DETERMINANTS OF MUTUAL FUNDS' CARBON FOOTPRINT

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Abstract: We analyze the determinants of mutual fund carbon footprint in France. The French market is different from the US market in terms of social norms and regulation deployment. We find that the measure of carbon footprint (e.g., emission level or emission intensity) matters when analyzing drivers of a fund's carbon footprint. Regulations play an important role in reducing fund carbon footprint. Funds' carbon footprint decreases after 2015, coinciding with the implementation of the French energy transition and green growth law, which mandates mutual funds to disclose the climate impacts of their investments. Funds investing in countries with strict regulations limiting carbon emissions, such as European countries, are more likely to have a lower carbon footprint. Large investors with better oversight ability and greater influence can exert pressure on funds to reduce their carbon footprint. We find some evidence of "greenwashing" in France. SRI funds attract more investors but have a higher absolute carbon footprint, measured by the level of emissions, than conventional funds. They are more exposed to the highest emitters, however, do not more engage with them to reduce carbon footprint.

Introduction

A question that has been at the center of political debates aiming at mitigating the consequences of climate change is how to finance the transition. Mutual funds play an essential role in this transition because they often manage assets on behalf of other asset owners, such as insurance companies or pension funds, and directly invest in firms. At the end of 2022, French mutual funds manage more than $ 2 236 billion of assets[1]. However, in order to orient funds to green investment, investors need to know whether funds are aligned with the Paris Agreement. Measuring a fund's carbon footprint is, therefore, the first step.

This article investigates the determinants of mutual funds' carbon footprint. We focus on carbon footprint rather than other metrics such as ESG footprint for three main reasons. First, recent studies show that the significant approach used by institutional investors when managing climate risk is to analyze portfolio firms' carbon footprints (Krueger., Sautner, and Starks, 2020). In addition, it is easier to obtain a fund's carbon footprint by aggregating the carbon footprint of holding firms. Second, the French Authority of Financial Markets (AMF) report in 2019 indicates that carbon footprint is the most common metric used when funds report climate-change-related information. Third, recent literature shows a significant disagreement between ESG ratings from different data providers (Berg., Kölbel, and Rigobon., 2022; Serafeim and Yoon., 2023). Each rater has a different measure of ESG performance, breaks down the concept into different indicators (e.g., Refinitiv has 282 indicators vs. 163 indicators used by Sustainalytics), and organizes them in different hierarchies (Berg., Kölbel, and Rigobon., 2022). The same authors call for greater attention to how the data underlying ESG ratings are generated. Although there may be inconsistency in carbon emissions between data providers (Busch et al., 2022), this inconsistency is much more minor (e.g., Busch et al. 2022 show that data on direct emissions are almost consistent among different providers) and mainly due to the carbon emission reporting of firms while ESG rating differences are due to both ESG reporting by firms and the ESG definition and methodology used by providers.

Understanding factors that drive a fund's carbon footprint is essential for investors and regulators. Knowing the characteristics of funds with a high or low carbon footprint is relevant for investors when selecting a fund. Recent research shows that investors pay attention to the sustainable attributes of funds in general and to funds' carbon emissions in particular (Hartzmark and Sussman, 2019; Ammann et al., 2019; Bauer et al., 2021; El Ghoul and Karoui.,

[1] Source : French Authority of Financial Markets (AMF) report, « Chiffre clés 2022 de la gestion d'actifs ».

2021; Ceccarelli et al., 2024). For instance, Ceccarelli et al. (2024) show that funds labeled as "low carbon" by Morningstar tend to obtain more inflows. Understanding the factors affecting a fund's carbon footprint is also essential for regulators who can identify funds that have a high carbon footprint and thus regulate them. For instance, Article 173 of the *French energy transition for green growth Act* requires only large funds, which are more likely to be a high-emission fund, to disclose their carbon footprint, among other disclosure requirements. However, to our best knowledge, there has been no research on the determinants of mutual funds' carbon footprint.

Even though there has been growing literature on climate finance, little research is conducted outside the US market. In this article, we focus on the French market. Regarding socially responsible investment (SRI), the French market differs from the US market. Environmental and social norms are relatively stronger in Europe and France (Dyck et al., 2019; Gibson-Brandon et al., 2022). Indeed, Amel-Zadeh and Serafeim's survey (2018) shows that ethical motives play a significant role in Europe, while commercial motives (e.g., to attract investor flows) are more prevalent in the US. In addition, in the US SRI industry, institutional investors focus on governance issues (e.g., executive pay, conflict of interest…), while French institutional investors focus on the broader integration of multiple ESG issues within their investment decision process (Crifo and Mottis, 2016). Thus, the pressure on institutional investors to integrate ESG criteria into their investment decisions can be more intense in Europe in general and France in particular than in the US (Gibson-Brandon et al., 2022). Moreover, while in the US market, there is regulatory uncertainty about whether responsible investing is consistent with investors' fiduciary duties (Gibson-Brandon et al., 2022), in France, disclosure requirements about the environmental impacts of institutional investors' actions are constantly deployed. For instance, as mentioned above Article 173 in France requires that all asset owners and asset managers disclose information about their climate-related risk management and integrate these risks into their investment policies. France is the first country to require such disclosure. Finally, regarding market maturity, the growth in responsible investing in the US is much later (Gibson-Brandon et al., 2022), while the French market is one of Europe's most dynamic and successful (Eurosif, 2018). Market maturity may lead to more pressure for ESG implementation.

We use a sample of equity mutual funds domiciled in France from January 2007 to June 2021. Our period starts in 2007 because data on carbon emissions was rare before 2007. First, our results show that the way how a firm's carbon footprint is measured matters and thus impacts

mutual funds' carbon footprint. Funds can be considered high carbon footprint funds when considering the absolute level of carbon emissions and low carbon footprint funds when using emission intensity, measured by dividing the absolute emissions by the firm's revenue. Second, regulation plays a vital role in diminishing funds' carbon footprint. Fund carbon footprint tends to decrease after 2015, coinciding with the introduction of Article 173 of the *French energy transition and green growth Act*. Funds investing in countries with many regulations limiting carbon emissions, such as European countries, tend to have lower carbon emissions. In contrast, funds focusing on geographical zones where regulations are less strict and carbon emission levels are high, such as Asia countries (except Japan), display a higher carbon footprint. Third, large investors with better oversight ability can pressure funds to reduce their carbon footprint. We show that funds serving investors with minimum initial investment requirements superior to $ 500,000 are likely to have a lower carbon footprint. Fourth, one of the striking results is that self-designed SRI funds display a higher absolute carbon footprint and invest a more significant proportion of their assets in the highest emitters than conventional funds. However, no evidence shows that these funds engage more with their holding firms to reduce their carbon emissions. Nevertheless, these funds attract more investors than conventional funds. Finally, other characteristics of funds such as fund size, fund age, fund style of management, or the family to which funds belong also influence their carbon footprint. Carbon footprint is lower for funds existing for a long time, belonging to a large family, investing in small capitalization firms and higher for large funds or funds investing in large capitalization firms.

Our study has critical managerial implications. First, if establishing regulations limiting carbon emissions is necessary, it would be essential to settle the debate on how to measure carbon footprint. While emission intensity allows for comparing firms of different sizes, it can also make it easier for firms and funds to cope with regulations. Ultimately, what matters is the amount of carbon emissions released into the air. Second, if large investors with better oversight ability can put more pressure on funds, how can small or retail investors guarantee that their funds respect sustainability commitments? Finally, our study contributes to the discussions about the "greenwashing" behavior of self-designed SRI funds. While these funds attract more investors, their carbon footprint is not always aligned with their sustainability commitments.

We also contribute to the literature at several levels.

