given the cost function, the manager f then chooses its stated greenness $\tilde{g}_f$ to maximize his profits:

$$\max_{\tilde{g}_f} \quad \pi_f(\tilde{g}_f) = \underbrace{\eta W_f(\tilde{g}_f; \tilde{g}^*_{-f})}_{\text{Revenue}} - \underbrace{\mathbb{1}\{\tilde{g}_f > \bar{g}\}\gamma}_{\text{Fixed Cost}} - \underbrace{\mathbb{1}\{\tilde{g}_f > g_f\}\phi(\tilde{g}_f - g_f)^2}_{\text{Variable Cost}}, \tag{6}$$

where η is the exogenously specified management fee. $W_f(\tilde{g}_f; \tilde{g}^*_{-f})$ is the f^{th} element of $W_F = \sum_i X_i(\tilde{g}) W_{0i}$, where portfolio weights X_i are determined by the investor's problem in equation (2) and manager f takes the equilibrium greenness signals of the other funds, $\tilde{g}^*_{-f}$ as given.

II.D. Equilibrium

In the Nash equilibrium, the fund manager and the investors maximize their objective function taking each other's best response into account. The manager chooses his signal $\tilde{g}_f$ in equation (6) knowing that the size of his fund W_f will depend on the investor decisions. Investors use the $F \times 1$ vector of signals sent by the funds to infer a joint density, $\psi(g|\tilde{g})$ for the vector of true greenness. They then choose their asset allocation according to equation (2). An equilibrium thus consists of a set of signals $\{\tilde{g}_1, \ldots, \tilde{g}_F : \tilde{g}_f \in \mathbb{R}\}$ by the funds and an asset allocation $\{X_1, \ldots, X_I : X_i \in \mathbb{R}^F\}$ by investors.

Separating equilibrium. A useful case to consider is when there is no fixed cost of labelling, i.e. $\gamma = 0$. In this case the equilibrium is fully separating and investors can perfectly infer the fund's true g_f from its signal $\tilde{g}_f$. Let $\sigma^2_{r,f}$ denote the variance of fund f's returns (equivalently, the f^{th} diagonal element of Σ_r). We can show that the equilibrium is for funds to overstate their greenness as follows.

Proposition 1. *If $\gamma = 0$, the fund f will signal $\tilde{g}^\dagger_f = g_f + K_f$, where*

$$\tilde{g}^\dagger_f = \underbrace{g_f}_{Truth} + \underbrace{\frac{\eta \sum_i \frac{W_{0i}}{a_i}\frac{d_i}{a_i}}{2\phi\sigma^2_{r,f}}}_{Overstatement\ \equiv K_f}, \tag{7}$$

The fund-specific constant K_f is known to investors. They infer the true g_f from the signal $\tilde{g}^\dagger_f$ and choose portfolio X^*_i from (3).

Proof. Suppose that funds signal their greenness according to (7). In this case, investors can infer the true greenness of the fund g_f and form their demand according to (3) with $g_f = \tilde{g}_f - K_f$. Consider now the fund manager's problem. Its profit given the investors' demand is

$$\max_{\tilde{g}_f} \quad \pi_f(\tilde{g}_f) = \underbrace{\eta \sum_i \frac{W_{0i}}{a_i \sigma^2_{r,f}} \left(\mu_{r,f} + \frac{d_i}{a_i}(\tilde{g}_f - K_f) - a_i \sum_{f' \neq f} X_{i,f'} \sigma_{r,ff'} \right)}_{\text{Revenue}} - \underbrace{\mathbb{1}\{\tilde{g}_f > g_f\}\phi(\tilde{g}_f - g_f)^2}_{\text{Costs}}. \tag{8}$$

where $\sigma_{r,ff'}$ denotes the covariance between the returns of fund f and fund f' (obtained from the element in row f and column f' of Σ_r). We assume that F is large enough that manager f does not need to consider the effect of his choice of $\tilde{g}_f$ on investors' holdings of other funds, $X_{if'}$. The first-order condition yields (7), which is thus the equilibrium signalling of the fund. □

The intuition behind Proposition 1 is that the fund's revenue is linear in the signal $\tilde{g}_f$ while the costs are convex and asymmetric. Increasing stated greenness provides a constant marginal revenue. However, the marginal cost is equal to zero at $\tilde{g}_f = g_f$ and increases as the fund overstates its greenness, which yields the interior solution $\tilde{g}^\dagger_f$. At this signal, funds do not want to further overstate their greenness because the costs of doing so would be greater than the extra revenue. They also do not want to send a lower signal because this would reduce their revenue more than the savings in costs. In equilibrium, all funds thus overstate their greenness, but investors understand this and the allocation of capital is equivalent to the perfect information benchmark. The extent of overstatement is the second term in (7), K_f. This term increases with the strength of green preferences of investors d_i and decreases with the cost of overstatement, ϕ.

Partial pooling equilibrium.

If $\gamma > 0$, some funds f for whom $\tilde{g}_f^\dagger$ is greater than the green label threshold ($\tilde{g}_f^\dagger > \overline{g}$) might choose to pool at $\overline{g}$ to avoid paying the fixed cost. Intuitively, suppose that a fund's optimal signal without the cost γ is just above the threshold $\overline{g}$. In that case, by reducing its signal to $\tilde{g}_f = \overline{g}$, it avoids paying the fixed cost while the impact on revenue and variable cost is limited. The equilibrium will then consist of two types of reporting strategies: some funds report $\tilde{g}_f = \tilde{g}_f^\dagger$ and investors are able to infer their greenness, while other funds instead pool their reporting at $\tilde{g}_f = \overline{g}$. For funds that pool, investors will update their prior ψ on the underlying distribution of fund greenness. In order to derive a closed form solution for the reporting strategy of the funds and the holdings of the investors, we assume the updated prior of investors follows a normal distribution:

Assumption 1. *If fund f pools ($\tilde{g}_f = \overline{g}$) , investors infer that true greenness is normally distributed, $\psi_f(g_f|\tilde{g}_f = \overline{g}, \mu_r, \Sigma_r) \sim \mathcal{N}(\overline{\mu}_{g,f}, \overline{\sigma}^2_{g,f})$, with $\overline{\mu}_{g,f}$ and $\overline{\sigma}^2_{g,f} \in \mathbb{R}$ and $\overline{\sigma}^2_{g,f} < [\Sigma_g]_{ff}$.*

Note that this assumption does not preclude having $\overline{\mu}_g$ and $\overline{\sigma}_{g,f}$ be functions of the other parameters such as return characteristics. The normality is however necessary to obtain a closed-form solution. In appendix B.A, we discuss the solution to the model without this assumption and show that it is very similar. We assume that $\overline{\sigma}^2_{g,f} < [\Sigma_g]_{ff}$ because it is intuitive that the signal should reduce uncertainty about true greenness, not increase it. The next proposition then summarizes the equilibrium.

Proposition 2 (Partial Pooling)**.** *Managers with $g_f \in \left[\underline{g}_f, \overline{\overline{g}}_f\right]$ pool their report at $\tilde{g}_f = \overline{g}$ and investors are unable to perfectly infer their greenness g_f. Other managers report $\tilde{g}_f^\dagger$ and investors infer g_f. Upon observing the vector of signals, $\tilde{g}$, investors' portfolio weights will be given by*

$$X_i^{*SFDR} = \frac{1}{a_i}\left(\Sigma_r + \frac{d_i^2}{a_i^2}\tilde{\Sigma}_g\right)^{-1}\left(\mu_r + \frac{d_i}{a_i}\tilde{\mu}_g\right) \tag{9}$$

with $\tilde{\mu}_{g,f} = g_f$ and $\tilde{\Sigma}_{g,ff} = 0$ if $f : g_f \notin \left[\underline{g}_f, \overline{\overline{g}}_f\right]$ and $\mu_{g,f} = \overline{\mu}_{g,f}$ and $\tilde{\Sigma}_{g,ff} = \overline{\sigma}^2_{g,f}$ otherwise. The *thresholds are given by the solution to*

$$\{\underline{g}_f, \overline{\overline{g}}_f\} = \left\{g_f : \pi_f(\tilde{g}_f = \overline{g}) = \pi_f(\tilde{g}_f = \tilde{g}_f^\dagger)\right\} \tag{10}$$

Proof. Consider first the fund's strategy, taking investors' demand as given. In this case, the fund manager faces two choices: either it pools and reports $\tilde{g}_f = \overline{g}$, or it sends a signal $\tilde{g}_f \neq \overline{g}$ in which case investors will infer a greenness $g_f = \tilde{g}_f - K_f$. In case of pooling, the profit of the fund manager is

$$\pi_f(\tilde{g}_f = \overline{g}) = \eta \sum_i W_{0i} X_{if}^{*SFDR}(\overline{\mu}_{g,f}; \tilde{\mu}_{g,-f}) - \mathbb{1}\{\overline{g} > g_f\}\phi(\overline{g} - g_f)^2, \tag{11}$$

where $X_{if}^{*SFDR}(\overline{\mu}_{g,f}; \tilde{\mu}_{g,-f})$ is the f^{th} element of the vector of portfolio weights in equation (9). Note that the greenness enters the revenue function as $\overline{\mu}_{g,f}$, so revenue is independent of the fund's true greenness g_f. On the other hand, the cost function is concave in g_f and quadratic when $\overline{g} > g_f$. If the fund manager does not pool and reports $\tilde{g}_f = \tilde{g}_f^\dagger = g_f + K_f$, its profit is

$$\pi_f(\tilde{g}_f = \tilde{g}_f^\dagger) = \eta \sum_i W_{0i} X_{if}^{*SFDR}(\tilde{g}_f - K_f; \tilde{\mu}_{g,-f}) - \phi K_f^2 - \mathbb{1}\{g_f + K_f > \overline{g}\}\gamma, \tag{12}$$

which is linear in g_f for the ranges $\left(-\infty, \overline{g} - K_f\right]$ and $\left(\overline{g} - K_f, \infty\right)$. The fund manager then chooses its reporting by comparing equations (11) and (12). Scenario 1 in Figure 8 depicts this choice between separating and pooling. Note that the profit of pooling must be higher than the profit of separating at $g_f = \overline{g} - K_f$ in order for this threshold equilibrium to exist. Scenario 2 in Figure 8 shows that if this is not the case, funds will have a profitable deviation from this equilibrium. If this condition is satisfied, then there are two solutions to the equation:

$$\pi_f(\tilde{g}_f = \overline{g}) = \pi_f(\tilde{g}_f = \tilde{g}_f^\dagger), \tag{13}$$

which correspond to the thresholds $\underline{g}_f$ and $\overline{\overline{g}}_f$. If g_f is between these thresholds, the fund pools and reports $\tilde{g}_f = \overline{g}$. Else, the funds report $\tilde{g}_f^\dagger$. The thresholds $\underline{g}_f$ and $\overline{\overline{g}}_f$ will be functions of the return characteristics of fund f (including its return covariance with other funds), as well as the cost parameters, environmental preferences and inferred mean and variance. See appendix A.B for details. Figure 1 illustrates the reporting strategy of the fund as a function of true greenness for several combinations of parameter values. In Figure 9, we show how the reporting strategy varies with the way that investors interpret the signal.

□

II.E. *Portfolio Reallocation with Disclosure*

We derived in subsections II.B and II.C the demand of investors and the reporting strategy of the funds.

Under assumption 1, the disclosure rule leads to a reallocation from the full uncertainty case of equation (4) to the reduced uncertainty case given by equation (9).

Proposition 3. *The change in the $F \times 1$ vector of portfolio weights for investor i is given by:*

$$\begin{aligned}\Delta X_i &= X_i^{*SFDR} - X_i^{*UNC} \\ &= \left[\frac{1}{a_i}\left(\Sigma_r + \frac{d_i^2}{a_i^2}\tilde{\Sigma}_g\right)^{-1}\left(\mu_r + \frac{d_i}{a_i}\tilde{\mu}_g\right) - \frac{1}{a_i}\left(\Sigma_r + \frac{d_i^2}{a_i^2}\Sigma_g\right)^{-1}\left(\mu_r + \frac{d_i}{a_i}\mu_g\right)\right].\end{aligned} \tag{14}$$

As illustrated by this expression, the disclosure regulation leads to a reallocation of capital through two channels.

