Are investors aware of climate-related transition risks? Evidence from mutual fund flows

Juan C. Reboredo[a*] and Luis A. Otero[b]

a. Department of Economics, Universidade de Santiago de Compostela, Spain
b. Department of Finance, Universidade de Santiago de Compostela, Spain

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Abstract

Using information on climate transition risks embedded in US equity mutual fund portfolios, we report evidence that mutual fund investors consider climate-related transition risk to be an undesirable fund feature and accordingly allocate more money to funds with lower climate-related transition risk. The size of the impact of this risk on fund flows differs depending on the performance expectations of investors, the socially responsible focus and the sustainability of the fund. Our results suggest that mutual fund investors are aware of climate-related transition risks as evidenced by their investment decisions.

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[*] Address for correspondence: Juan Carlos Reboredo. Universidade de Santiago de Compostela. Departamento de Fundamentos del Análisis Económico. Avda. Xoán XXIII, s/n, 15782 Santiago de Compostela, SPAIN. E-mail: juancarlos.reboredo@usc.es. Phone: +34 881811675. Fax: +34 981547134.
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1. Introduction

Climate change entails risks for the value of firms, either due to the impact of natural disasters (e.g., floods, droughts, increasing the sea levels) on firm's activity and assets value (Dietz et al., 2016); or due to the use of new technologies, changes in consumer preferences and regulatory policies limiting carbon emissions that are required for a transition to a low-carbon economy (Bolton and Kacperczyk, 2020). Although there is a broad consensus on the potentially great impact of the transition towards a low-carbon economy on the economic value of companies, it is still unclear from their trading activity whether investors are becoming aware of climate-related transition risks.

In this paper we study how investors respond to climate-related risks associated with the transition to a low-carbon economy by examining how fund flows respond to information about climate-related transition risks embedded in fund portfolios. In addressing this issue, the main challenge is to identify and assess climate-related transition risks. Some studies use information on carbon emissions or extreme weather conditions in order to explore whether climate risks are priced into financial markets (e.g., Bolton and Kacperczyk, 2020; Hong, Li and Xu, 2019). However, while those measures are suitable for measuring a firm's exposure to carbon emissions or a particular climate risk related to weather conditions, they are silent on the risk that a low-carbon transition implies for a company's economic value and on how this risk is managed by firms.

This study uses climate transition risk scores as computed by Sustainalytics on the basis of residual unmanaged carbon risk in a company, i.e., risk remaining after all actions to mitigate risk exposure to the transition to a low-carbon economy are taken into account. Sustainalytics assigns companies a carbon risk score (CRS) reflecting their vulnerability, calculated as negligible (0), low (0-10), medium (10-30), high (30-50) or severe (>50). The distinctive feature of the CRS metric is that it internalizes the cost of the carbon externality by scoring the impact on the firm's value, whereas carbon emissions, in contrast, only reflect the firm's exposure to the externality but not the implications for the firm's value. Consequently, the CRS provides useful information for investors to internalize the cost of carbon emissions in their investment decisions.

Morningstar Direct Mutual Fund uses Sustainalytics CRS information at the firm level to provide quarterly information on climate risk, embedded in mutual fund portfolios as the weighted sum of CRS values, with weights determined by the company's share in the portfolio. In this research we use Morningstar CRS portfolio scores — released and made available to investors since the second quarter of 2018 — as a baseline for assessing a fund's capacity to manage carbon risk and pledge to the management of climate-related risk. Morningstar also provides additional carbon metrics for the fund portfolio, including a percentile category rank for the CRS and the level of fossil fuel involvement (FFI), as well as a low-carbon label, awarded to funds with portfolios with a CRS and FFI falling below predetermined thresholds.

Using low-carbon transition risk information for fund portfolios in a quasi-natural experimental manner, we explore the salience of carbon metrics in shaping mutual fund investor decisions. Specifically, our analysis focuses on the impact of the diffusion of climate-related transition risks information on US equity mutual fund flows. Our main finding is that mutual fund investors consider climate transition risk to be an undesirable fund feature and consequently allocate relatively more money to funds with lower CRS values. Our results further point to the fact that the CRS metric conveys specific information that reinforces the positive effect of sustainability and SRI ratings on fund flows, as documented in the literature (Ammann, Bauer, Fischer and Müller, 2019; Hartzmark and Sussman, 2019). Furthermore, our difference-in-differences (DiD) analysis indicates that, before CRS publication, there are no differences in fund flows according to carbon risk, whereas after CRS publication, investors flee out of high carbon risk mutual funds. Fund flow differences between funds in the CRS fifth and first quintiles after the publication of the CRS yield a relative loss of 3.12 billion USD for the funds with a higher carbon risk.