Our work is related to the literature on the sustainability (ESG) footprint of institutional investors (Gibson Brandon., Krueger., and Mitali, 2020; Gibson-Brandon., Glossner., Krueger., Matos., Steffen, 2021; Kim & Yoon, 2023). The first two studies measure the sustainability

footprint of institutions (*i.e.,* at the family level), while Kim and Yoon (2023) measure the ESG scores of mutual funds. Our research is different from these previous studies in several ways. First, we measure the carbon footprint instead of the sustainability footprint. As mentioned above, there is a significant inconsistency between ESG providers. In addition, carbon footprint is the most common metric systematically calculated by mutual funds when reporting. Second, like Kim and Yoon (2023), we focus on one financial product: mutual funds rather than institutions. It allows us to have a homogenous analysis. An institution may have numerous products (including mutual funds), and its portfolio footprint is measured at the family level. Previous studies highlight that even though fund members may be affected by the policies of their family, there can be substantial differences in shareholder voting within the same family (Morgan et al., 2011; Dikolli et al., 2022). Finally, our study investigates the determinants of a fund's carbon footprint. To our knowledge, there has been no research on this question.

Our study also contributes to the literature on greenwashing in institutional investors in general and in mutual funds in particular (Li, Naaraayanan, Sachdeva, 2023; Michaely, Ordonez-Calafi and Rubio, 2024; Kim and Yoon., 2023; Gibson-Brandon et al., 2022; Andrikogiannopoulou A., Krueger P., Mitali, Papakonstantinou, 2022; Markku Kaustia., Wenjia Yu, 2021; Liang., Sun., Teo., 2021). Gibson-Brandon et al. (2022) and Kim and Yoon (2023) find that US PRI signatories are not superior performers in ESG issues before signing in compared with non-PRI funds and do not improve their ESG scores after signing. Commercial motives, lower ESG market maturity, and uncertainty in regulation can explain why US signatories do not follow their commitment (Gibson-Brandon et al., 2022). Andrikogiannopoulou., Krueger., Mitali., and Papakonstantinou (2022) show that greenwashing has been more prevalent since 2016 (coinciding with the Paris Agreement). Similarly, Kaustia and Yu (2021) highlight the greenwashing behavior in the US mutual fund industry. When analyzing mutual funds' voting, Li, Naaraayanan, Sachdeva (2023) and Michaely, Ordonez-Calafi and Rubio (2024) find similar results: ESG funds vote in favor of ESG proposals only when they believe that their vote do not matter. When their vote tends to be pivotal, they do not favor ES proposals. Finally, Liang, Sun, and Teo (2022) find that greenwashing is not only for mutual funds; some hedge funds endorse responsible investment to cater to investor preferences. While the previous studies highlight the greenwashing behavior in the US market, our study shows that greenwashing might also be present in the French market, where self-design SRI funds are more likely to have a higher carbon footprint than conventional funds.

Our article is organized as follows. Section 1 presents the theoretical background and hypothesis. Section 2 describes the data. Section 3 analyzes the determinants of mutual funds' carbon footprint. Section 4 examines whether SRI funds are more exposed to high emitters than conventional funds. We investigate whether SRI funds engage more with their firms to reduce their carbon footprint than conventional funds in section 5. Section 6 tests whether SRI funds attract more investors than conventional funds. Finally, we conclude.

1. Drivers of funds' carbon footprint: theoretical background and hypothesis

This section provides the theoretical background explaining the factors influencing a fund's carbon footprint. A fund's carbon footprint drivers can be categorized into different groups.

1.1.Investor pressure: institutional vs. retail investors

Funds have more and more pressure from their clients regarding sustainability (Riedl and Smeets, 2017; Bauer et al., 2019; Hartzmark and Sussman, 2019). However, pressure "power" might differ between retail and institutional investors for different reasons.

First, funds that serve institutional investors are more likely to be subject to public scrutiny and under pressure from their investors. Indeed, institutional investors (e.g., pension funds, insurance companies…) often manage significant assets on behalf of their clients and have pressure from their clients. For instance, Bauer et al. (2019) find, in the case of Dutch pension funds, that over 67% of participants favor increasing the pension fund's engagement to increase the sustainability of the companies in which they invest, even though these engagements may hurt the financial performance and this support for sustainable investments lasts over time. Moreover, institutional investors often invest a significant amount in a fund. Therefore, an institutional investor withdrawing their investment might substantially impact the fund, but this is not the case for an individual investor. Under their own clients' pressure, institutional investors tend to put more pressure on their funds to reduce the fund's carbon footprint.

Second, there are substantial differences in the levels of sophistication between institutional and retail investors. Research has shown that retail investors tend to use simple measures when evaluating funds, such as past raw returns. On the other hand, institutional investors use more sophisticated performance measures (Del Guercio & Tkac, 2002; Evans & Fahlenbrach, 2012; Ben-David et al., 2022). When considering a fund's sustainability, retail investors often lack up-to-date information about fund investments and struggle to process complex information. In contrast, institutional investors typically have access to databases that provide information on

the holdings of the funds and the sustainability levels of the firms held by the funds (Ammann et al., 2019). The same authors show that retail investors strongly consider a fund's Morningstar sustainability ratings because Morningstar's sustainability ratings have made it easier for retail clients to understand a fund's sustainability level. In contrast, institutional investors pay less attention to this information. Overall, it would be easier for institutional investors to track a fund's carbon footprint.

For these reasons, we formulate the following hypothesis:
Hypothesis 1: Funds serving institutional investors tend to have a lower carbon footprint.

1.2. Sustainability commitment factor

Recent studies highlight a rapid demand for responsibility investment (Bialkowski., Starks, and Wagner, 2021). To meet the increasing need for sustainable investments, more funds specializing in sustainability and green investment are available to investors. SRI funds experience one of the fastest-growing rates, with Europe being the largest market in the number of funds and assets under management (Morningstar, 2022). On the one hand, SRI funds, subject to more public scrutiny regarding the environmental impact of their investments, are more likely to reduce their carbon footprint. On the other hand, the SRI concept involves incorporating a degree of subjectivity in the investment management process. Thus, there can be a risk of "greenwashing" among these funds in the absence of a regulatory framework (AMF, 2015).

In order to attract more inflows, funds that are not self-designed as SRI funds may try to distinguish themselves from other funds and signal their sustainability by committing to some organizations such as PRI (principles for responsible investment). PRI network, founded in 2006, is the largest and the most influential network with more than 2000 signatory institutions (https://www.unpri.org/about-the-pri). Being a PRI signatory signifies that the asset management company shows the public that they consider sustainability in their investment criteria. Lewellen and Lewellen (2019) show that a significant incentive to join a coalition is to enhance reputation. It helps funds attract future flows from E&S-conscious investors and retain existing investors. However, there are no fiduciary or legal repercussions when the management company does not follow its commitments.
Without greenwashing behavior, we would expect that SRI and PRI funds have a lower carbon footprint than conventional funds.
Hypothesis 2: SRI funds and PRI funds tend to have a lower carbon footprint.

1.3.Geographical focus

A fund's carbon footprint may depend on the investment geographical zone on which the fund focuses. Previous studies on climate change underline the importance of the spatial distribution of climate policies (Nordhaus & Yang, 1996; Cruz & Rossi-Hansberg, 2023). Indeed, different geographical zones have different exposure to climate change and different adaptation capacities. Firms in different regions are subject to different social pressures, policies, or headline risks. For instance, Bolton and Kacperczyk (2023) show that a country's economic development level can affect the climate policy. Richer countries tend to have more substantial commitments to combat climate change. They are more responsible for combatting climate change because they are the source of the most significant cumulative emissions. In developing countries, there are low emissions levels because these countries' economies depend less on fossil fuel energy consumption. The same authors find a positive and significant carbon premium in most areas but at different magnitudes.

Similarly, Jacob, Riordan, Nerlinger, and Rohleder (2020) find that carbon betas are high and positive in countries like South Africa, Brazil, and Canada. Thus, they are negatively affected if the world speeds up the transition to a low-carbon economy. In contrast, carbon betas are negative in European countries and Japan.

We may formulate the following hypothesis:

Hypothesis 3: A fund's carbon footprint depends on the geographical zones in which the funds invest.

1.4.Size factor

Fund size

Large funds might have a higher carbon footprint because of the size of their portfolio. Indeed, the French SRI market is mainly based on « positive » strategies, with two investment strategies dominating the French market: « best-in-class » and « ESG integration » (AMF, 2020). These strategies differ from the « negative screening » consisting of selecting stocks based on religious or ethical criteria. These « positive » strategies do not eliminate complete industries from the investment universe. Initially, a fund might choose the best stock regarding sustainability; when its portfolio size increases, it has to widen its choices to a lower sustainability stock. We will test the following hypothesis:

Hypothesis 4a: large funds have a higher carbon footprint.