1. *An* expectations channel*: by changing perceived average greenness from μ_g to $\tilde{g}$, investment increases in funds for which $\mu_g > \tilde{g}$ and decreases in funds for which the opposite is true. The reallocation that occurs through this channel is illustrated by setting $\Sigma_g = \tilde{\Sigma}_g = [0]_{F\times F}$ in equation (14) to obtain:*

$$\Delta X_i^{Ch1} = \frac{d_i}{a_i^2}\Sigma_r^{-1}(\tilde{\mu}_g - \mu_g) \tag{15}$$

2. *An* uncertainty channel*: by reducing uncertainty Σ_g on ESG and non-ESG funds, investment in both funds increases.[5] The reallocation that occurs through this channel is illustrated by setting $\tilde{\mu}_g = \mu_g$ in equation (14) to obtain:*

$$\Delta X_i^{Ch2} = \frac{1}{a_i}\left[\left(\Sigma_r + \frac{d_i^2}{a_i^2}\tilde{\Sigma}_g\right)^{-1} - \left(\Sigma_r + \frac{d_i^2}{a_i^2}\Sigma_g\right)^{-1}\right]\left(\mu_r + \frac{d_i}{a_i}\mu_g\right) \tag{16}$$

[5]The only exception is if $(\mu_r + \frac{d_i}{a_i}\mu_g) < 0$. The intuition in this case is portfolio weights would be negative for investor-fund pairs where this is the case, so, all else equal, reducing uncertainty leads weights to become more negative. We ignore this case in the discussion that follows.

Proposition 3 implies that the disclosure regulation always increases the investment in funds for which the expected greenness implied by the signal, $\tilde{\mu}_{g,f}$ is higher than prior expected greenness, $\mu_{g,f}$. However, the impact on funds where this is not the case is ambiguous: the uncertainty channel suggests that investors will welcome the higher precision regarding greenness (lower risk), but the expectations channel suggests that they will move capital away from these funds because of the lower average greenness.

From Proposition 3, we can see that the effect of SFDR will be largest for assets where $\tilde{\mu}_g$ is further from μ_g (expectations channel) and where the relevant diagonal element of Σ_g is larger than the corresponding element of $\tilde{\Sigma}_g$ (uncertainty channel). As we demonstrate in Panel B of Figure 2, reduction of uncertainty matters for portfolio allocation even if the signal simply confirms the prior.

II.F. Role of environmental preferences

The empirical analysis features two key sources of variation: across countries and across financial sectors. At the country level, we will observe the environmental preferences using survey data. The model yields a simple prediction regarding environmental preferences across countries:

Proposition 4. *The magnitude of both channels of reallocation will be increasing in d_i.*

Proposition 4 follows directly from taking the derivative with respect to d_i of the expressions in equations (15) and (16). It is illustrated using a numerical example in Figure 2, which shows the change in portfolio weights as a function of environmental preferences d_i. The figure focuses on four types of assets: two funds (green and brown lines) that receive an SFDR signal, a risk free asset (yellow line) and the sum of the two funds (blue line). Panel A focuses on the expectations channel by assuming that uncertainty about greenness is zero for all assets both before and after the regulation. Panel B focuses on the uncertainty channel by assuming that expected and realized greenness are equal for both funds. Panel C depicts the combined effect of both channels, by assuming that the policy affects both the level and the variance of perceived greenness. The effect on all funds (blue line) in Panel C is interesting because it shows that (although the numerical example is designed symmetrically), the fund sector as a whole receives inflows. This is because utility is concave in greenness, so the reduction of uncertainty about greenness implies that regulated assets become less risky from the perspective of green investors.

III. Data

We combine three datasets to explore the predictions of the model: the holdings of investment fund shares from SHS, fund characteristics from Morningstar and environmental preferences from the Eurobarometer.

III.A. Holdings of fund shares

The Securities Holding Statistics (SHS) data reports the holdings of securities by the different financial sectors for 24 countries in the European Union. The reporting countries include all E.U. members except Sweden, Hungary and Poland. The financial sectors are banks (Monetary and Financial Institutions), Insurance Companies and Pension Funds (ICPF), Mutual Funds, the household sector and other sectors (including for instance the government sector). For each sector and country (the investor), the SHS report the market value in euros of the all securities held by the investor. As in Koijen et al. (2021), we use the information on the total value of each security outstanding to compute the holdings of the foreign sector, defined as the residual between the total value of a share issued and the holdings that we observe in SHS.

The holdings are reported at the security (ISIN code) level, and we focus on holdings of UCITS investment fund shares. UCITS, or Undertakings for Collective Investment in Transferable Securities, are regulated investment fund shares that are also available to retail investors. UCITS account for around 60% of investment fund shares in Europe. UCITS funds are more regulated than other funds such as alternative investment funds, and they are also subject to stronger disclosure rules so that better data is generally available for these funds.

In addition to the holdings, the SHS also provides the capital flows, or changes in holdings, broken down into transaction flows (initiated by investors), returns due to changes in the price of the fund share, and other capital flows including foreign exchange revaluations.

The SHS also include security characteristics downloaded from the Centralised Securities Database of the Eurosystem which combines data from various providers. We use in particular the issuer country, the price as well as the total amount of shares issued for each security, which we use to compute foreign holdings.

III.B. Fund Characteristics

We complement the SHS data with fund characteristics data from Morningstar. The data includes the Morningstar Sustainability Rating, which is computed using data on the sustainability of the holdings of the funds. For each holding, Morningstar collects a number of indicators of ESG performance and computes a weighted average of the different indicators, which are then aggregated at the level of the fund. The funds are then split into five sustainability categories, also know as globes (Hartzmark and Sussman 2019). A fund is rated "High" (5 globes) if it is in the top decile of its category. A fund is given four globes and rated as "Above Average" if it is ranked between 10% and 32.5%, it is given three globes and rated "Average" if it is ranked between 32.5% and 67.5% and it is given two globes and rated "Below Average" if it is ranked between 67.5% and 90%. Finally, it is given one globe and rated "Low" if it is ranked in the bottom 10% of its fund category. Morningstar has computed the sustainability ratings since 2016 and our data covers the period 2018 Q4 to 2021 Q4. In case of missing data, we use the last rating available.

We also use information on the classification of the fund under the SFDR, documenting whether the fund is an article 8 or 9 ESG fund, or whether the type is undisclosed or missing. We downloaded the current SFDR type for all European funds as of December 2022. We thus do not observe the date at which the fund declared its SFDR status and extrapolate the status to the earlier periods.

The combination of Morningstar and SHS gives us three potential identifiers: the ISIN code, which identifies the securities in SHS and is used to match to Morningstar, and the fund ID and share class ID in Morningstar. In the empirical analysis of section V, we will focus on the Fund ID, aggregating the holdings and flows of different ISIN codes that belong to a same fund.

III.C. Environmental Preferences

We use the Eurobarometer to measure the environmental preferences of investors. The Eurobarometer is a Survey conducted regularly by the European Commission in all countries of the European Union, covering a broad range of topics. We focus on the 2020 survey, before the introduction of the SFDR rules, and use the answers to the question "How important is protecting the environment to you personally?" Respondents choose between 5 answers ranging from 'Very important', 'important', neutral, 'not important' and 'not at all important'.

For each country, we use the net share of households who consider that protecting the environment is important, computed as

$$\text{Net Agreement} = \frac{\text{\#(Very important or fairly important)-\#(Not very important or Not at all important)}}{\text{Total respondents}}$$

This measure is in the spirit of the work of Gennaioli et al. (2022) or Aghion et al. (2023) who use survey data to proxy for country level preferences. Our measure is in line with other surveys such as the European Values Survey (EVS), which also includes a question on the environment. Figure 3 illustrates this, focusing on answers to the question 'Would you agree or disagree with the following statement: "Many of the claims about environmental threats are exaggerated." As for the Eurobarometer, we compute the share of respondents who disagree with that statement. The correlation between the two measures is high, and we choose the Eurobarometer data because it includes all the countries in our sample.

III.D. Data coverage and merge overview

Our data covers most of the UCITS market in Europe. This point is illustrated in Figure 4 which compares the total holdings of investment fund shares in our data with publicly available data on the issuance of UCITS funds from the European Fund and Asset Management Association (EFAMA), an industry group. The coverage of the EFAMA is larger than that of SHS as it also include issuances in non-EU countries such as Switzerland, the United Kingdom and Turkey. The SHS data however covers around 80% of the UCITS market, and follows closely the evolution of the broader market.

The total holdings in our sample increased from around €7.5 trillion at the end of 2018 to €9 trillion in late 2022. Table I provides a breakdown of the average holdings of fund shares across the different financial sectors. Domestic investors own about 62% of the UCITS market in our data, i.e around €5.5 trillion worth of investment fund shares. Among domestic investors, the household sector is the largest investor with a portfolio of €1.9 trillion worth of assets. ICPF and Mutual Funds are also large investors while banks or other investors are relatively smaller.

In the empirical analysis of section V, we restrict the sample to funds that are also present in Morningstar. As shown in the third column of Table I, we match 81% of the SHS holdings to Morningstar. The match rate is broadly similar across investors, except for banks where it is smaller at 40%.

In an additional check to the quality and relevance of the holdings data, we explore in Table II whether the identity of the investor's country seems to correspond with the ultimate owner of the asset. Given that the European investment fund industry is highly concentrated in Ireland and Luxembourg, one concern could be that the investment fund shares are held by entities located in these countries, which are themselves held by investors in other countries. To explore this, we break down the holdings of investment fund shares by investor country and issuer country. We then consider three country groups in Table II: Ireland and Luxembourg, other SHS countries, and foreign (non-SHS) countries. The table confirms that Ireland and Luxembourg have a leading role in the issuance of investment funds, with 61% of funds in our data being domiciled in these two countries. However, investors from these two countries hold a relatively small fraction of these funds (9%). Most of the domestic holders of investment fund shares are in fact located in other SHS countries, and a look at the identity of the countries confirms that the size of the holdings are in line with the size of the countries with e.g. Germany, France, Spain and Italy being the largest holders of investment fund shares. In the analysis, we will mostly focus on the country of the investor.

IV. Stylized Facts

IV.A. The UCITS Funds Market

The SHS provides a unique overview of the identity of investors in the European UCITS market and the allocation of their portfolios. Table III breaks down the holdings of each sector by fund category. The categories are taken from Morningstar and include equity funds, bond (fixed income) funds, money market funds, allocation (mixed) funds and other funds (including funds with missing category). Equity funds are the largest category, with €2.5 trillion of holdings, followed by fixed income funds (€1.8 trillion) and allocation funds (€1.2 trillion).

Households have the highest fraction of their portfolio invested in allocation or 'mixed' funds (33% of portfolio). They invest relatively less in money market funds (2% of portfolio) which are predominantly held by institutional investors. Mutual Funds, ICPF and households invest around a quarter of their portfolio in equity funds (respectively 26%, 26% and 28% of their portfolio). Foreign investors are most present in money market funds where they account for 56% of total holdings and in the equity market (45%). Allocation funds and fixed income funds are instead predominantly held by domestic investors (with 79% and 63% of domestic holdings for these categories).

The SHS data also provides insights on the drivers of the growth in the UCITS market. In Figure 5, we decompose the capital flows in investment funds into 3 categories: (1) transaction flows, that are initiated by investors, (2) returns from the fund investments and (3) other flows, such as foreign exchange revaluations. In any quarter, the flows from returns tend to be larger than the transaction flows. However, they are also more volatile so that over the full period, from 2018 Q4 to 2022 Q3, transaction flows are in fact the main source of growth of investment funds, accounting for €1.4 trillion of the €1.9 trillion growth in assets over that period.

IV.B. The SFDR

Most of the regulatory efforts in the area of sustainable finance have focused on improving the disclosure of climate and ESG-related information by non-financial corporations. The Task Force on Climate-related Financial Disclosures (TCFD) of the Financial Stability Board has for instance proposed a number of new indicators of greenhouse gas emissions and exposure to physical and transition risks (TCFD 2020). These principles have been behind regional efforts such as the Corporate Sustainability Reporting Directive in the EU, the UK's climate-related financial disclosure law or SEC proposals for climate-related disclosures.