Interestingly, we find that the FFI of the fund portfolio has a positive effect on flows, reflecting a trade-off between climate transition risk and the FFI. This evidence is consistent with the investor association of FFI with profitability, and also with the fact that, while investors appreciate funds with low climate-related risk, they do not fully disregard portfolios with higher FFI; this finding is in line with that of Monasterolo and De Angelis (2020) for carbon-intensive assets. Examining the percentile rank underlining the CRS distribution by category, we find no evidence on the impact of this relative measure on fund flows, suggesting that investors focus on a continuous measure but ignore information embedded in percentile ranks of that continuous measure. We further document the absence of a low-carbon labelling effect: our regression discontinuity analysis reveals no significant differences between labelled and unlabelled mutual funds; this is explained by the trade-off between the positive and negative effects of FFI and of the climate-related risk in the fund portfolio observed around the cutoffs. In contrast to Hartzmark and Sussman (2019) and Cecarelli, Ramelli and Wagner (2020), who report that discrete information on sustainability and on low-carbon designations have positive effects on fund flows, we find that only continuous information on climate-related risk — easily interpretable and useful in identifying extreme risk — shapes investor decisions as reflected by fund flows.

We furthermore explore whether the use of low-carbon transition information by investors is based on pecuniary or non-pecuniary motives (Derwall et al., 2011; Døskeland and Pedersen, 2016, Hart and Zingales, 2017). Thus, while *altruistic* personal values, as stated in the value-belief-norm theory (Stern et al, 1999), lead to a pro-environmental attitude consistent with reductions in carbon emissions, *egoistic* personal values are negatively related to low-carbon investments unless those investments yield compensation commensurate with a higher performance (Brodback, Guenster & Mezger, 2019). This distinction in personal values is relevant as performance-oriented investors may reverse their bets on funds with low-carbon transition risk when those funds underperform. Likewise, the disclosure of low-carbon transition risk information may not provide the necessary incentives to drive egoistic investors towards pro-environmental funds if those funds do not offer sufficiently convincing performance expectations. Using a rating system of stars as a proxy for future fund performance (Blake and Morey, 2000; Del Guercio and Tkac, 2008), we find that flows of funds with low star ratings are sensitive to climate-related transition risk, whereas four-star and five-star funds are independent of carbon risk. This result shows that investors in the high star-rated funds accept the higher carbon risk, as the expected performance is reasonably good. Similarly, we document that the flows of SRI funds and funds with high-sustainability features (according to sustainability information as reflected in a ranking based on one to five globes) are more sensitive to climate-related transition risk than other funds. As in Hartzmark and Sussman (2019), our evidence on the effects of climate-related transition risk on fund flows is consistent with the coexistence of different investors' sensitivities to climate risks, even though average investors positively value the low climate risk profile of fund portfolios.

The remainder of the paper is laid out as follows. Section 2 outlines the related literature. Section 3 describes climate-related transition risk scores and our data and the corresponding descriptive statistics. Section 4 explores the impact of climate-related transition risk on mutual fund flows. Section 5 discusses the interaction between climate-related transition risk and investment focus on the flow of funds. Finally, Section 6 discusses the economic implication of climate-related transition risk for fund flows and Section 7 concludes the paper.