Family size

A fund's family size might impact the fund's carbon footprint. A fund's sustainability policies tend to follow its family's strategy in terms of sustainability. In addition, a large family has more resources to develop strategies incorporating sustainability characteristics (e.g., large families might develop their database and methodology to incorporate sustainability characteristics of firms). In addition, a large family tends to attract more public attention and scrutiny. For these reasons, we expect a negative relationship between a fund's carbon footprint and family size. The following hypothesis will be tested:

Hypothesis 4b: A fund's carbon footprint decreases with family size.

1.5.Regulation

There are more and more regulations trying to limit carbon emissions. Regulators believe mandatory carbon emission disclosure is the first step to limit carbon emissions. For firms, some countries, such as the UK, have mandated carbon emission disclosure in 2012. However, for institutional investors, carbon emission disclosure was only mandated after the Paris Agreement, and France was the first country to adopt such a regulation. As mentioned above, article 173 of the *Energy Transition and Green Growth Act* in France requires institutional investors that manage more than € 500 million to be transparent about the climate impacts of their investment. The law has been effective since 2016.

Previous studies show that mandatory carbon emission disclosure tends to discipline firms and, thus, institutional investors to reduce their carbon footprint (Mésonnier and Nguyen., 2021; Ilhan et al., 2023; Becker et al., 2022; Gajewski and Tran Dieu., 2023). Using a sample of securities (bonds and equities) issued by energy companies worldwide from 2013 to 2019, Mésonnier and Nguyen (2021) show that the number of France-domiciled financial institution participants in fossil fuel companies decreased after the adoption of Article 173 in France. Ilhan et al. (2023) show that firms owned by French financial institutions improved their climate disclosure after the adoption of Article 173. Becker et al. (2022) analyze the effect of the introduction of the regulation on sustainability-related disclosure in the financial services sector (SFDR) in Europe that entered into force in 2021. The authors find that after the regulation was introduced, funds increased their ESG scores. Gajewski and Tran Dieu (2023) find that mutual funds reduce more their carbon footprint after the introduction of Article 173 in France.
We formulate the following hypothesis:
Hypothesis 5: Funds' carbon footprint diminished after the introduction of Article 173 in 2016.

1.6. Other factors

A fund's other characteristics, such as fund age and management style, can affect its carbon footprint. A fund that has existed for a long time might attract more public attention and scrutiny, leading to a reduction in its carbon footprint. A fund with a management style focusing on small firms (i.e., small capitalization) might have a lower carbon footprint. In contrast, a fund investing mainly in large firms (i.e., large capitalization) tends to have a higher carbon footprint because large firms are more likely to emit more. We will test the following hypothesis:

Hypothesis 6a: A fund's carbon footprint decreases with its age.

Hypothesis 6b: Funds focusing on small capitalization firms have a lower carbon footprint, while funds investing in large capitalization firms have a higher carbon footprint.

2. Data and method

Our sample contains French equity mutual funds and is from Lipper Refinitiv. We have access to holdings of funds and other information such as fund return, fund net asset, and fund characteristics.

Fund promotors often offer "umbrella" funds with several classes. They have different International Securities Identification Number (ISIN) codes and different Lipper codes attributed by Lipper Refinitiv, even though there is only one portfolio for these subclasses. We manually verified whether the funds belonged to the same class. We worked at the portfolio level. We calculate a portfolio's total net asset by summing the holdings of all the classes. We remained only funds for which holding information represented at least 50% of the total assets under management.

We merged the data on portfolio holdings with the carbon emissions of firms in these portfolios by using the firms' Refinitiv codes. The data on carbon emissions are from Refinitiv ESG. This database is one of the best sources for firms' ESG information (Benz et al., 2020). Carbon emissions of firms are divided into three scopes according to the GHG protocol. Scope 1 emissions occur from sources owned or controlled by a company. Scope 2 emissions are from purchasing electricity, heating, cooling, or steam generated off-site but purchased by the firm. Scope 3 emissions are indirect emissions related to a firm's value chain. Scope 3 emissions have the most significant GHG impact for most companies. However, the reporting level remains low for this scope due to a lack of standardization in reporting.

We keep only funds that manage assets over $ 5 million to avoid incubation bias (Evans, 2010). We also eliminate extreme observations where the average yearly flows into the fund are more than 100%. We focus only on actively managed funds and thus exclude index funds because these funds have constraints to replicate an index. Because we focus on diversified funds, we eliminate funds holding fewer than ten stocks. These funds are unlikely to be diversified. At the end, we have 513 equity funds from 2007 to 2020.

Measure of a fund's carbon footprint

The main difficulties in measuring a fund's carbon footprint stem from a lack of data. First, not all data on portfolio holdings are available. Second, data on carbon emissions are not available for all stocks.

A fund's carbon footprint is measured as follows:

$$fund\ carbon\ footprint_{\ i,t} = \sum_{j=1}^{N_{it}} w_{jit} \times stock\ emission_{jt}, \quad (1)$$

where $fund\ carbon\ footprint_{\ i,t}$ is the carbon footprint of fund *i* at date t; N_{it} is the number of stocks for which carbon footprints are available of fund *i*; w_{jit} is the weight of stock *j* in the available stocks; and $stock\ emission_{jt}$ is the carbon emissions of firm *j*.

Concerning firms' carbon emissions, we use both carbon intensity, measured by the ratio of carbon dioxide (CO2) emissions in tons to sales, and absolute carbon emissions of firms. In fact, large companies are likely to have high GHG emissions levels (Andersson et al., 2016). On the one hand, normalizing carbon emissions allows us to identify wasteful firms. A high emissions intensity signifies a more wasteful firm. On the other hand, the absolute value of emissions allowed us to have an idea of the level of carbon emissions for which a fund is responsible. Indeed, regulators tend to target firms with high absolute carbon emissions (Bolton & Kacperczyk, 2021). Notably, Refinitiv provides absolute carbon emissions for all three scopes. However, carbon intensity is calculated only for total equivalent carbon emissions.

Statistic description

Overall, we have 513 funds for the period from 2007 to 2020. Table 1 presents the number of funds according to fund categories. Some rating agencies, such as Morningstar, define institutional funds as those with minimum initial investment requirements of at least $100,000 or funds that designate themselves as institutional. Following this definition, we have 40

institutional funds. Our sample contains mainly retail funds, representing more than 90% of the funds in the sample. SRI funds represent more than 30% of the whole sample.

Scope 3 is much larger than scope 1 and 2. However, most firms do not consider their scope 3 when measuring their total emissions. Consequently, funds' carbon footprint is much smaller when using total carbon emissions than when considering only scope 3 emissions. On average, funds have around 14 years of existence and manage more than $ 300 million.

Table 1: Number of funds according to different categories

Fund category	**Fund number**
Large capitalization	101
Small capitalization	65
SRI funds	162
Institutional funds	40
Retail funds	473
PRI signatory funds	157
Total funds	**513**

Table 2: Statistics of variables

A fund's relative carbon footprint is measured as the weighted average of emission intensities of holdings firms. A firm's emission intensity is measured by dividing the firm's total emissions by the firm's revenue. A fund's absolute carbon footprint is measured by the weighted average of holding firms' total emissions. A fund's Scope 1 carbon footprint is calculated by the weighted average of the holding firms' Scope 1 emissions. A fund's Scope 2 carbon footprint is measured by the weighted average of the holding firms' Scope 2 emissions. A fund's Scope 3 carbon footprint is measured by the weighted average of the holding firms' Scope 3 emissions. Flows is measured as follows: $flows_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1}}{TNA_{i,t-1}} - R_{i,t}$ with $TNA_{i,t}$ is the total net asset of fund *i* at the end of year *t,* $R_{i,t}$ is the return of fund *i* in year *t* (See Section 6 for the measure of fund flows).