The SFDR differs from these initiatives by being the first regulation aimed directly at the financial sector, more specifically the investment fund sector. The goal of the SFDR is to improve the ESG information available to end-investors. Under the SFDR, market participants must classify their funds in one of three categories. Article 6 funds are funds that do not promote ESG. While these funds should nevertheless discuss their exposure to sustainability risks, they face smaller ESG disclosure requirements. The second category of funds are "Article 8" funds. These are funds that make decisions based on ESG characteristics. They face additional disclosure requirements and must report how they meet the ESG characteristics. The third category are "article 9" funds. These funds have sustainability as an objective. They must indicate how their investments contribute to achieving the stated sustainability objective and how this differs from a traditional market objective. The general interpretation of these categories is that article 9 funds are "greener" than article 8 funds, which are in turn greener than article 6 funds.

The SFDR was enacted in November 2019 and came into effect in March 2021. The introduction of the regulation was done in two phases, or 'levels'. Level 1 covered the reporting year 2022. Over that period, the rule was to 'comply or explain': funds had to publish ESG statistics or to explain why they were not publishing them. Level 2 came into effect in January 2023. From this date, funds will face more detailed guidance on how to report their exposure to sustainability risks, including with 18 mandatory principle adverse impact (PAI) statements to assess the sustainable impact of their investments. Funds will also have to prove their alignment to one of six environmental objectives in the Taxonomy regulation.

Environmental PAIs include greenhouse gas emissions (scope 1, 2 and 3), the carbon intensity of trustee companies or the share of investment in companies active in the fossil fuel sector. Social PAI include board diversity, exposure to controversial weapons or violations of UN Global Compact principles by firms in the portfolio.

IV.C. The mutual funds market after SFDR

At the launch of the SFDR, 46% of funds by AUM opted to classify as article 8 or 9. As documented in Table V, the majority of funds opted for the article 8 status, representing €4.2 trillion of assets while article 9 funds amounted to €0.3 trillion. The share of the portfolio invested in SFDR (article 8 or 9) funds was broadly similar across the different financial sectors, except for banks where it was lower at 32 %.

Table VI documents the flows into investment funds after the SFDR, from 2021 Q2 to 2022 Q3. The flows are broken down in transaction flows, returns and other flows. In the period considered, the returns were negative for both types of funds which lost around €300 billion in value each. The transaction flows were however positive, and article 8 and 9 funds experienced larger inflows over the period (€280 billion versus €131 billion for non-SFDR funds). The household sector, ICPF and mutual funds were particularly active in rebalancing their portfolio to SFDR funds.

Tables V and VI document the development of SFDR funds, covering both the holdings at the onset of the regulation (table V) and the flows thereafter. To compare the growth of article 8 and 9 funds across countries, neither the initial holdings or the flows are an ideal indicator taken individually. The reason for this is that, in contrast to e.g. the introduction of Morningstar labels studied by Hartzmark and Sussman (2019), the decision to categorize a fund as article 8 or 9 is a choice of the fund, while Morningstar introduced the labels for all funds as a third party. The development of article 8 and 9 funds in any country can thus take place both at the launch of the regulation, where a large number of funds could opt in for SFDR status, or in the aftermath through the launch of new funds and the reallocation of capital by investors.

To account for this, we construct a measure of the combined flows δ into SFDR funds as the sum of holdings at the launch of SFDR, in 2021 Q1, and the transaction flows in the aftermath, from 2021 Q2 to 2022 Q3. For a fund f and investor i, the combined flow δ_{if} is defined as

$$\delta_{if} = (q_{if} \times p_f)_{2021Q1} + \sum_{t > 2021Q1} T_{ift}$$

where the first term is the market value of holdings in 2021 Q1 and the second term is the sum of transaction flows thereafter. This hybrid measure is preferable to using either holdings or flows on their own. Unlike flows, our measure captures the fact that the initial SFDR label may be related to environmental preferences. It thus captures both the choices made at the start of the SFDR and the reallocation in the following quarters. This measure is also preferable to using holdings of investors in each quarter, which raises the identification challenge of disentangling flows due to active rebalancing and the portfolio changes due to returns. Our measure instead uses only the transaction flows that are triggered by the investor after the SFDR.

The combined flows can be used to compare the development of SFDR funds across countries and how they relate to environmental preferences. In Figure 7, we compute for each country the combined flows into SFDR funds as a share of the total combined flows. This measure is positively correlated with environmental preferences. Countries that attach a greater importance to protecting the environment tend to have experienced a stronger development of SFDR funds relative to other countries. The relationship holds both when countries are equally weighted and when they are weighted according to the total size of their portfolio in 2021 Q1.

IV.D. Quantifying Greenwashing

Given the large shift to article 8 and 9 status, a reasonable question is whether the SFDR status truly reflected a better ESG profile or whether the move was driven by a marketing desire to project a 'green image' given the relatively loose initial regulatory constraints. Figure 6 shows that article 9 funds had better Morningstar sustainability ratings than article 8 funds, which in turn had better ratings than other funds. However the consensus between the Morningstar ratings and the SFDR classification is relatively weak: close to 10% of article 9 funds are still rated 'Low' or 'Below average' by Morningstar, and this figure rises to 20% for article 8 funds.

Table VII shows that funds whose Morningstar Globe rating and SFDR status appear to be misaligned account for a substantial portion of assets under management. In particular, brownwashers, which we define as funds with 4 or 5 Globes that choose Article 6, account for €468 billion of assets. Light greenwashers, which we define as funds with 1 or 2 Globes that choose Article 8, account for €418 billion. Dark greenwashers, which we define as funds with 1 or 2 Globes that choose Article 9, account for €17 billion - around 7% of all Article 9 holdings. To the extent that we believe the Morningstar Globes are a good proxy for true greenness, the non-negligible quantity of assets that fall into these three categories is consistent with the model in Section II.C, in which the of label involves a tradeoff between costs and benefits of choosing a higher category.

From the regulator's perspective, it is important to understand whether funds that choose an incorrect label ultimately change their portfolios to conform with their chosen label. If the regulator's objective is to increase the amount of capital invested in green firms, then his ideal outcome is that: (1) green funds who choose the brown label (brownwashers) maintain their high levels of portfolio greenness and (2) brown funds who choose the green label (greenwashers) conform to their chosen classification by increasing their greenness. The worst-case scenario for a regulator with such an objective would be that the brownwashers become less green and the greenwashers remain brown.

Table VII provides some first evidence on the changes in fund greenness by comparing Q1 2021, when the SFDR was launched, with Q4 2021 which is the last quarter for which we observe the Morningstar ratings. Panel B of the Table suggests that there was some alignment between Morningstar and the SFDR categories, with 47% of one globe funds being article 6 initially, versus 67% at the end of the year. The alignment between the two measures thus improved for the lowest rated funds.

The third panel of Table Table VII then provides additional evidence using the funds' carbon intensity to measure greenness, instead of the Morningstar ratings. The Table confirms that article 8 funds typically have a lower carbon intensity than article 6 funds, while the carbon intensity of article 8 and 9 funds seems similar. There does not seem to be an improvement in the carbon intensity of article 8 and 9 funds after the regulation.

Since labels are not assigned randomly, our setting does not enable us to test these effects causally.[6] However, we do observe fund-level carbon intensity over time (obtained from Morningstar). Firm-level carbon intensity is defined as emissions scaled by revenue and is aggregated to the fund level using an asset-weighted average across all the holdings of the fund. To shed light on whether funds in the three categories (brownwashers, light greenwashers and dark greenwashers) appear to adjust their portfolios to conform to their chosen label, we regress the change in carbon intensity from Q4 2019 to Q4 2022 on indicator functions for each of the three categories.[7] Brownwashers are funds with 4 or 5 globes that choose Article 6, light greenwashers are funds with 1 or 2 globes that choose article 8 and dark greenwashers are funds with 1 or 2 globes that choose article 9. As shown in Table IX, we find that (1) brownwashers increase their carbon intensity following the regulation and (2) both light and dark greenwashers appear to decrease their carbon intensity. This suggests that the average fund that might appear to be a greenwasher (in the sense that it was previously thought to be brown, but chose a green label) is in fact improving the greenness of its portfolio.

[6]The main concern would be that, for example, a brown fund that chooses Article 9 because it had pre-existing plans to make its portfolio more sustainable.

[7]We choose Q4 2019 as our baseline for carbon intensity because the SFDR was first enacted, so carbon intensity in future quarters might be effected by anticipation of the implementation of the regulation.

IV.E. Investor Preferences and Fund SFDR Choice

To the extent that Morningstar Globes are a good proxy for "true" greenness, the results shown in Figure 6 and Table VII (both discussed in Section IV.D) would suggest that other factors matter for a manager's choice of SFDR classification. The model presented in Section II.C implies that there could be several such factors, including cost parameters, fees and parameters of the covariance matrix of returns. Additionally, if there is segmentation, such that each fund is available to only a subset of investors, then the wealth-weighted environmental preferences of the fund's investor set will also be a key determinant of the fund's choice of classification. In particular, this would imply that equation (7) becomes:

$$\tilde{g}_f^{\dagger} = g_f + \frac{\eta}{2\phi\sigma_{r,f}^2} \sum_{i \in I_f} \frac{W_{0i}}{a_i} \frac{d_i}{a_i},$$

where I_f is the set of investors available to fund f.

To examine whether there is empirical evidence that investor preferences play a role in SFDR choice, we compute a holdings-weighted environmental preference measure for each fund. Using holdings as of Q4 2020 (pre-SFDR), we compute:

$$\bar{d}_f = \sum_{i \in I_f} \frac{(q_{if} \times p_f)_{2020\text{ Q4}}}{\text{AUM}_{f,2020\text{ Q4}}} \times d_{c(i)},$$

where the first term is the share of fund f owned by investor i in Q4 2020 and the second term is the environmental preferences of the country of investor i. We run a multinomial logit regression of SFDR classification on $\bar{d}_f$, with Article .6 as the baseline category. Column (1) of Table X, shows that, relative to Article 6, a fund whose investors are ten percentage points greener are two percent less likely to choose Article 8. Similarly, the second column shows that, relative to Article 6, a fund whose investors are ten percentage points greener are eight percent more likely to choose Article 9. Importantly, the results control for Morningstar Globes rating, which is our measure of observable greenness, as well as fund category and issuer country fixed effects. As above, we do not claim that these effects are causal because it is plausible that there are characteristics other than Morningstar Globes that are correlated with both investor greenness and fund SFDR choice. However, they do suggest that it is possible that investor preferences play a role in determining a fund's sustainability classification.

V. Empirical Analysis

Our objective is to measure the impact of the SFDR on the allocation of investment in mutual funds and how environmental preferences shaped the allocation. Building on Hartzmark and Sussman (2019), we focus on the period after the implementation of SDFR (Q1 2021), comparing flows into article 8 and 9 ESG funds relative to other funds. The main innovation is that our data is at the fund-investor level instead of aggregate fund-level flows. This allows us to overcome a key identification challenge related to the endogeneity of fund characteristics. The concern is that article 8 or 9 funds could have, for instance, better (or worse) managers so that flows to these funds would be determined by the unobserved manager skills. The variation across investors within a fund instead allow us to control for a broad range of fund characteristics, including fund fixed effects in the most stringent specifications.

We conduct the empirical analysis in three steps. In the first step, we explore to what extent article 8 and 9 funds experienced larger inflows than other funds using aggregate, fund-level data. This specification closely follows that of Hartzmark and Sussman (2019), but ignores the heterogeneity across investors. In a second step, we decompose the flows at the investors' country level, focusing on the combined measure of flows that we introduced in equation (IV.C). The variation across investor countries allows us to explore how the differences in the development of SFDR funds correlate to country preferences. In the third step, we then use the full granularity of our data to study the response of the different sectors and countries to the SFDR.

In all the specifications, we focus only on funds that are matched to Morningstar and for which an environmental rating is available. We also exclude funds with less than €1 million in assets, and we winsorize all continuous variables at the 1% level.

V.A. Aggregate fund flows

We first explore to what extent article 8 and 9 funds experienced higher flows than other funds after the introduction of the SFDR. The analysis is conducted at the level of funds, aggregating flows across all investors for a given fund. While this ignores the heterogeneity across investors, it allows us to replicate the empirical specification of Hartzmark and Sussman (2019). For each fund f and quarter t, we compute the aggregate transaction flows into the fund as a share of Total Net Assets. As Hartzmark and Sussman (2019), we then regress the flows against the SFDR category after the introduction of the new disclosure rules. We control for the Morningstar globe rating, past flows and returns of the fund and also include fund category - quarter interaction effects.