Variables	**Minimum**	**Maximum**	**Mean**	**Standard deviation**
Relative carbon footprint	0.54	2630.43	215.94	220.81
Absolute carbon footprint (tCO2eq)	1070	177 850 962	8 168 157	13 519 497
Scope 1 carbon footprint (tCO2eq)	149.98	90 590 100	6 289 773	7 678 345
Scope 2 carbon footprint (tCO2eq)	256	28 161 000	1 183 937	1 178 553
Scope 3 carbon footprint (tCO2eq)	125	482 435 309	31 730 060	38 830 913
Fund total net asset ($ million)	5.01	12 990.98	308.74	6 709.89
Age	0	56	14.58	9.60
Family total net assets ($ million)	5.97	92 561.70	13 740.99	18 381.98
Flows	-0.99	0.99	0.0043	0.2648

Method

Our main model is presented as follow:

$$carbon\ footprint_{i,t} = \propto_i + \beta_1 institutional_i + \beta_2 SRIfund_i + \beta_3 PRIfund_{i,t-1} + \beta_4 fundsize_{i,t-1} + \beta_5 familysize_{i,t-1} + \beta_6 regulation_t + \beta_7 small\ cap_i + \beta_8 large\ cap_i + \beta_9 fund\ age_{i,t-1} + \sum_{j=1}^{5} \theta_j geographical\ zone_{i,j} + \varepsilon_{i,t} \quad \textbf{(1)}$$

Where $carbon\ footprint_{i,t}$ is fund i's carbon footprint at the end of year t. $institutional_i$ is equal to 1 if fund *i* serves institutional investors and 0 otherwise. $SRIfund_i$ is equal to 1 if a fund is declared itself as a socially responsible investing fund and 0 otherwise. $PRIfund_{i,t-1}$ is equal to 1 if a fund belongs to a family that is a signatory member of the PRI network. $fundsize_{i,t-1}$ is measured by the natural logarithm of the asset under management of the fund in year (t-1). $familysize_{i,t-1}$ is measured by the natural logarithm of the asset under management of the fund family in year (t-1). $regulation_t$ is equal to 1 for the period from 2016 to 2020 and 0 for the period from 2007 to 2015. $small\ cap_i$ is equal to 1 for a fund that focuses on small capitalization firms and 0 otherwise. $large\ cap_i$ is equal to 1 for a fund that focuses on large capitalization firms and 0 otherwise. $geographical\ zone_{i,j}$ represents the different geographical focus of funds. We identify the following geographical zones: North America, Europe, Emerging market, Asia including Japan, Asia excluding Japan.

Concerning the econometrical method, we use the "cluster" method developed by Cameron *et al.* (2011) and Thompson (2011), which corrects the standard error bias in the presence of both time and individual effects. Indeed, our sample is panel data. We have information about funds for the period from 2007 to 2020. There may be two forms of dependence for this type of data: individual and time effects. Petersen (2009) demonstrates that the cluster method produces a less biased standard error when individual and time effects exist in the data. We use the double cluster (i.e., cluster on periods and cluster on funds).

3. Determinants of mutual funds' carbon footprint

Table 3 presents the results. Below, we present the impact of different factors on fund carbon footprint.

Regulation

We observe that funds' carbon footprint tends to diminish after 2015, coinciding with the adoption of Article 173 of France's energy transition and green growth. Indeed, the coefficient

associated with the variable "*regulation*" is significantly negative for all cases except for scope 3. The different result in scope 3 can be explained by the fact that Article 173 also regulates large French firms by requiring more comprehensive emission reporting from these firms. Significantly, the law highly recommends the reporting of scope 3. Thus, large French firms may have a higher scope 3 footprint than other firms because they must report all significant items as required by the law. French funds, often subject to "home bias" might display a higher scope 3 footprint.

Moreover, when considering Scope 3 emissions, results need to be interpreted with caution because, in general, firms tend not to report Scope 3 emissions. For instance, in countries with less strict regulations, firms might not report or provide incomplete scope 3 reporting. Therefore, they might appear to have a low scope 3 footprint. Later, we will see that, for many variables, the sign of their coefficient is opposite when considering scope 3 compared with scope 1 and 2.

Investor oversight ability and pressure

We observe that institutional funds display a lower carbon footprint. However, this result is significant only in the case of emission intensity. Like other asset managers, institutional funds might use only emission intensity when filtering firms. Under the pressure of their clients, these funds might try to reduce their relative carbon footprint. However, studies on institutional investors' behavior suggest that even among institutional investors, the degree of sophistication and their oversight ability can differ depending on their size (James and Karceski., 2006). The same authors show that investor oversight tends to be lower for funds with low minimum initial investment requirements. In contrast, funds with large minimum initial investment requirements are more likely to be sold to large pension funds, foundations, corporate accounts, and high-net-worth individuals. These clients are more sophisticated and less subject to agency conflicts. Thus, they can better oversee and put more pressure on the funds they invest in. We verify whether the carbon footprint of funds sold to large institutional investors is inferior to other institutional funds. Following James and Karceski (2006), we define large-institutional-investor funds as funds with minimum initial investment requirements superior to $ 500,000. We re-run the regression (1) by replacing the variable "*institutional fund*" with two dummy variables, "*large-institutional-investor fund*" and "*small-institutional-investor fund*," that represent institutional funds having their minimum initial investment requirements, respectively superior and inferior to $500 000. The result is presented in Annex 1. We find that

the lower relative carbon footprint for institutional investor funds, observed previously, is due to the lower carbon footprint of large institutional-investor funds.

Moreover, even when considering absolute emissions, large-institutional-investor funds appear to have a smaller carbon footprint than conventional funds. Indeed, large-institutional investors such as, large pension funds, are more subject of public scrutiny. Public attention and regulation often target activities with the highest level of carbon emissions. In contrast, small-institutional-investor funds do not experience a smaller carbon footprint than conventional funds.

Overall, our results suggest that not all institutional investors would put more pressure on their funds regarding sustainability; only large institutional investors with a higher degree of sophistication and a better oversight ability can discipline funds to reduce their carbon footprint.

Sustainability commitments

SRI funds have a higher absolute carbon footprint than conventional funds. This result is robust for different measures of absolute carbon footprint. By definition, SRI funds should invest responsibly and thus avoid "sin" stocks (Hong & Kacperczyk, 2009). Regarding environmental aspects, high-emission firms can be considered "sin" stocks. Thus, SRI funds must avoid investing in sectors or firms that are important emitters. However, in the French SRI market, "positive" or "best-in-class" approaches, that consist of selecting the most socially responsible companies, whatever their sector, are prevalent (Crifo & Mottis, 2016). Therefore, SRI funds might invest in high-emission sectors, leading to a higher carbon footprint of SRI funds. The higher absolute carbon footprint of SRI funds can be due to the exposition of these funds to high emitters. In section 5, we verify whether SRI funds are more exposed to high-emission firms than conventional funds.

On the other hand, a higher carbon footprint of SRI funds does not always signify that these funds practice "greenwashing" and do not respect their sustainability engagement (Dumitrescu., Gil-Bazo, and Zhou., 2022). SRI funds can invest in high emitters and pressure these firms to reduce carbon emissions. We verify whether this is the case in section 6.

When considering relative carbon footprint (i.e., emission to revenue), we do not find a significant difference in carbon footprint between SRI and conventional funds. As mentioned above, asset managers often use emission intensity when filtering firms. However, a firm with the highest emission level can be classified as a low emission intensity if the firm realizes a high revenue. While reducing the amount of carbon emissions can be difficult, it may be easier to reduce the emission intensity because firms have another variable they can act on: their

revenue. In the same way, it would be easier for funds to cope with regulations, especially when regulations do not impose any specific methodology or a precise measure of carbon footprint, if they use emission intensity. Nevertheless, to limit global warming, what matters is the amount of carbon emissions, not emission intensities.

In contrast to SRI funds, funds belonging to a family that is a signatory member of the PRI network seem to have a lower carbon footprint than conventional funds. However, this result is verified only for emission intensities. As mentioned above, asset managers often base their decisions on emission intensity when they select stocks, and it would be easier to align with the PRI engagement when using this measure. Notably, we observe a higher absolute scope 3 carbon footprint for PRI funds. PRI funds appear to have a higher scope 3 emissions because these funds might invest in firms that are more transparent and have a better quality in emission reporting.

Overall, PRI funds seem to respect their sustainable engagement better than SRI funds. This result is inconsistent with the results of Nofsinger and Varma (2023). Using a sample of US funds, these authors show that SRI funds have a lower carbon risk score than conventional funds, while PRI funds display a higher carbon risk score than conventional funds. Moreover, due to the release of Morningstar's carbon risk rating, SRI funds reduce their carbon risk score more than PRI funds when they face greater transparency. They explain this result by fiduciary and reputational considerations. Indeed, SRI funds declare their primary investment criteria and strategy in their prospectus whereas being a PRI signatory involves a public display of commitment to considering investment criteria. Considering sustainability as a part of the core investment strategy is a much stronger commitment than the commitments made by joining the PRI network. In addition, there are no fiduciary, legal, or regulatory repercussions for deviating from the commitments for PRI funds, while a perception of violating the primary investing might severely affect the reputation of SRI funds.

Two reasons can explain the difference between our result and Nofsinger and Varma's (2023) result. First, there is a difference in carbon footprint and carbon risk measures. The latter is much more complex. Morningstar uses firms' carbon risk, calculated by the rating agency *Sustainability*. A firm's carbon risk combines the firm's carbon emissions and management aiming to reduce this carbon exposition. Therefore, a firm with a high carbon footprint can have a lower carbon risk. Second, as mentioned above, while in the US market, "negative" strategies are often used by SRI funds, "positive" or "integration" strategies are common in the French

SRI market (Crifo & Mottis, 2016). Thus, French SRI funds that invest in all sectors, including high-emission sectors, might have a higher carbon footprint.

Geographical focus factor

The geographical focus of funds affects the funds' carbon footprint. We observe that funds investing in Asia, except Japan, seem to have a higher carbon footprint. This result is robust for most carbon footprint measures, except for scope 3. Indeed, this geographical zone contains firms in China with the highest level of emissions (Bolton & Karcepkys, 2022). While firms start to report Scope 1 and Scope 2, scope 3 remains rare. In countries where regulation is less strict, such as in Asian countries, firms often do not report scope 3 or have an incomplete scope 3 reporting. Thus, funds investing in these countries appear to have a lower scope 3 footprint.

In contrast, funds investing in Europe tend to have a lower carbon footprint. This result is significant for both relative and absolute carbon footprint. Europe has introduced many regulations that limit the level of carbon emissions. It may discipline firms located in this area to reduce their carbon footprint. Funds investing mainly in North America seem to have a lower carbon footprint. However, these funds do not display a lower absolute carbon footprint, reflecting a less strong commitment to combat global warming in the US. Indeed, the pressure on asset managers to integrate sustainability criteria into their investment decisions can be more intense in Europe than in the US, where the debate about whether responsible investing is consistent with investors' fiduciary duties has not been settled yet (Gibson-Brandon et al., 2022).

For funds investing in Asia, including Japan, it seems to have a lower absolute carbon footprint. This result is consistent with the findings of Görgena et al. (2021), where the authors show that carbon betas are negative in European countries and Japan.

Finally, for funds that invest in emerging markets, the coefficient is insignificant except for scope 3 emissions. On the one hand, these countries' economies depend less on fossil fuel energy consumption, leading to a low emission level. On the other hand, regulations limiting global warming are less strict in these countries. Notably, when considering scope 3 emissions, these funds tend to have a lower carbon footprint, reflecting that firms in these countries often do not report scope 3 emissions due to a lack of strict regulation.

Size factor

The size of the fund appears to have a significant impact on its carbon footprint. Larger funds tend to have a larger carbon footprint, and this finding is consistent across all cases. In fact, French regulators have identified large funds as having a high carbon footprint and have taken steps to limit their impact by requiring them to disclose their carbon footprint and climate-related information if they manage more than $500 million. Consistently with our hypothesis, funds affiliated with larger families seem to have a lower carbon footprint.

Other factors

Funds investing in large capitalization firms are more likely to have a higher absolute carbon footprint. This result is comprehensible because large firms tend to emit more. However, the coefficient is insignificant when carbon footprint is measured by emission intensity. As mentioned above, a large firm might have an important emission level while disclosing a low emission intensity thanks to its high revenue. Therefore, the carbon footprint of funds that invest in large capitalization firms can be different, depending on the measure of firms' carbon footprint (i.e., absolute emissions vs. emission intensity). Unlike large capitalization funds, funds investing in small capitalization firms are more likely to have a smaller level of carbon emissions. This result is robust for all the measures of absolute carbon footprint. Indeed, small capitalization firms emit less, leading to a lower absolute carbon footprint of funds that invest in these firms. However, this result is not remained when we consider emission intensity. Finally, funds existing for a long time tend to have a smaller carbon footprint. However, this result is insignificant when we decompose the carbon footprint into Scope 1 and 2.

In resume, our analysis of mutual fund carbon footprint determinants shows that the measure of firms' carbon footprint matters. A fund can be considered a high or low carbon footprint fund, depending on the measure of carbon footprint: level of emissions or emission intensity. Regulation plays an important role. Funds' carbon footprint has diminished after 2015, when France's energy transition and green growth law were effective. Funds investing in countries with many regulations limiting carbon emission levels, such as European countries, display a lower carbon footprint. In contrast, funds investing in countries where regulation is less strict, such as Asia, except Japan, experience a higher carbon footprint. Investor oversight ability and investor pressure seem to affect funds' carbon footprint. Indeed, funds serving large institutional investors display a lower carbon footprint. Other fund characteristics can influence the fund's carbon footprint, such as fund size, age, or the size of the fund's family. Finally, a striking result is the higher absolute carbon footprint of the funds that make sustainability commitments like SRI funds.

Table 3: Determinants of mutual funds' carbon footprint

In column 1, the dependent variable is relative carbon footprint, measured by the weighted average of the holding firms' emission intensity. In column 2, 3, 4, 5, the dependent variable is the absolute carbon footprint, measured by the weighted average of the holding firms' total emissions, Scope 1 emissions, Scope 2 emissions and Scope 3 emissions, respectively. *SRI fund* is equal to 1 if a fund is self-designed as SRI fund and 0 otherwise. *Institutional fund* is equal to 1 if a fund requiring minimum initial investment requirements of at least $100,000 or designing itself as institutional fund, and 0 otherwise. *Large capitalization* is equal to 1 if a fund focuses on large capitalization firms and 0 otherwise. *Small capitalization* is equal to 1 if a fund invests mainly on small capitalization firms and 0 otherwise. *Fund size* is the natural logarithm of a fund's total net assets. *Age* measures a fund's age. *Family size* is the natural logarithm of the total assets under management of a fund's family. *PRI signatory* is equal to 1 if a fund's family is a signatory member of the PRI network and 0 otherwise. *Regulation* is equal to 1 for the period from 2016 to 2020 and 0 for the period before 2016. *Emerging* is equal to 1 for funds whose geographical focus is emerging markets and 0 otherwise. *North America* is equal to 1 if a fund focuses on firms located in North America and 0 otherwise. *Europe* is equal to 1 if a fund invests mainly on firms located in Europe and 0 otherwise. *Asia except Japan* is equal to 1 for funds that invest in Asian countries except Japan and 0 otherwise. *Asia including Japan* is equal to 1 for funds that invest in Asian countries including Japan and 0 otherwise. Double clusters (for year and fund) are used.