Table VIII shows the fund-level summary statistics. The average quarterly flows represent 0.86% of the total net assets. This is broadly similar in magnitude to Hartzmark and Sussman (2019) who had average monthly flows of -0.41%. The average size of funds in our sample is €336 million, somewhat smaller than the $ 2,184 million of Hartzmark and Sussman (2019). This can be explained by the relatively larger number of funds included in the analysis: we include around 13,500 while Hartzmark and Sussman (2019) focus on around 3,000 funds. The average fund in our data has a Morningstar rating of 3.27 globes. One of the main findings of Hartzmark and Sussman (2019) is that highly rated, five globe funds experienced higher inflows than other funds in 2016. While our sample is quite different from theirs, we also find in panel B that five globe funds experienced larger flows than the other funds (1.24% relative to an average of 0.47% for all funds).

Table XI shows the results of the regression of aggregate fund flows. In specifications (1) and (2), we omit the SFDR category of the fund and focus on the role of the sustainability ratings. Specification (1) suggests that funds with higher Morningstar globe rating experience higher flows over our sample period. In specification (2), we use separate dummy variables for each globe category. Consistent with the summary statistics, the regressions confirm that five globe funds experienced higher flows than other funds. In specifications (3) and (4), we then explore the role of the SFDR categories, controlling for the sustainability rating. We find that article 8 and 9 funds experienced higher flows than other funds, even when controlling for their sustainability rating. The results suggest that article 8 and 9 funds experienced 1.2 percentage point higher flows than their peers, which is relatively sizeable given the average flow of 0.47% in Table VIII.

V.B. *Investor country fund flows and environmental preferences*

The analysis at the fund-level suggests that article 8 and 9 funds experienced greater inflows than other funds. We next want to explore how the development of SFDR funds correlates with the environmental preferences of investors. To measure the development of these funds, we use the combined flows defined in (IV.C) as the sum of the holdings in 2021 Q1 (the launch of the SFDR), and the transaction flows in the following quarters. This measure captures both the endogenous choice of a fund to classify itself as article 8 or 9, and the active rebalancing of investor portfolios towards these funds.

Before considering the full variation across sectors, we initially aggregate the combined flows for each fund at the country level, summing the flows across sectors. We then regress the combined flows on a dummy for article 8 or 9 status, and an interaction of the dummy and environmental preferences of the country of the investor,

$$\delta_{if} = \beta_1 ESG_f \times d_i + \alpha_i + \alpha_f + \epsilon_{if},$$

where ESG_f is an indicator for whether fund f is classified as Article 8 or 9 and d_i is the environmental preference measure for the country of investor i (in this case, summed across all sectors within the country). All specifications include investor country fixed effects α_i as well as fund controls α_f.

Table XII shows the summary statistics. In addition to the €1 million minimum fund size threshold, we also impose that the combined flow must be higher than €0.5 million. Article 8 and 9 funds have investors from around 7.2 different countries. The average number of investor countries for non-SFDR funds is 5.5. The average combined investment of article 8 and 9 funds is of €76 million against €55 million for non-SFDR funds, who also have a smaller sustainability rating (3 globes versus 3.25 globes for SFDR funds). The sample contains around 34,000 funds, with article 8 and 9 funds being somewhat more represented (21,416 funds versus 13,700 funds).

The regression results are shown in Table XIII. We consider a broad range of specifications, starting with investor country and fund fixed effects (1), then adding individual dummies for the number of globes (2), issuer country fixed effects (3) and fund fixed effects in specification (4). In all specifications, the interaction between the article 8 and 9 dummy and the environmental preferences of the country is positive, suggesting that SFDR funds experienced a stronger growth in countries with stronger environmental preferences.

To explicitly consider the two channels discussed in Proposition 3, we construct a measure of fund-level greenness uncertainty, which is defined as the four-quarter standard deviation of a fund's Morningstar sustainability rating prior to the SFDR. In Table XIV, we repeat the analysis in Table XIII, adding greenness uncertainty and its interaction with environmental preferences. The positive and significant coefficient on the interaction between greenness uncertainty and preferences indicates that the uncertainty channel plays a role in portfolio allocation of green investors following the regulation, which is consistent with Proposition 3. In particular, it indicates that the SFDR had a larger impact on fund-investor pairs where the fund had a volatile sustainability rating and the investor had stronger environmental preferences. This result indicates that the noise in ESG ratings, documented by Berg et al. (2022b) and Berg et al. (2022a), matters for the portfolio allocation decisions of green investors.

V.C. *Sector-level flows*

In a third set of regressions, we compute the combined flows at the fund, investor country and sector level. We then run the cross-country and fund regression of equation (V.B) separately for each financial sector. The results, shown in Table XV, suggest that the relationship between SFDR funds and environmental preferences was particularly strong for the ICPF and mutual funds sector. In contrast, the coefficient for the household sector is relatively more muted.

Within our model, one way to explain this is that institutional investors could be more averse to the uncertainty in the greenness of assets. For instance, negative events such as environmental catastrophes could lead to a backlash against the investors funding the project. This could harm the reputation of institutional investors. Instead, households holding a stake in the project would arguably be less affected by the reputational damage from the controversy. In our model, this is equivalent to institutional investors having higher environmental preferences d_i. The model therefore suggests that institutional investors will be more responsive to the disclosure regulation than the household sector, which seems in line with the empirical result.

There are of course other reasons that could explain these results, such as regulatory constraints or trust in the SFDR classification which may have encouraged the investment to article 8 and 9 funds by institutional investors such as ICPF and mutual funds. We plan to explore these in future iterations.

VI. Conclusion

The disclosure of sustainability indicators is a main area of focus for regulators and investors. We study in this paper how the preferences of investors can shape the impact of such disclosure rules, focusing on the introduction of the SFDR in Europe in 2021. The SFDR represented a major change in the European mutual funds market, with funds worth more than €4.4 trillion choosing to be labelled as ESG fund with increased disclosure requirements.

We first build a model of portfolio allocation where investors are uncertain about the true greenness of the funds. If funds choose their reporting, we show that some funds may choose to overstate their greenness while other funds may understate their greenness when disclosure costs are high. We also highlight two channels through which disclosure affects asset allocation, by reducing the uncertainty about the underlying greenness and by reallocating investment from brown to green funds.

To explore the predictions of the model, we use unique data on holdings of mutual fund shares in Europe combined with survey data on country preferences for protecting the environment. We find in particular that funds whose investor base has stronger environmental preferences were more likely to choose article 8 or 9 status, even after controlling for their Morningstar sustainability rating.

We then estimate the impact of the SFDR on flows to mutual funds and the role of country preferences using three broad sets of empirical specifications. At the fund level, we first use the specification of Hartzmark and Sussman (2019) to document that article 8 and 9 funds experienced higher flows than other funds. We then use the heterogeneity of the data across countries to highlight the role of environmental preferences. We show that countries with stronger environmental preferences experienced a higher growth of article 8 and 9 funds, and that institutional investors were particularly more responsive to the regulation in countries with stronger environmental preferences.

Overall, our results confirm the importance of the environmental preferences of investors in determining the impact of disclosure rules on financial markets. Our work shows that increased disclosure leads to a reallocation of capital across mutual funds. It also opens a number of fruitful avenues for future research, including the quantification of the costs of misreporting by funds and whether the reallocation of investment ultimately affects the real economy. We hope to tackle these questions in future work.

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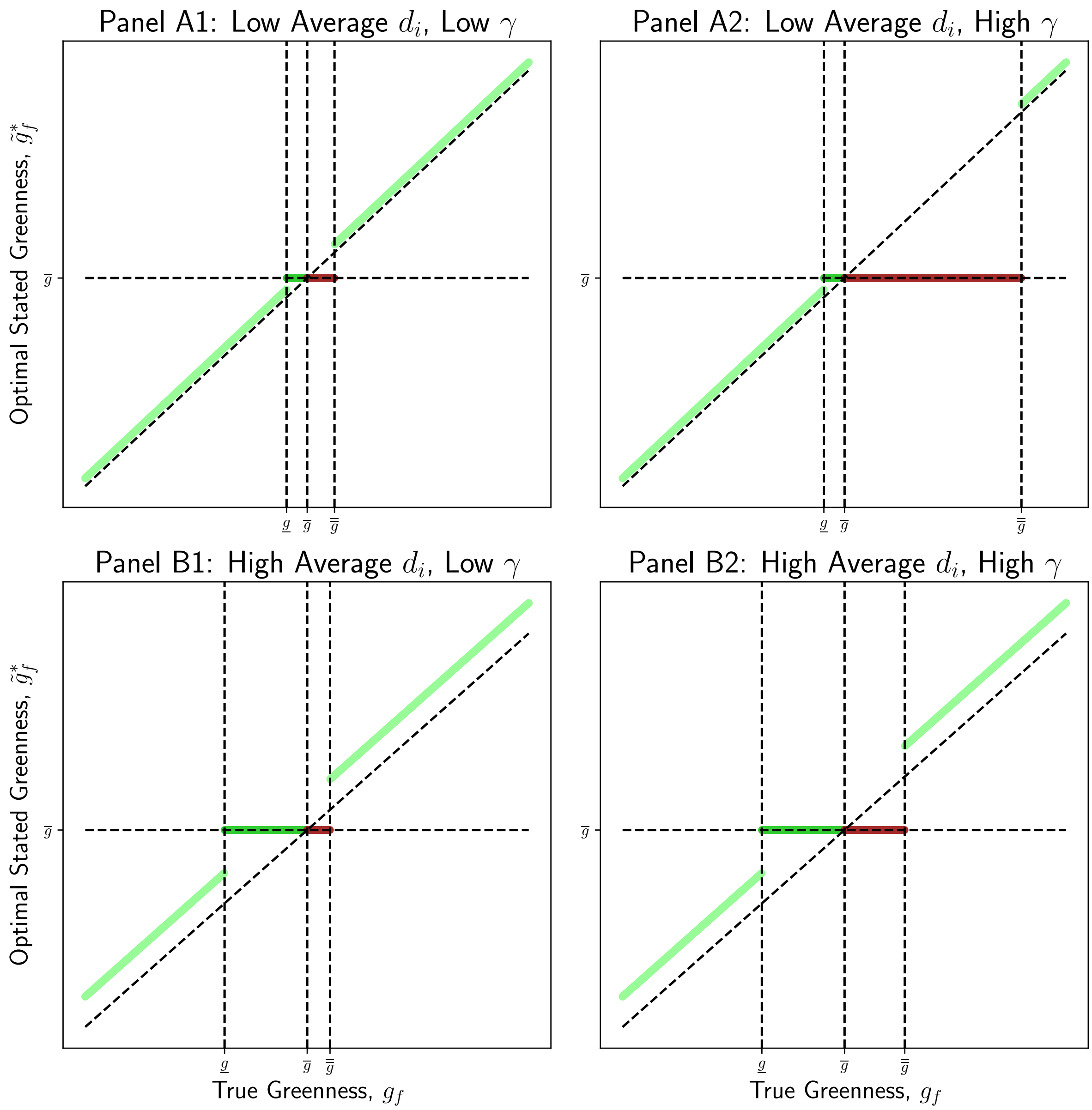


Figure 1. Fund reporting strategy in the partial pooling equilibrium

This figure illustrates the optimal signal, $\tilde{g}_f^*$ as a function of g_f under four different parameterizations: low or high environmental preferences and low or high fixed cost.