	Relative carbon footprint	**Absolute carbon footprint**			
Variables	**Emissions to revenue (Column 1)**	**Total emission (Column 2)**	**Scope 1 emission (Column 3)**	**Scope 2 emission (Column 4)**	**Scope 3 emission (Column 5)**
Constant	**298.03**	**13.14**	**12.82**	**12.95**	**13.69**
	(5.15)	**(34.63)**	**(27.98)**	**(46.54)**	**(25.24)**
SRI fund	7.07	**0.24**	**0.26**	**0.27**	**0.17**
	(0.82)	**(4.14)**	**(3.81)**	**(6.33)**	**(1.93)**
Institutional fund	**-23.77**	-0.04	0.03	0.01	0.20
	(-1.93)	(-0.40)	(0.29)	(0.27)	(1.48)
Large capitalization	-12.34	**0.71**	**0.86**	**0.54**	**1.00**
	(-1.55)	**(11.96)**	**(11.81)**	**(13.43)**	**(11.41)**
Small capitalization	0.23	**-1.73**	**-1.92**	**-1.45**	**-2.21**
	(0.01)	**(-19.10)**	**(-17.47)**	**(-19.06)**	**(-16.39)**
Fund size	**14.68**	**0.25**	**0.26**	**0.13**	**0.26**
	(3.86)	**(9.65)**	**(8.01)**	**(6.75)**	**(6.91)**
Age	**-11.63**	**-0.08**	-0.02	-0.003	0.06
	(-2.25)	**(-2.10)**	(-0.58)	(-0.10)	(1.14)
Family size	**-11.89**	**-0.09**	**-0.12**	**-0.06**	**-0.13**
	(-4.29)	**(-5.28)**	**(-5.52)**	**(-4.49)**	**(-5.13)**
PRI signatory	**-42.54**	-0.09	-0.04	0.01	**0.17**
	(-5.25)	(-1.48)	(-0.62)	(0.24)	**(1.96)**
Regulation	**-55.07**	**-0.61**	**-0.54**	**-0.45**	**0.34**
	(-7.00)	**(-10.61)**	**(-7.64)**	**(-10.35)**	**(4.09)**
Emerging	11.45	0.005	-0.24	-0.36	**-2.41**
	(0.24)	(0.02)	(-0.52)	(-1.38)	**(-8.08)**
North America	**-83.49**	-0.16	-0.10	-0.09	**-0.73**
	(-4.49)	(-1.50)	(-0.75)	(-1.29)	**(-3.91)**
Europe	**-25.15**	**-0.30**	**-0.18**	**-0.59**	-0.07
	(-1.63)	**(-4.33)**	**(-2.17)**	**(-12.62)**	(-0.64)
Asia except Japan	**123.11**	**0.63**	**0.51**	**0.78**	**-0.95**
	(3.04)	**(4.93)**	**(2.74)**	**(6.62)**	**(-3.04)**
Asia including Japan	-15.16	**-0.17**	-0.14	0.05	**0.34**
	(-0.41)	**(-1.65)**	(-1.13)	(0.66)	**(1.81)**
R2	0.06	0.26	0.22	0.32	0.17
Observation number	3007	3001	2994	2872	2949

4. Are SRI funds more exposed to high emission firms?

One striking result found in the previous section is that SRI funds have a higher absolute carbon footprint than conventional funds. This section investigates whether SRI funds are more exposed to high-emission firms than conventional funds. For this, we first identify high-emission firms. Each year, we rank firms according to their carbon footprint, measured by emissions to revenue, total emissions, scope 1, scope 2, or scope 3. To account for the difference in firm number across years, we normalize a firm's rank by dividing the rank by the number of available firms for the considered year. Thus, a rank's value is between 0 and 1, with the highest emission firm having a rank equal to 1 and the lowest emission firm having a rank equal to 0. A firm belonging to 20% of the highest emission firms (i.e., rank superior or equal to 0.8) is considered a high emitter. We calculate the proportion of each fund's asset invested in high emitters each year.

Table 4 presents the average proportion of funds' assets invested in large emission firms. There is a higher exposition of SRI funds in the highest emitter firms than conventional funds. The t-test verifying the difference in the asset proportion that finances large emitters is significant for all cases. SRI funds seem to be more exposed to large emission firms, with around 14% of their assets invested in firms having the highest total emission firms compared with around 11,5% of assets for conventional funds. On the one hand, this higher exposition of SRI funds to the most significant emitters might raise suspicion of greenwashing. By definition, SRI funds must invest responsibly and thus avoid "sin" stocks (Hong & Kacperczyk, 2009). In transition economies, high emitters' stocks can be considered "sin" stocks. In reality, regulations tend to target firms with the highest emissions level (Bolton & Kacperczyk, 2021). The same authors find a "carbon premium" for high emitters, and this premium is related to the level of emissions but not to emission intensity (i.e., emissions to revenue). On the other hand, SRI funds might invest in high emitters and engage with them to reduce the firms' carbon footprint. We verify this *"engaging" hypothesis* in the below section.

Table 4: Average proportion of funds' assets invested in high emitting firms

Each year, firms are ranked according to their carbon footprint. Ranks are then normalized by dividing to the number of available firms in the considered year. A rank's value is thus between 0 and 1. The highest emission firm obtains a rank equal to 1 and the lowest emission firm has a rank equal to 0. A firm is considered as a high emission firm if it belongs to 20% of the highest emission firms (i.e., its rank is superior to 0.8). Each year, we calculate the proportion of a fund's assets that is invested in high emission firms. T-tests verify whether the proportion of assets used to finance high emission firms is different between SRI funds and conventional funds.

Measure of firm carbon footprint	SRI fund	Conventional fund	t-test (p-value)
Carbon emission to revenue	5,44%	4,17%	<.0001
Total carbon emission	14,74%	11,73%	<.0001
Scope 1	12,83%	10,25%	<.0001
Scope 2	17,05%	12,92%	<.0001
Scope 3	14,81%	11,47%	<.0001

5. Do SRI funds engage with high emitters to reduce their carbon footprint?

In the previous section, we showed that SRI funds are more exposed to high-emission firms than conventional funds. One may assume that these funds invest in these firms and then engage with them to reduce their carbon footprint. If SRI funds engage with high emitters, they would keep these stocks in their holdings and work with these firms to reduce their carbon footprint.

To verify this "engagement" hypothesis, we examine whether SRI funds' carbon footprint decreases and this reduction is due to the reduction of the remaining stocks' carbon emissions or to the reallocation of the fund's portfolio towards lower carbon emission stocks. Following Gajewski and Tran Dieu (2023), we separate these two impacts by decomposing the evolution of a fund's carbon footprint into two components: the first component (component 1) represents the evolution of the fund's carbon footprint due to the variation of the remaining stocks' carbon emissions; the second component (Component 2) reflects the variation due to the reallocation of the fund's portfolio.

The evolution of a fund's carbon footprint is expressed as follows:

$$fund\ carbon\ footprint_{i,t} - fund\ carbon\ footprint_{i,t-1} = \sum W_{R,t} stock\ emission_{R,t} + \sum W_{I,t} stock\ emission_{I,t} - \sum W_{R,t-1} stock\ emission_{R,t-1} - \sum W_{E,t-1} stock\ emission_{E,t-1} \quad (3)$$

Where $W_{R,t}$ is the weight of remaining stock R in date t, $W_{I,t}$ is the weight of stock I that is included in the fund's portfolio in date t; $W_{E,t-1}$ is the weight in (t-1) of stock E that is excluded from the fund's portfolio in t. $stock\ emission_{R,t}$ is the emission of the remaining stock R in

date t; $stock\ emission_{I,t}$ is the emission of the including stock I in date t; $stock\ emission_{E,t-1}$ is the emission of the excluding stock E in date (t-1).

We decompose the evolution of a fund's carbon footprint as follows[2]:

$$fund\ carbon\ footprint_{i,t} - fund\ carbon\ footprint_{i,t-1} = \sum W_{R,t}(stock\ emission_{R,t} - stock\ emission_{R,t-1}) + \sum(W_{R,t} - W_{R,t-1})stock\ emission_{R,t-1} + (\sum W_{I,t}stock\ emission_{I,t} - \sum W_{E,t-1}stock\ emission_{E,t-1}) \quad (4)$$

The first term, $\sum W_{R,t}(stock\ emission_{R,t} - stock\ emission_{R,t-1})$, reflects the fund's carbon footprint variation due to the variation of the carbon footprints of the remaining stocks in the fund's portfolio. The second term, $\sum(W_{R,t} - W_{R,t-1})stock\ emission_{R,t-1}$, represents the variation due to the change in position of the remaining stocks. The third term, $(\sum W_{I,t}stock\ emission_{I,t} - \sum W_{E,t-1}stock\ emission_{E,t-1})$, reflects the variation due to the difference in carbon emissions of including and excluding stocks. Thus, the sum of the second and the third terms represents the variation of the fund's carbon footprint due to the reallocation of the fund's portfolio.