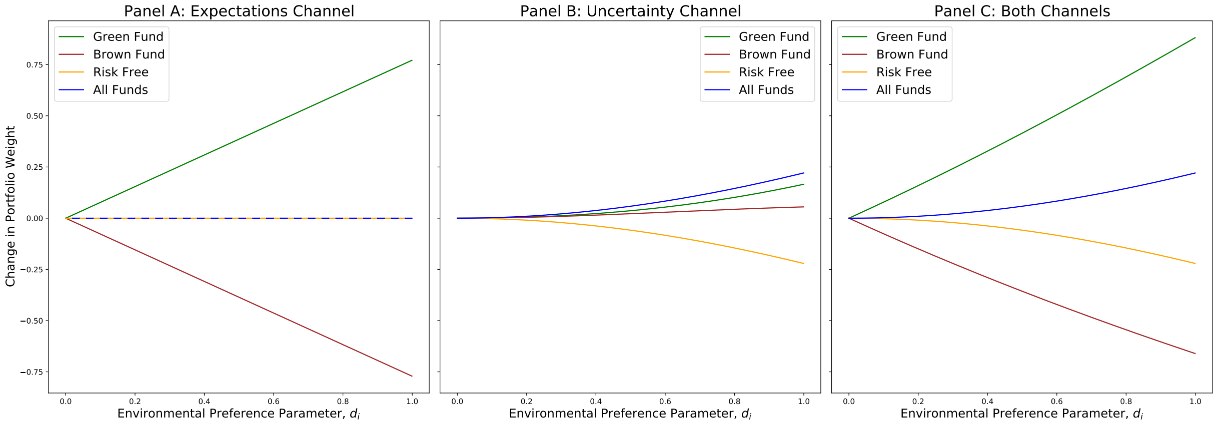


Figure 2. Portfolio reallocation and environmental preferences

This figure shows the model-implied changes in portfolio weights in a numerical example with two funds and a risk free asset. All three panels use the following set of parameters: $a_i = 2$, $\mu_{r,f} = 10\%$ and $\sigma_{r,f} = 18\%$ for both funds and $\sigma_{r,fj} = 0$ for $f \neq j$. In Panel A, $\mu_{g,f} = 0$ for both funds, $g_1 = 0.1$ (green fund), $g_2 = -0.1$ (brown fund) and $\sigma_{g,f}$ is zero before and after the disclosure for both funds. In Panel B, $\mu_{g1} = g_1 = 0.1$ (green fund), $\mu_{g2} = g_2 = -0.1$ (brown fund) and $\sigma_{g,f}$ goes from 10% to zero for both funds. In Panel C, $\mu_{g,f} = 0$ for both funds, $\tilde{g}_1 = 0.1$ (green fund), $\tilde{g}_2 = -0.1$ (brown fund) and $\sigma_{g,f}$ goes from 10% to zero for both funds.

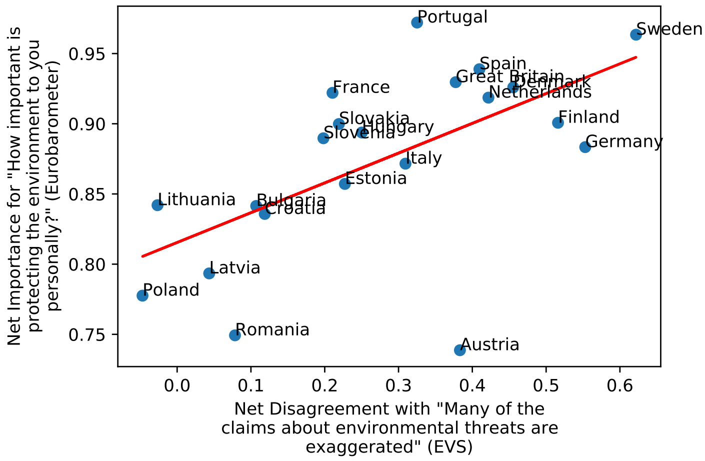


Figure 3. Scatter plot and fitted line for EVS and Eurobarometer environmental concerns measures.

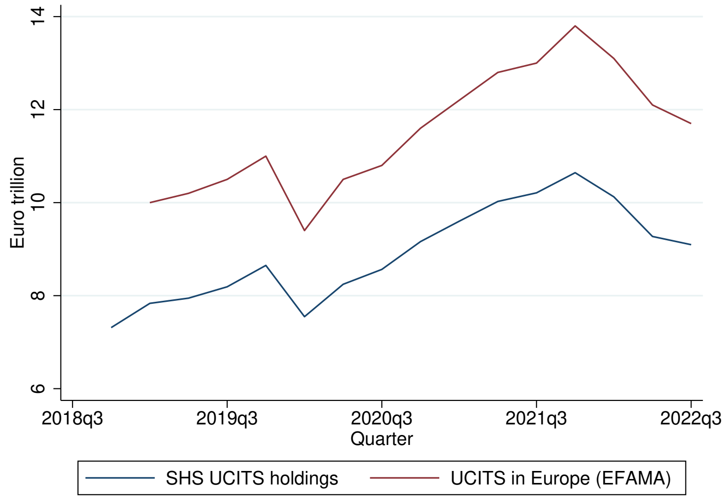


Figure 4. UCITS investment fund shares outstanding for SHS and EFAMA

This figure compares the total value of UCITS fund shares in SHS with the statistics published by the EFAMA. The EFAMA data is for all Europe including countries such as the United-Kingdom, Sweden, Switzerland and Turkey which are not included in SHS.

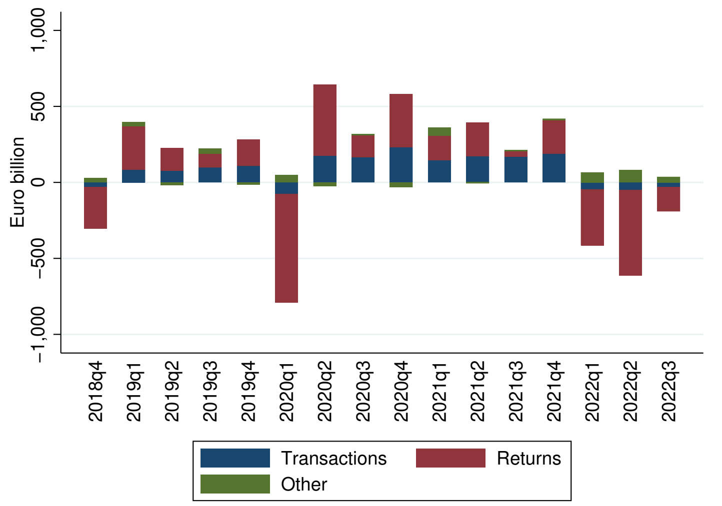


Figure 5. Decomposition of capital flows to investment funds

This figure decomposes the changes in holdings of investment fund share into (1) Transaction flows initiated by investors; (2) Returns from assets under management and (3) Other flows, including foreign exchange revaluations.

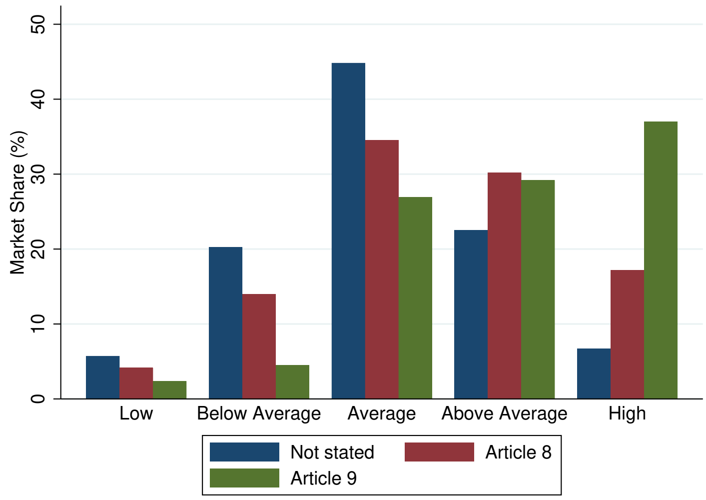
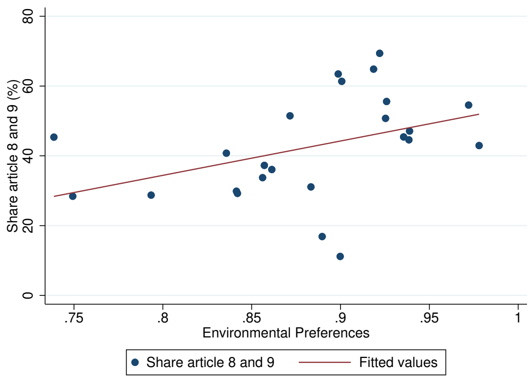
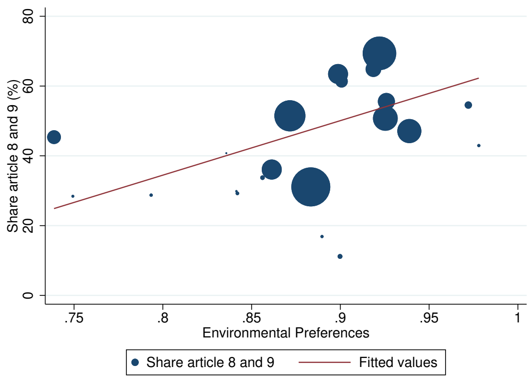


Figure 6. Distribution of sustainability rating by SFDR category

This figure shows the distribution of investment fund shares outstanding by Morningstar Sustainability rating for SFDR Article 8, Article 9 and other investment funds.



(a) Equal weight by country



(b) Weighted by total country holdings

Figure 7. Share of combined flows in SFDR funds and environmental preferences by country

These figures show the share of combined investment flows that are invested in article 8 or 9 funds for SHS countries in 2021 Q1, plotted against the environmental preference of each country and the regression lines. Figure 7a is equal weighted while Figure 7b weights each country by its total holdings of investment fund shares.

Table I
Holdings of UCITS fund shares and match to Morningstar

This table shows in column 2 the holdings of investment shares by financial sector, averaged over the period 2018 Q4 to 2022 Q3. Column 3 shows the share of holdings that are matched to Morningstar.

Sector	Holdings (euro bn)	Matched to MS (%)
Banks	150	40
Mutual Funds	1,585	75
ICPF	1,473	75
Household	1,922	85
Other	397	79
Foreign	3,376	85
Total	8,902	81

Table II
Distribution of fund shares by issuer and holder country

We consider 3 country groups: Luxembourg and Ireland; the other SHS countries (excluding Luxembourg and Ireland) and Foreign (non-SHS) countries. The columns indicate the amount of investment fund shares by issuer country, and the rows the owner of the fund shares.

		Issuer Country			Total	Share of
		Lux. and Irl.	Other SHS	Foreign		Total
Holder country	Lux. and Irl.	705	89	40	834	9
	Other SHS	2,258	2,421	13	4,692	53
	Foreign	2,507	400	469	3,376	38
	Total	5,470	2,910	522	8,902	.
	Share of total	61	33	6	.	100

Table III
Holdings by fund category

This table shows the holdings of investment fund shares broken down by fund category and investor sector, in billion euro. The figures are the average over the quarters 2018 Q4 - 2022 Q3.

Sector	Fund Category					
	Equity	Bond	Money M.	Allocation	Other	Total
Banks	8	18	23	7	93	150
Mutual Funds	419	409	199	89	469	1,585
ICPF	389	272	147	225	440	1,473
Household	533	358	29	630	372	1,922
Other	73	95	84	45	100	397
Foreign	1,150	681	628	257	661	3,376
Total	2,572	1,832	1,110	1,253	2,134	8,902

Table IV
Flows by fund category

This table shows the transaction flows into investment funds by investor sector and fund category. The flows are the totals over the period 2018 Q4 to 2022 Q3 and figures are in euro billion.

Sector	Fund Category					Total
	Equity	Bond	Money M.	Allocation	Other	
Banks	0	-1	-17	0	18	0
Mutual Funds	28	67	62	16	84	257
ICPF	66	66	17	41	27	217
Household	153	35	2	159	54	403
Other	15	13	22	17	14	80
Foreign	111	114	14	82	93	415
Total	373	295	100	315	289	1,372

Table V
Holdings by fund SFDR category at the introduction of the SFDR

This table shows the holdings of investment fund shares in 2021 Q1, at the launch of the SFDR. Figures in euro billion.

Sector	SFDR Category			Total	% Share
	Art. 8	Art. 9	Other		art. 8 and 9
Banks	51	1	111	162	32
Mutual Funds	781	69	853	1,702	50
ICPF	670	53	855	1,577	46
Household	908	70	1,061	2,038	48
Other	239	11	179	429	58
Foreign	1,540	67	2,083	3,690	44
Total	4,188	271	5,141	9,600	46

Table VI
Flow decomposition by fund SFDR category

This table decomposes capital flows in investment fund shares for the different investor sectors. Capital flows are broken down into transaction flows, returns of assets and other flows; and by fund SFDR type (articles 8 and 9, or non stated). Figures are computed over the post-SFDR period, from 2021 Q2 to 2022 Q3.