A fund's carbon footprint evolution, $\Delta_{i,t}$, is decomposed into two parts as follows:

$$\Delta_{i,t} = \Delta_{1,t} + \Delta_{2,t} \quad (5)$$

Where $\Delta_{1,t} = \sum W_{R,t}(stock\ emission_{R,t} - stock\ emission_{R,t-1})$

$$\Delta_{2,t} = \sum(W_{R,t} - W_{R,t-1})stock\ emission_{R,t-1} + \left(\sum W_{I,t}stock\ emission_{I,t} - \sum W_{E,t-1}stock\ emission_{E,t-1}\right)$$

The evolution of funds' carbon footprint therefore depends on the variation in carbon footprint of "remaining" firms ($\Delta_{1,t}$), *Component 1*, and the reallocation of the fund's portfolio ($\Delta_{2,t}$) *Component 2*.

Table 5 presents the results. We observe that in general funds' carbon footprint tends to diminish, and the reduction of fund carbon footprint is due to the reduction of the remaining firms' carbon emissions and the reallocation of the fund portfolio. Indeed, the average evolution of fund carbon footprint is significantly negative for the main measures of carbon footprint (emissions to revenue and total emissions). However, in terms of magnitude, the fund's carbon

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$$\begin{aligned} &Fund\ Carbon\ footprint_{i,t} - fund\ carbon\ footprint_{i,t-1} \\ &= \sum W_{R,t}stock\ emission_{R,t} + \sum W_{I,t}stock\ emission_{I,t} - \sum W_{R,t-1}stock\ emission_{R,t-1} \\ &- \sum W_{E,t-1}stock\ emission_{E,t-1} \\ &= \sum W_{R,t}stock\ emission_{R,t} - \sum W_{R,t}stock\ emission_{R,t-1} + \sum W_{R,t}stock\ emission_{R,t-1} \\ &+ \sum W_{I,t}stock\ emission_{I,t} - \sum W_{R,t-1}stock\ emission_{R,t-1} - \sum W_{E,t-1}stock\ emission_{E,t-1} \end{aligned}$$

footprint reduction is mainly due to the reallocation of the fund's portfolio. Indeed, the average absolute value of Component 2 is much larger than that of Component 1. This result is robust for all carbon footprint measures (except for scope 3). As explained above, due to the introduction of Article 173 in France, scope 3 emissions can increase over time. This policy may explain why we do not observe a reduction in scope 3 emissions. Finally, the t-tests verifying the difference between SRI and conventional funds are not significant for most cases, suggesting no differences in carbon footprint evolution between these two funds. In other words, SRI funds are exposed more highly to high emitters, but they do not engage more with firms to reduce the firms' carbon footprint relative to conventional funds.

Table 5: Decomposition of a fund carbon footprint's evolution

Fund carbon footprint evolution $_{i,t} = fund\ carbon\ footprint_{i,t} - fund\ carbon\ footprint_{i,t-1}$

Component 1 is measured as follows: $\sum W_{R,t}\left(stock\ emission_{R,t} - stock\ emission_{R,t-1}\right)$. Component 2 is calculated as follows:

$$\sum\left(W_{R,t} - W_{R,t-1}\right)stock\ emission_{R,t-1} + \left(\sum W_{I,t} stock\ emission_{I,t} - \sum W_{E,t-1} stock\ emission_{E,t-1}\right)$$

	SRI fund (p-value)	**Conventional fund (p-value)**	**t-test verify whether there is a difference between SRI fund and conventional fund (p-value)**
Emissions to revenue			
Fund carbon footprint evolution	**-18.01 (0.0003)**	**-10.57 (0.0408)**	0.3756
Component 1	**-3.36 (0.0003)**	-3.59 (0.1779)	0.9538
Component 2	**-17.64 (0.0003)**	**-9.96 (0.0207)**	0.2847
Total emission (tCO2eq)			
Fund carbon footprint evolution	**-1 817 440 (<.0001)**	**-1 914 377 (<.0001)**	0.8342
Component 1	**-98 375 (<.0001)**	**-102 145 (<.0001)**	0.8670
Component 2	**-1 779 640 (<.0001)**	**-1 776 063 (<.0001)**	0.9937
Scope 1 (tCO2eq)			
Fund carbon footprint evolution	**-413843 (0.0291)**	**-389716 (0.0075)**	0.9235
Component 1	**-107 634 (<.0001)**	**-92 516 (<.0001)**	0.4462
Component 2	**-395 992 (0.0348)**	**-300 022 (0.0300)**	0.6904
Scope 2 (tCO2eq)			
Fund carbon footprint evolution	**-63 811 (0.0126)**	**-80 150 (0.0014)**	0.6903
Component 1	**-5932 (0.0751)**	**-11928 (<.0001)**	0.1166
Component 2	**-66263 (0.0090)**	**-57803 (0.0029)**	0.8004
Scope 3 (tCO2eq)			
Fund carbon footprint evolution	901 431 (0.2220)	990 685 (0.1552)	0.9378
Component 1	-153 438 (0.2408)	**-467 071 (<.0001)**	**0.0656**
Component 2	803 484 (0.2609)	**1 762 855 (0.0087)**	0.3823

6. Do SRI funds attract more investors?

Our previous results show that SRI funds are more exposed to high-emission firms than conventional funds. However, they are not more engaged with these firms to reduce their carbon footprint than conventional funds. Contrary to expectations, SRI funds do not invest more responsibly than conventional funds, at least in environmental issues. Yet, recent studies suggest that investors pay more attention to the sustainable characteristics of their investments and are willing to invest more in funds that appear to be socially responsible (Riedl & Smeets, 2017; Hartzmark & Sussman, 2019; Ammann et al., 2019; Bauer et al., 2021; Ceccarelli et al., 2024). Some funds even changed their name to sustainability-related appellation to attract more investors (El Ghoul and Karoui., 2021). This section analyzes whether SRI funds attract more investors than conventional funds.

We run the following regression:

$$flows_{i,t} = \alpha_i + \beta * SRI\ fund_i + \sum_{j=1}^{k} \theta_j control_{i,j,t-1} + \varepsilon_{i,t}$$

Where $flows_{i,t}$ is the net flows of fund *i* at time *t*. $SRI\ fund_i$ is equal to 1 if it is a SRI fund and 0 otherwise. $control_{i,j,t-1}$ represents control variables that can affect a fund's flows. β and θ_j are coefficients associated to explanatory variables. $\varepsilon_{i,t}$ is the error term.

Our dependent variable *flows* is calculated as follows:

$$flows_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1}}{TNA_{i,t-1}} - R_{i,t}$$

Where $TNA_{i,t}$ is the total net asset of fund *i* at the end of date *t*; $R_{i,t}$ is the return of fund *i* for year *t*.

This measure of net flows is widely used in previous literature on the flow-performance relationship (Sirri & Tufano, 1998; Huang et al., 2007; among others).

Our main explanatory variable is *SRI fund*, which is equal to 1 if a fund is self-declared as a SRI fund and 0 otherwise. We expect a positive relationship between SRI funds and flows.

We consider other control variables that can affect the net flows of a fund.

First, we consider the impact of fund performance by adding dummy variables representing the highest and the lowest return funds. Literature on the determinants of fund flows suggests that investors are more likely to respond to extreme values and are less sensitive to medium values (Hartzmark & Sussman, 2019). We use a simple measure of return to analyze the impact of performance on flows because investors, especially retail investors, are not sophisticated and

tend to use simple measures such as return (Del Guercio & Tkac, 2002; Evans & Fahlenbrach, 2012; Ammann et al., 2019; Ben-David et al., 2022). Indeed, our sample contains more than 90% of funds that target retail clients. For each category of fund (institutional or individual investors) and each year, funds belonging to the same geographical focus are ranked according to their yearly return. The ranks are then normalized by dividing them by the number of funds in a given geographical zone. Thus, a rank has a value between 0 and 1. The highest return fund has a rank equal to 1, and the lowest return fund has a rank equal to 0. We include two dummy variables: "*low performance*" is equal to 1 if a fund belongs to 20% of the lowest return (i.e., rank is inferior or equal to 0.2), and "*high performance*" is equal to 1 if a fund belongs to 20% of the highest return (i.e., rank is superior or equal to 0.8).