Sector	Flows		Returns		Other		Total
	Other	Art. 8 or 9	Other	Art. 8 or 9	Other	Art. 8 or 9	
Banks	6	-12	-9	-1	2	0	-15
Mutual Funds	-3	46	-52	-61	42	20	-8
ICPF	-9	20	-68	-59	5	18	-94
Household	93	139	-108	-123	43	34	78
Other	18	3	-15	-19	9	5	1
Foreign	27	85	-50	-36	-9	10	27
Total	131	280	-302	-299	92	87	-11

Table VII
Quantifying Greenwashing

This table shows the 2021 Q1 and Q4 holdings of funds across all combinations of SFDR categories and Morningstar Globe ratings. Panel A shows the holdings in billion euro, and panel B shows the share of holdings within each Sustainability rating. We define brownwashers as those with 4 or 5 Globes that chose Article 6; light greenwashers as those with 1 or 2 Globes that chose Article 8; and dark greenwashers as those with 1 or 2 Globes that chose Article 9.

Panel A: Holdings by sustainability rating (billion euro)

Globes	Q1 2021				Q4 2021			
	SFDR			Total	SFDR			Total
	Art. 6	Art. 8	Art. 9		Art. 6	Art. 8	Art. 9	
One globe	91	96	6	192	111	62	2	175
Two globes	291	322	11	623	456	430	11	897
Three globes	678	796	64	1,539	1,149	1,177	88	2,414
Four globes	344	697	70	1,111	594	1,031	121	1,746
Five globes	124	397	89	610	185	510	109	804
Not rated	3,614	1,881	32	5,526	3,132	1,449	26	4,607
Total	5,141	4,188	271	9,600	5,627	4,660	357	10,644

Panel B: Share of holdings by sustainability rating

Globes	2021 Q1				2021 Q4			
	SFDR			Total	SFDR			Total
	Art. 6	Art. 8	Art. 9		Art. 6	Art. 8	Art. 9	
One globe	0.47	0.50	0.03	1.00	0.64	0.36	0.01	1.00
Two globes	0.47	0.52	0.02	1.00	0.51	0.48	0.01	1.00
Three globes	0.44	0.52	0.04	1.00	0.48	0.49	0.04	1.00
Four globes	0.31	0.63	0.06	1.00	0.34	0.59	0.07	1.00
Five globes	0.20	0.65	0.15	1.00	0.23	0.63	0.14	1.00
Not rated	0.65	0.34	0.01	1.00	0.68	0.31	0.01	1.00
Total	0.54	0.44	0.03	1.00	0.53	0.44	0.03	1.00

Panel C: Carbon intensity by SFDR category

SFDR	Percentile	Quarter			
		2019 Q4	2020 Q4	2021 Q4	2022 Q3
Article 6	p10	10.8	9.5	9.8	11.9
	p50	17.6	16.3	16.0	17.3
	p90	23.7	22.6	22.4	23.3
Article 8	p10	6.9	6.2	6.9	8.4
	p50	15.6	14.4	14.3	15.8
	p90	22.4	21.9	20.9	21.8
Article 9	p10	10.0	9.2	9.9	11.1
	p50	16.4	15.8	16.1	16.3
	p90	20.2	21.2	22.1	21.5

Table VIII
Fund level summary statistics

This table shows the summary statistics of flows aggregated across investors at the fund-level. *Flow* is the total transaction flows to the fund f in quarter t, in % of Total Net Assets. *Size* is the size of the fund in €million. *MSR* is the Morningstar Sustainability Rating, ranging from 1 Globe (low) to 5 Globes (high). Panel B shows the average size, flow and globes (rating) in the quarters following the introduction of SFDR, broken down by globe rating.

Panel A: Full sample summary stats (2018q4-2022q3)

	Mean	SD	p10	p25	p50	p75	p90
Flow	0.86	15.69	-9.26	-2.80	0.00	3.30	12.15
Size	335.68	676.34	10.17	29.20	94.77	302.97	860.91
MSR	3.27	1.08	2.00	3.00	3.00	4.00	5.00

Panel B: Post SFDR statistics by Globe (2021q2-2022q3)

	Obs	Size	Flow	Globes
All	80,822	350.06	0.47	3.29
One globe	4,133	291.81	-0.28	1.32
Two globes	10,411	333.62	-0.38	2.24
Three globes	21,033	389.07	-0.01	3.08
Four globes	17,414	357.24	0.42	3.94
Five globes	9,106	387.60	1.24	4.75

Table IX
Carbon Intensity and SFDR Choice

The dependent variable is the change in fund-level carbon intensity from 2019 Q4 to 2022 Q4. $\mathbb{1}\{\text{Brownwasher}\}$ is an indicator for whether the fund had a Morningstar Globe rating in 2019 Q4 of 4 or 5 and chose Article 6. $\mathbb{1}\{\text{Light Greenwasher}\}$ is an indicator for whether the fund had a Morningstar Globe rating in 2019 Q4 of 1 or 2 and chose Article 8. $\mathbb{1}\{\text{Dark Greenwasher}\}$ is an indicator for whether the fund had a Morningstar Globe rating in 2019 Q4 of 1 or 2 and chose Article 9.

	Carbon Intensity Change (2019-2022)			
	(1)	(2)	(3)	(4)
$\mathbb{1}\{\text{Brownwasher}\}$	0.942***	0.983***	0.943***	0.983***
	(0.138)	(0.140)	(0.138)	(0.140)
$\mathbb{1}\{\text{Light Greenwasher}\}$	-1.199***	-1.285***	-1.235***	-1.328***
	(0.249)	(0.252)	(0.250)	(0.253)
$\mathbb{1}\{\text{Dark Greenwasher}\}$	-4.046**	-4.099**	-4.085**	-4.149**
	(1.708)	(1.710)	(1.718)	(1.719)
Observations	5,153	5,137	5,153	5,137
SFDR Category	Yes	Yes	Yes	Yes
Fund Category	No	Yes	No	Yes
Issuer Country	No	No	Yes	Yes
R^2	0.024	0.040	0.035	0.051

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table X
Investor preferences and fund SFDR choice

This table shows the results from a multinomial logit regression of each fund's SFDR choice on the holdings-weighted environmental preferences of its investors, $\bar{d}_f$. The baseline category is Article 6. All specifications control for Morningstar Globe rating, fund category and issuer country fixed effects.

	Art. 8	Art. 9
Weighted green pref.	0.21296***	0.82730***
	(0.07236)	(0.19604)
1 Globe	-0.45895***	-0.80616***
	(0.08033)	(0.28001)
2 Globes	-0.16082***	-0.45201**
	(0.05498)	(0.18258)
4 Globes	0.30016***	0.89905***
	(0.04800)	(0.12822)
5 Globes	0.70590***	2.07507***
	(0.06577)	(0.13815)
Fund Category	Yes	
Issuer Country	Yes	
Fund	No	
Observations	13692	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XI
Fund-level transaction flows and SFDR category

The dependent variable is the quarterly total transaction flows to a fund in % of total net assets. The sample includes the quarters after the introduction of the SFDR (2021 Q2 to 2022 Q3). Other controls include the lagged return and flow of the fund.

	Transaction Flow			
	(1)	(2)	(3)	(4)
Sustainability score	0.432***		0.299***	
	(0.051)		(0.053)	
Article 8 or 9			1.254***	1.249***
			(0.113)	(0.113)
One globe		-0.331		-0.120
		(0.253)		(0.255)
Two globes		-0.676***		-0.590***
		(0.157)		(0.157)
Four globes		0.184		0.036
		(0.130)		(0.131)
Five globes		1.160***		0.836***
		(0.168)		(0.170)
Observations	80,826	80,826	80,826	80,826
Fund Cat.x quarter	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes
R^2	0.015	0.015	0.017	0.017

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XII
Fund - holder country summary statistics

This table shows summary statistics of the fund-holder country sample used to assess the role of environmental preferences in the development of article 8 and 9 funds. For each holder country and fund, the combined flow is the sum of holdings in 2021 Q1 (the launch of SFDR) and transaction flows by investors in the country to the fund. Panel A shows the summary statistics of the number of investor countries in the funds, the combined flow and the average sustainability rating (globes) for article 8 and 9 funds, while panel B shows the same statistics for other, non-SFDR funds.

	Mean	SD	p10	p25	p50	p75	p90
Panel A: SFDR Funds (21416 observations)							
Count of investor countries in fund	7.24	3.92	2.00	4.00	7.00	10.00	13.00
Combined flow (euro million)	75.95	168.24	0.92	2.31	10.99	59.62	207.95
Globes	3.25	1.07	2.00	3.00	3.00	4.00	5.00
Panel B: Other Funds (13700 observations)							
Count of investor countries in fund	5.51	3.62	2.00	3.00	4.00	8.00	11.00
Combined flow (euro million)	54.57	137.90	0.82	1.82	7.24	36.13	136.46
Globes	3.00	1.06	2.00	2.00	3.00	4.00	4.00

Table XIII

Investor country-level combined flow to mutual funds and environmental preferences

The dependent variable is the combined flows of all fund investors by holder country. The independent variables include a dummy for article 8 or 9 status, and the same variable interacted with the environmental preferences of the holder country. The preferences are taken from the Eurobarometer survey.

	Combined Flow			
	(1)	(2)	(3)	(4)
Art. 8 or 9 $\times$ Env. pref.	138.093***	137.433***	137.781***	122.475***
	(20.237)	(20.235)	(20.266)	(22.876)
Article 8 or 9	-99.934***	-99.204***	-98.669***	
	(17.884)	(17.886)	(17.938)	
Sustainability score	1.940**			
	(0.966)			
Observations	35,118	35,118	35,118	35,118
Investor country	Yes	Yes	Yes	Yes
Fund Category	Yes	Yes	Yes	-
Globes	-	Yes	Yes	Yes
Issuer Country	-	-	Yes	-
Fund	-	-	-	Yes
R^2	0.053	0.053	0.065	0.303

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XIV
Investor country-level combined flows and fund-level greenness uncertainty

The dependent variable is the combined flows of all fund investors by holder country. The independent variables include greenness uncertainty, which is defined as the pre-SFDR four-quarter volatility of a fund's Morningstar sustainability rating, the same variable interacted with the environmental preferences of the holder country, a dummy for SFDR article 8 or 9 status, and an interaction of article 8 or 9 status with environmental preferences. The preferences are taken from the Eurobarometer survey.

	Combined Flow			
	(1)	(2)	(3)	(4)
Env. pref. × Greenness Uncertainty	57.051***	57.802***	48.112***	58.899***
	(17.108)	(17.157)	(17.868)	(19.777)
Env. pref. × Article 8 or 9	139.918***	138.747***	138.475***	124.681***
	(20.517)	(20.526)	(20.681)	(23.936)
Greenness Uncertainty	-54.733***	-55.381***	-47.401***	
	(14.304)	(14.357)	(14.735)	
Article 8 or 9	-98.072***	-96.825***	-96.540***	
	(18.179)	(18.193)	(18.377)	
Sustainability score	3.224***			
	(1.039)			
Observations	25,980	25,980	25,980	25,980
Investor country	Yes	Yes	Yes	Yes
Fund Category	Yes	Yes	Yes	-
Globes	-	-	Yes	Yes
Issuer Country	-	-	Yes	-
Fund	-	-	-	Yes
R^2	0.056	0.057	0.068	0.293

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XV

Sector-level combined flows to article 8 and 9 funds and environmental preferences

The dependent variable is the combined flow to a fund across countries for a given financial sector. For each sector, we compute the cross-country specification (3) in table XIII.