Second, other fund characteristics often used as control variables in the literature about the determinants of net flows, such as fund total expense ratio, fund age, fund size, and family size, are also added as control variables. Notably, we added a dummy variable, *"PRI signatory,"* equal to 1 if a fund belongs to a family that is a PRI signatory member and 0 otherwise, as a control variable. By joining the PRI network, fund families might expect a reputation enhancement and attract more investors. Therefore, we expect a positive relation between this variable and fund net-flows. We use the double cluster (on time and fund) method for these regressions.

Table 6 presents the results. We observe that SRI funds are more likely to obtain more net flows. Indeed, the coefficient associated with the variable "SRI fund" is significantly positive. This result is consistent with previous studies indicating that SRI funds experience more significant growth than conventional funds (Białkowski and Starks, 2016; Kaustia and Yu, 2021). For instance, Kaustia and Yu (2021) highlight the greenwashing behavior in the US mutual fund industry. They find self-design ESG funds tend to obtain more flows than conventional funds. However, ESG funds tend to have lower ESG scores than other funds. Their result remains for both retail and institutional funds. Moreover, fund families tend to convert funds with difficulties attracting flows into ESG funds.

Concerning control variables, we observe that funds that obtain a high result attract more investors. In contrast, low-result funds are not penalized by significant outflows. This convex relation between net flows and performance is consistent with previous literature (Chevalier & Ellison, 1997; Sirri & Tufano, 1998; Huang et al., 2007, among others). We observe a negative relation between fund size and net flows because of how net flows are measured (i.e., relative to a fund's net assets). There is a positive relationship between fund flows and family size.

Indeed, funds belonging to a large family may benefit the family's reputation, reducing search costs for investors and thus attracting more flows. In contrast, fund age negatively affects fund net flows. Literature on the determinants of fund flows shows that fund families tend to allocate more subvention to young funds (Chevalier & Ellison, 1997), allowing them to attract more investors. Notably, we do not find evidence that PRI funds obtain more inflows than other funds.

Table 6: Determinants of fund flows

Variables	**Estimator (t-student)**
Constant	**0.56 (6.34)**
SRI fund	**0.028 (2.13)**
Low performance (20% the lowest return)	-0.009 (-0.65)
High performance (20% the highest return)	**0.05 (3.97)**
Total expense ratio (TER)	-0.013 (-1.57)
Fund size	**-0.03 (-5.72)**
Age	**-0.05 (-6.86)**
Family size	**0.007 (1.92)**
PRI signatory	**-0.039 (-3.08)**
R2	0.06
Observation number	2258

Conclusion

There is growing literature on climate finance; however, little research has been done outside the US market. This article investigates the determinants of French mutual funds' carbon footprint. Understanding factors determining a fund's carbon footprint is essential for investors when selecting funds and for regulators to orient financing from "brown" to "green" firms. We find some results that may have important managerial implications.

First, our results show that funds tend to reduce their carbon footprint after 2015, coinciding with the introduction of the French energy transition and green growth law. Funds investing in countries with strict regulations limiting carbon emissions, such as European countries, tend to have a lower carbon footprint. These results contribute to the debate about the importance of regulation limiting carbon emissions.

Second, we show that the way we measure carbon footprint matters. A fund can be considered a low carbon footprint when using emission intensity and a high carbon footprint if considering the level of emissions. While asset managers widely use emission intensity to filter firms, it can also be easier for them to cope with regulation. Ultimately, what really matters is the total amount of carbon emissions released into the air, as mentioned by Bolton and Kacperczyk (2022), who find a carbon premium related to the level of emissions but not to emission intensity. While the debate about the importance of regulations seems to be settled, the methodology firms and funds use to cope with regulations remains an open question. For instance, French law requires institutional investors, including mutual funds, to be transparent about the climate impacts of their investments. However, it does not impose any specific reporting method, leading to diversity in the methods and approaches (Evain et al., 2018).

Third, we show that funds serving large investors, often having a better oversight ability and a higher power to pressure funds, are more likely to have a lower carbon footprint. This result contributes to the debate on protecting small and retail investors who cannot effectively oversee the operation of their funds. Indeed, in a transition world, carbon risk has been recognized as a significant risk that financially impacts investment performance (Amel-Zadeh & Serafeim, 2018).

Fourth, one of the most striking results is that SRI funds are more exposed to the highest emitters than conventional funds. However, these funds do not engage with their holding firms to reduce carbon emissions. While investors are more attracted to SRI funds, a higher exposition of SRI funds to the highest emitters might raise suspicion of "greenwashing."

Finally, our study contributes to the literature on the carbon footprint of financial institutions in general and mutual funds in particular. Future research can be conducted for other countries with different "climate-conscious" norms and legal systems.

Annex

Annex 1: Small vs. large institutional investors

	Relative carbon footprint	Absolute carbon footprint			
Variables	**Emissions to revenue (column 1)**	**Total emission (column 2)**	**Scope 1 emission (column 3)**	**Scope 2 emission (column 4)**	**Scope 3 emission (column 5)**
Constant	**299.66 (5.18)**	**13.17 (34.80)**	**12.87 (28.18)**	**12.97 (46.74)**	**13.72 (25.26)**
SRI fund	7.09 (0.83)	**0.24 (4.15)**	**0.26 (3.83)**	**0.27 (6.34)**	**0.17 (1.93)**
Large institutional investor	**-46.61 (-2.16)**	**-0.54 (-2.51)**	**-0.65 (-2.38)**	-0.24 (-1.31)	-0.17 (-0.66)
Small institutional investor	-18.58 (-1.31)	0.07 (0.69)	0.19 (1.53)	0.07 (1.03)	**0.29 (1.88)**
Large capitalization	-12.60 (-1.58)	**0.70 (11.84)**	**0.85 (11.69)**	**0.53 (13.34)**	**1.00 (11.32)**
Small capitalization	0.27 (0.01)	**-1.73 (-19.06)**	**-1.92 (-17.42)**	**-1.45 (-19.02)**	**-2.21 (-16.36)**
Fund size	**14.50 (3.78)**	**0.24 (9.44)**	**0.25 (7.80)**	**0.12 (6.62)**	**0.25 (6.77)**
Age	**-11.58 (-2.24)**	**-0.08 (-2.08)**	-0.02 (-0.55)	-0.002 (-0.08)	0.07 (1.15)
Family size	**-11.81 (-4.25)**	**-0.09 (-5.18)**	**-0.12 (-5.40)**	**-0.06 (-4.41)**	**-0.13 (-5.06)**
PRI signatory	**-41.99 (-5.13)**	-0.08 (-1.28)	-0.03 (-0.41)	0.01 (0.37)	**0.18 (2.05)**
Regulation	**-55.42 (-7.02)**	**-0.62 (-10.70)**	**-0.55 (-7.76)**	**-0.45 (-10.41)**	**0.33 (4.01)**
Emerging	11.15 (0.23)	-0.0008 (-0.00)	-0.25 (-0.54)	-0.36 (-1.39)	**-2.42 (-8.10)**
North America	**-82.25 (-4.40)**	-0.14 (-1.23)	-0.06 (-0.47)	-0.08 (-1.07)	**-0.70 (-3.75)**
Europe	**-25.28 (-1.64)**	**-0.30 (-4.40)**	**-0.19 (-2.23)**	**-0.59 (-12.75)**	-0.07 (-0.66)
Asia excluded Japan	**122.92 (3.04)**	**0.63 (4.91)**	**0.50 (2.72)**	**0.78 (6.61)**	**-0.96 (-3.05)**
Asia included Japan	-16.32 (-0.44)	**-0.20 (-1.87)**	-0.17 (-1.40)	0.03 (0.49)	**0.32 (1.70)**
R2	0.06	0.26	0.22	0.32	0.17
Observation number	3007	3001	2994	2985	2949

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