	Combined Flow				
	(1) Household	(2) ICPF	(3) Mutual Fund	(4) Bank	(5) Other
Art. 8 or 9 × Env. pref.	34.014**	99.688***	118.483***	16.805	58.601***
	(16.260)	(16.937)	(15.545)	(26.379)	(12.724)
Article 8 or 9	-13.318	-80.759***	-95.143***	-12.289	-43.727***
	(14.520)	(15.210)	(13.492)	(21.988)	(10.882)
Observations	27,100	20,945	19,882	1,667	12,609
Investor country	Yes	Yes	Yes	Yes	Yes
Fund Category	Yes	Yes	Yes	Yes	Yes
Globes	Yes	Yes	Yes	Yes	Yes
Issuer Country	Yes	Yes	Yes	Yes	Yes
R^2	0.102	0.088	0.066	0.131	0.057

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A. Derivations

A.A. *Derivation of Pre-SFDR Portfolio Weights*

Recall that the investors' problem is:

$$\begin{aligned} &\max_{X_i} \quad \mathbb{E}_0 \left[-e^{-a_i(1+r_f+X_i' r)-d_i X_i' g} \right] \\ \iff &\max_{X_i} \quad -e^{-a_i(1+r_f)} \mathbb{E}_0 \left[e^{-a_i X_i' \left(r + \frac{d_i g}{a_i} \right)} \right] \end{aligned} \tag{17}$$

Assume that g and r are jointly normal. Under this assumption, the exponentiated term inside the expectation, $-a_i X_i \left(r + \frac{d_i g}{a_i} \right)$, follows a normal distribution with mean $-a_i X_i' \left(\mu_r + \frac{d_i \mu_g}{a_i} \right)$ and variance $a_i^2 X_i' \left(\Sigma_r + \frac{d_i^2}{a_i^2} \Sigma_g + 2 \frac{d_i}{a_i} \Sigma_{rg} \right) X_i$. This means that the term inside the expectation follows a lognormal distribution, so we can rewrite the investor's problem:

$$\max_{X_i} \quad -e^{-a_i(1+r_f)} e^{-a_i X_i \left(\mu_r + \frac{d_i \mu_g}{a_i} \right) + \frac{1}{2} a_i^2 X_i' \left(\Sigma_r + \frac{d_i^2}{a_i^2} \Sigma_g + 2 \frac{d_i}{a_i} \Sigma_{rg} \right) X_i} \tag{18}$$

The FOC is:

$$[X_i] : a_i \left(\mu_r + \frac{d_i \mu_g}{a_i} \right) = a_i^2 \left(\Sigma_r + \frac{d_i^2}{a_i^2} \Sigma_g + 2 \frac{d_i}{a_i} \Sigma_{rg} \right) X_i, \tag{19}$$

which implies that the portfolio weights of investor i are given by:

$$X_i = \frac{1}{a_i} \left(\Sigma_r + \frac{d_i^2}{a_i^2} \Sigma_g + 2 \frac{d_i}{a_i} \Sigma_{rg} \right)^{-1} \left(\mu_r + \frac{d_i \mu_g}{a_i} \right) \tag{20}$$

A.B. *Derivation of Thresholds for Pooling and Separating*

Recall that the profit of fund f if the manager chooses to pool or separate are given by:

$$\pi_f(\overline{g}; \tilde{g}^*_{-f}) = \eta \sum_i \left[W_{0i} \frac{a_i \mu_{r,f} + d_i \overline{\mu}_{g,f} - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2 + d_i^2 \overline{\sigma}_{g,f}^2} \right] - \mathbb{1}\{\overline{g} > g_f\} \phi (\overline{g} - g_f)^2 \tag{21}$$

$$\pi_f(\tilde{g}_f^\dagger; \tilde{g}^*_{-f}) = \eta \sum_i \left[W_{0i} \frac{a_i \mu_{r,f} + d_i g_f - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2} \right] - \mathbb{1}\{g_f + K_f > \overline{g}\} - \phi K_f^2 \tag{22}$$

The thresholds $\underline{g}_f$ and $\overline{\overline{g}}_f$ are the two values of f such that these two profit functions are equal to each other. As depicted in Figure 8, $\underline{g}_f < \overline{g} - K_f$, so there will be no fixed cost in either case (pooling or separating), but there will be a variable cost in both cases. Thus, $\underline{g}_f$ solves:

$$\begin{aligned} &\eta \sum_i \left[W_{0i} \frac{a_i \mu_{r,f} + d_i \overline{\mu}_{g,f} - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2 + d_i^2 \overline{\sigma}_{g,f}^2} \right] - \phi(\overline{g} - \underline{g}_f)^2 \\ =&\eta \sum_i \left[W_{0i} \frac{a_i \mu_{r,f} + d_i \underline{g}_f - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2} \right] - \phi K_f^2, \end{aligned} \tag{23}$$

which implies that

$$\underline{g}_f = \frac{-\theta_{1,f} - \sqrt{\theta_{1,f}^2 - 4\phi\theta_{2,f}}}{2\phi}, \tag{24}$$

where

$$\theta_{1,f} = \left(\eta \sum_i \frac{W_{0i} d_i}{a_i^2 \sigma_{r,f}^2} - 2\phi \overline{g} \right)$$

and

$$\theta_{2,f} = \phi(\overline{g}^2 - K_f^2) + \eta \sum_i W_{0i} \left(\frac{a_i \mu_{r,f} - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2} - \frac{a_i \mu_{r,f} + d_i \overline{\mu}_{g,f} - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2 + d_i^2 \overline{\sigma}_{g,f}^2} \right).$$

As depicted in Figure 8, $\overline{\overline{g}}_f > \overline{g}$, so there will be both a fixed and variable cost for separating and no cost for pooling. Thus, $\overline{\overline{g}}_f$ solves:

$$\begin{aligned} &\eta \sum_i \left[W_{0i} \frac{a_i \mu_{r,f} + d_i \overline{\mu}_{g,f} - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2 + d_i^2 \overline{\sigma}_{g,f}^2} \right] \\ =&\eta \sum_i \left[W_{0i} \frac{a_i \mu_{r,f} + d_i \overline{\overline{g}}_f - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2} \right] - \gamma - \phi K_f^2, \end{aligned} \tag{25}$$

which implies that:

$$\overline{\overline{g}} = \frac{\eta \sum_i W_{0i} \left(\frac{a_i \mu_{r,f} + d_i \overline{\mu}_{g,f} - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2 + d_i^2 \overline{\sigma}_{g,f}^2} - \frac{a_i \mu_{r,f} - a_i^2 \sum_{f' \neq f} X_{if'} \sigma_{r,ff'}}{a_i^2 \sigma_{r,f}^2} \right) + \phi K_f^2 + \gamma}{\eta \sum_i W_{0i} \frac{d_i}{a_i^2 \sigma_{r,f}^2}} \tag{26}$$

B. Model Extensions

B.A. Fully Rational Investors

Assume that, for each fund, there are two thresholds $\underline{g}_f$ and $\overline{g}_f$ that will determine whether fund f pools by choosing $\tilde{g}_f = \overline{g}$ or separates by choosing $\tilde{g}_f = \tilde{g}^{\dagger}$. These thresholds will be a function of μ_r and Σ_r. If the true greenness of fund f satisfies $\underline{g} < g_f < \overline{\overline{g}}$, then fund f will pool. Otherwise, fund f will separate. Recall that the investor's prior is $g^{prior} \sim \mathcal{N}(\mu_g, \Sigma_g)$, where Σ_g is assumed to be a diagonal matrix. Denote investors belief about the greenness of fund f, $g_f \sim \mathcal{N}(\mu_{g,f}, \sigma^2_{g,f})$. Because Σ_g is assumed to be diagonal, $g_f \perp\!\!\!\perp g_{f'}$ for $f \neq f'$.

After observing a vector of signals, $\tilde{g}$, and inferring a conditional density, $\psi(g|\tilde{g})$, the investor's problem is:

$$\max_{X_i} \quad -e^{-a_i(1+r_f)} e^{-a_i X_i' \mu_r + \frac{1}{2} a_i^2 X_i' \Sigma_r X_i} \int_{\mathbb{R}^F} e^{-d_i g' X_i} \psi(g|\tilde{g}) dg. \tag{27}$$

If a fund, f, chooses to separate by signalling $\tilde{g}_f \neq \overline{g}$, investors will infer the true $g_f = \tilde{g}_f - K_f$. On the other hand, if a fund, f, chooses to pool, investors will infer that the true g_f lies between $\underline{g}_f$ and $\overline{\overline{g}}_f$. Since investors are aware that g_f was drawn from a normal distribution, they will infer that, conditional on $\tilde{g}_f = \overline{g}$, g_f follows a truncated normal distribution. Let $Z_f \equiv \Phi\left(\frac{\overline{\overline{g}}_f - \mu_{g,f}}{\sigma_{g,f}}\right) - \Phi\left(\frac{\underline{g}_f - \mu_{g,f}}{\sigma_{g,f}}\right)$, where Φ is the standard normal CDF. Then, the conditional density for g_f is:

$$\psi(g_f|\tilde{g}_f = \bar{g}, \mu_r, \Sigma_r) = \frac{1}{\sigma_{g,f}\sqrt{2\pi} Z_f} e^{-\frac{1}{2}\left(\frac{g_f - \mu_{g,f}}{\sigma_{g,f}}\right)^2}. \tag{28}$$

Let F^S and F^B denote the set of funds who separate (signal $\tilde{g}_f \neq \overline{g}$) and pool (signal $\tilde{g}_f = \overline{g}$), respectively. Similarly, let g_S, $X_{i,S}$, g_B, and $X_{i,B}$ denote the vectors containing the elements of g and X_i representing the funds who separate and pool. Then, because of the assumption that $g_f \perp\!\!\!\perp g_{f'}$ for $f \neq f'$, the investor's problem can be rewritten:

$$\max_{X_i} \quad \underbrace{-e^{-a_i(1+r_f)} e^{-a_i X_i' \mu_r + \frac{1}{2} a_i^2 X_i' \Sigma_r X_i}}_{\text{Monetary Part, } \equiv M(X_i)} \times \underbrace{\left(e^{-d_i g_S' X_{i,S}}\right)}_{\text{Separating Part, } \equiv S(X_{i,S})} \underbrace{\prod_{f \in B} \int_{\underline{g}_f}^{\overline{\overline{g}}_f} e^{-d_i g_f X_{i,f}} \psi(g_f|\tilde{g}_f = \overline{g}, \mu_r, \Sigma_r) dg_f}_{\text{Pooling Part, } \equiv B(X_{i,B})}. \tag{29}$$

Because g_f follows a truncated normal distribution, conditional on $\tilde{g}_f = \overline{g}$,

$$
\begin{aligned}
B(X_{i,B}) &= \prod_{f\in B} \int_{\underline{g}_f}^{\overline{\overline{g}}_f} \frac{e^{-d_i g_f X_{i,f} - \frac{1}{2}\left(\frac{g_f-\mu_{g,f}}{\sigma_{g,f}}\right)^2}}{\sigma_{g,f}\sqrt{2\pi} Z_f} dg_f \\
&= \prod_{f\in B} \frac{e^{-\mu_{g,f} d_i X_{i,f} + \frac{1}{2} d_i^2 X_{i,f}^2 \sigma_{g,f}^2}}{Z_f} \int_{\underline{g}_f}^{\overline{\overline{g}}_f} \underbrace{\frac{1}{\sigma_{g,f}\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{g_f-(\mu_{g,f}-d_i X_{i,f}\sigma_{g,f}^2)}{\sigma_{g,f}}\right)^2}}_{\text{PDF of a } \mathcal{N}(\mu_{g,f}-d_i X_{i,f}\sigma_{g,f}^2, \sigma_{g,f}^2)} dg_f \\
&= \prod_{f\in B} e^{-\mu_{g,f} d_i X_{i,f} + \frac{1}{2} d_i^2 X_{i,f}^2 \sigma_{g,f}^2} \frac{\Phi\left(\frac{\overline{\overline{g}}_f-(\mu_{g,f}-d_i X_{i,f}\sigma_{g,f}^2)}{\sigma_{g,f}}\right) - \Phi\left(\frac{\underline{g}_f-(\mu_{g,f}-d_i X_{i,f}\sigma_{g,f}^2)}{\sigma_{g,f}}\right)}{\Phi\left(\frac{\overline{\overline{g}}_f-\mu_{g,f}}{\sigma_{g,f}}\right) - \Phi\left(\frac{\underline{g}_f-\mu_{g,f}}{\sigma_{g,f}}\right)}.
\end{aligned}
\tag{30}
$$

If fund f separates (chooses $\tilde{g}_f \neq \overline{g}$), so that $f \in F_S$, the first order condition for the weight in fund f, denoted X_{if}, will be given by:

$$
\begin{aligned}
[X_{if}]: \quad & \frac{\partial M(X_i)}{\partial X_{if}} S(X_{i,S}) + M(X_i)\frac{\partial S(X_{i,S})}{X_{if}} = 0 \\
\Longrightarrow X_{if}^{*SFDR}(\tilde{g}_f^{\dagger}; \tilde{g}_{-f}^{*}) &= \frac{\mu_{rf} + \frac{d_i}{a_i} g_f - a_i \sum_{f'\neq f} X_{if'}\sigma_{r,ff'}}{a_i \sigma_{r,ff}^2}.
\end{aligned}
\tag{31}
$$

Note that the equilibrium portfolio weight on fund f will depend on the greenness of the other funds through the term $X_{if'}$ terms. Intuitively, the greenness of a fund f' matters more for the portfolio weight of fund f when the two funds' returns are more correlated (i.e. $\sigma_{r,ff'}$ is larger).

If fund f pools (chooses $\tilde{g}_f = \overline{g}$), so that $f \in F_B$, the first order condition for the weight in fund f, denoted X_{if}, will be given by:

$$
[X_{if}]: \quad \frac{\partial M(X_i)}{\partial X_{if}} B(X_{i,B}) + M(X_i)\frac{\partial B(X_{i,B})}{X_{if}} = 0. \tag{32}
$$

Note that because of the form of $B(X_{i,B})$ in equation (30), this will not have a closed form solution. Let $X_{if}^{*}(\overline{g}, \tilde{g}_{-f}^{*})$ denote the equilibrium portfolio weight implicitly defined by this first order condition.

Given $X^*_{if}(\tilde{g}^\dagger_f, \tilde{g}^*_{-f})$ and $X^*_{if}(\overline{g}, \tilde{g}^*_{-f})$, fund f's revenue is:

$$\mathcal{R}_f(\tilde{g}_f) = \begin{cases} \eta \sum_{i=1}^{I} W_{0i} X^*_{if}(\tilde{g}^\dagger_f, \tilde{g}^*_{-f}) & \text{if } \tilde{g}_f \neq \overline{g} \\ \eta \sum_{i=1}^{I} W_{0i} X^*_{if}(\overline{g}, \tilde{g}^*_{-f}) & \text{if } \tilde{g}_f = \overline{g} \end{cases}$$

Fund f will then choose to separate or pool by comparing the profits from each action as described in equation (6). Panel B of Figure 9 shows the optimal choice of $\tilde{g}_f$ as a function of g_f.

B.B. *Model Variation Where Funds Adjust Their Portfolios to Conform to Stated Greenness*

As discussed in Section II.C, the variable cost has two interpretations. It could represent the cost of increasing the fund's portfolio greenness from g_f to $\tilde{g}_f$ or it could represent the cost of risking a penalty from the regulator for lying about greenness. If we interpret the cost in the first way, then investors who care about the greenness of their holdings would use $\tilde{g}_f$ itself to choose portfolio weights instead of inferring a distribution of possible true greenness, g_f from the signal, $\tilde{g}_f$.

In this case, equation 9 is unchanged except that $\tilde{\mu}_{g,f} = \tilde{g}_f$ and $\Sigma_{g,ff} = 0$ for all funds, regardless of whether they separate or pool. The optimal reporting strategy for funds in this case is depicted in Panel C of Figure 9.

B.C. *The Role of Trust*

In the simple version of the model, we assumed that the SFDR classification dominates the prior for all investors. However, in practice, investors likely treat the SFDR classification as a signal that they combine with their prior to form a posterior. The way they treat the SFDR signal may vary with the extent to which investors trust the signal. To demonstrate why trust in green labels matters for the investor response to SFDR, we will have to be more explicit about how investors view the SFDR signal. Investors are Bayesian updaters with prior $g^{prior} \sim \mathcal{N}(\mu_g^{prior}, \Sigma_g^{prior})$ (assume all investors have the same prior). Investors view the SFDR signal as being drawn from a distribution $g^{SFDR} \sim \mathcal{N}(\mu_g^{prior}, \Sigma_{g,i})$. The interpretation of $\Sigma_{g,i}$ is that investors with higher diagonal elements of $\Sigma_{g,i}$ are less trusting of the signal. After observing the signal g^{SFDR}, investor i's posterior is normal with mean:

$$\mu_{g,i}^{post} = \Sigma_g^{prior}\left(\Sigma_g^{prior} + \Sigma_{g,i}\right)^{-1} g^{SFDR} + \Sigma_{g,i}\left(\Sigma_g^{prior} + \Sigma_{g,i}\right)^{-1} \mu_g^{prior} \tag{33}$$

and covariance matrix:

$$\Sigma_{g,i}^{post} = \Sigma_g^{prior}\left(\Sigma_g^{prior} + \Sigma_{g,i}\right)^{-1} \Sigma_{g,i} \tag{34}$$

Investors' portfolio weights depend on their individual posterior (setting $\Sigma_{rg} = 0$):

$$X_i^{*Post} = \frac{1}{a_i}\left(\Sigma_r + \frac{d_i^2}{a_i^2}\Sigma_{g,i}^{post}\right)^{-1}\left(\mu_r + \frac{d_i \mu_{g,i}^{post}}{a_i}\right) \tag{35}$$

To illustrate more the role of trust, we turn to a three asset numerical example. As in that example, assets 1 and 2 are funds (have an SFDR signal) and asset 3 is a stock (no signal). The three assets are ex-ante identical and uncorrelated with expected returns of 10% and return volatility of 18%. All three assets have expected greenness is 0 with standard deviation of 10%. All investors have environmental preferences $d_i = 0.5$ and relative risk aversion $a_i = 2$. For each investor i, the covariance matrix of the signal, $\Sigma_{g,i}$, is a diagonal matrix with identical diagonal elements, denoted $\sigma_{g,i}^2$ (i.e. investors don't trust the signal about one asset more than another). Here, we are interested in exploring how the effect of the SFDR varies with $\sigma_{g,i}$ and with the combination of $\sigma_{g,i}$ and d_i. Figure 10 illustrates these effects. Specifically, note that when d_i is fixed (left panel), the magnitude of the effect of the SFDR decreases as $\sigma_{g,i}^2$ increases. The right panel shows that the SFDR has the largest effect for investors with low $\sigma_{g,i}^2$ and high d_i. Intuitively, this means that investors who both trust the signal and care about greenness are most responsive to the SFDR.

C. Appendix Figures

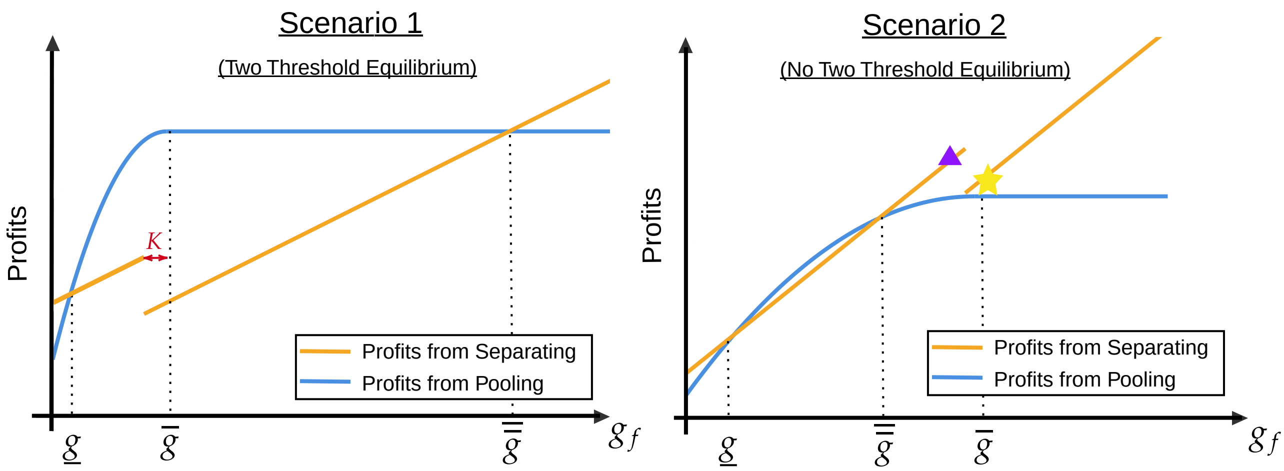


Figure 8. This figure shows the profits that a fund of type g_f would earn from pooling vs. separating. The pooling region is $[\underline{g}, \overline{\overline{g}}]$. In Scenario 1, a partial pooling equilibrium with thresholds $[\underline{g}, \overline{\overline{g}}]$ is possible and in Scenario 2, it is not. Scenario 2 cannot be an equilibrium because the fund depicted by the point "yellow star" has a profitable deviation by signaling a $\tilde{g}_f$ that would make investors believe is has greenness equal to the "purple triangle" fund.

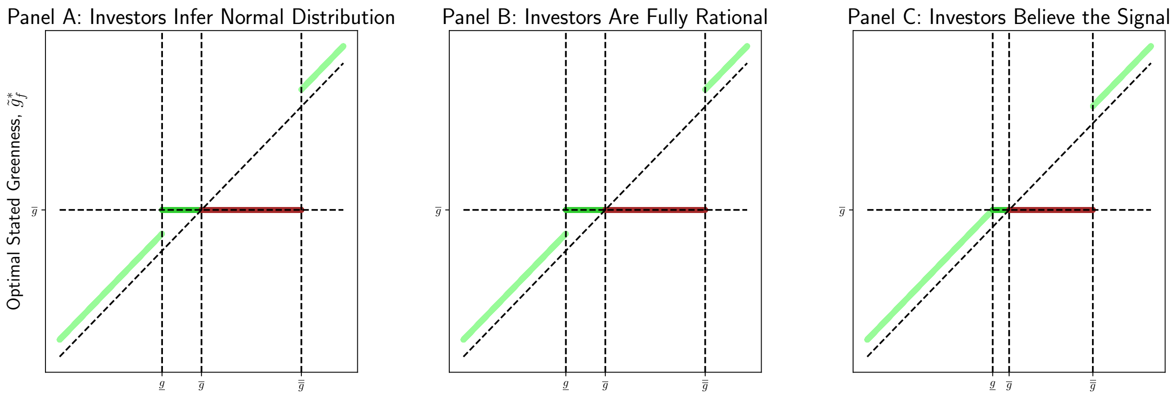


Figure 9. This figure shows the profit-maximizing choice of $\tilde{g}_f$ as a function of true greenness, g_f, holding all other parameters constant. In Panel A, which corresponds to our baseline case, investors infer true g_f if $\tilde{g}_f \neq \overline{g}$ and infer a normal distribution if $\tilde{g}_f = \overline{g}$. In Panel B, investors correctly infer a truncated normal distribution if $\tilde{g}_f = \overline{g}$. In Panel C, investors believe the signal and base their portfolio decisions on $\tilde{g}_f$ directly. The parameters of the normal distribution inferred by investors in Panel A are equal to the mean and variance of the truncated normal distribution in Panel B.

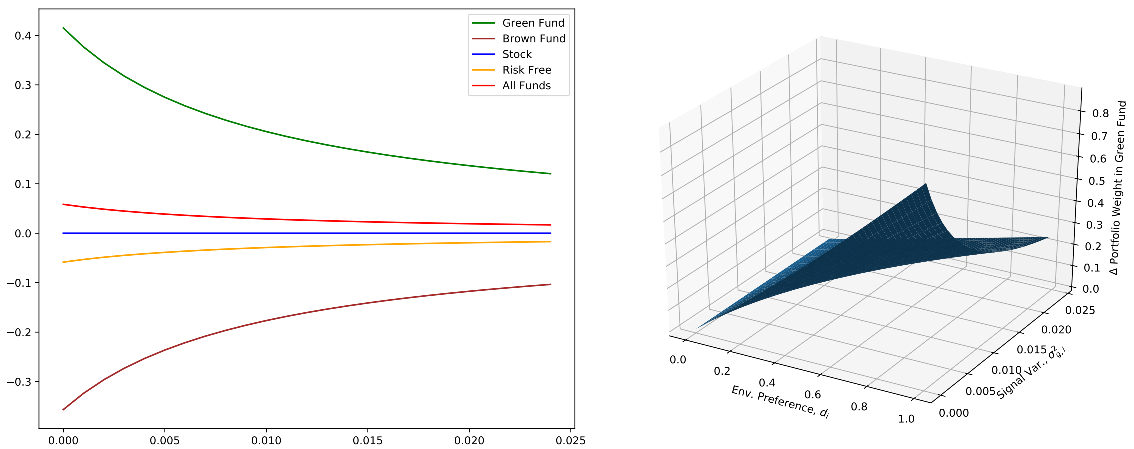


Figure 10. Portfolio weights as a function of signal variance (higher signal variance implies lower trust) and environmental preferences.