2. Related literature

The effects of climate risk on financial markets have been examined by a recent flourishing literature (Hong, Karolyi and Scheinkman, 2020). Some studies that have analysed the impact of carbon emissions on stock pricing find that carbon emissions reduce a firm's value and increase the cost of capital (Matsumura et al., 2014; Chava, 2014; El Ghoul et al., 2011), have mixed negative (In, Park and Monk, 2019; Garvey, Iyer and Nash, 2018) or positive effects on firm returns (Bolton and Kacperczyk, 2020; Hsu, Li and Tsou, 2019; Oestreich and Tsiakas, 2015), and increase downside risk (Ilhan, Sautner and Vilkov, 2019). Also, Trinks, Mulder and Scholtens (2019) show that improvements in carbon emissions efficiency reduce systematic risk and improve financial performance; while Horváthová (2010; 2012) document that the relationship between environmental and financial performance may differ in the short and in the long run. For the particular case of equity mutual funds, low-carbon transition risk is positive related with a better risk-adjusted performance (Reboredo and Otero, 2019; Domínguez, Matallín, Mingo and Tortosa, 2020).

Other studies that have examined the pricing effects of risks related to climate events (such as droughts, flooding or high temperatures) report that firms exposed to such risks exhibit lower returns (Hong, Li and Xu, 2019; Choi, Gao and Jiang, 2018) and that houses vulnerable to sea-level rise are priced at discount (Bernstein, Gustafson and Lewis, 2019; Murfin and Spiegel, 2020).

Likewise, a related strand of the literature has explored how hedging climate risk affects portfolio performance, showing that reducing carbon exposure does not seem to impair portfolio performance (see, e.g., Andersson, Bolton and Samama, 2016; De Jong and Nguyen, 2016; Trinks, Scholtens, Mulder and Dam, 2018; Boermans and Galema, 2019; Monasterolo and De Angelis, 2020).

Our analysis contributes to this literature by considering how climate-related transition risk impacts on investment decisions as reflected by investors' trading activity in mutual funds. Arguably, awareness of climate related risk should be reflected by capital movements away from highly exposed investments. In a survey analysis, Krueger, Sautner and Starks (2020) document that that investors consider climate risks in their investment decisions as that those risks might have implications for their portfolios. Consistently, Ammann, Bauer, Fischer and Müller (2019) and Hartzmark and Sussman (2019) provide evidence that investors value sustainable fund portfolios, whereas Cecarelli, Ramelli and Wagner (2020) show that low-carbon mutual funds have improved flows compared to non-labelled funds.

Also, our paper is closely related to the literature on sustainable investments and investments in "doing well by doing good" (e.g., Benabou and Tirole, 2010; Hart and Zingales, 2017; Chowdhry, Davies and Waters, 2019; Riedl and Smeets, 2017). Some studies analyse investors' preferences for SRI products (see, e.g., Renneboog et al., 2011, Bauer et al., 2018 and Barber et al., 2019; Bassen et al., 2019), but without considering the environmental dimension.

Reflecting the environmental and risk aversion features of investors' preferences, our analysis suggest that the disclosure of climate-related transition risk information embedded in fund portfolios induces inflows to funds with low climate-related transition risks and outflows in the opposite case; there is, however, no evidence on the impact of the low-carbon transition risk label.

3. Data and summary statistics

3.1 Climate transition risk rating in fund portfolios

In the second quarter of 2018, Morningstar launched a quarterly assessment of the low-carbon transition or climate-related transition risk embedded in its funds in the form of a CRS metric, meaning that investors can now better understand the carbon risk exposure of a portfolio and can use this information in decision-making aimed at reducing investment exposure to climate-related transition risks. The CRS metric is computed each quarter based on the corresponding Sustainalytics CRS ratings for companies included in fund portfolios. Sustainalytics computes this score on the basis of: (a) the company's exposure to carbon risk, determined by its business, operations and products and services, and (b) the company's carbon risk management approach, which reflects its ability to manage carbon emissions, energy efficiency and greener products and services. Accordingly, Sustainalytics assigns scores to a company depending on unmanageable carbon risks remaining after considering a company's management actions designed to diminish carbon risk exposure. As mentioned above, the CRS metric is based on five carbon risk categories, ranging from negligible risk to severe risk (scored 0 to >50, respectively). This CRS metric provides deeper insights than those reported by environmental, social and governance (ESG) factors, as it specifically evaluates the risk entailed by the transition to a low-carbon economy for a company's economic value.[1] The CRS also goes beyond carbon footprint measures reporting information on carbon emissions, as this is just one of many items of information necessary to compute the climate-related risk measure.

Based on the Sustainalytics CRS metric reflecting the vulnerability of the company's value to the transition to a low-carbon economy, Morningstar computes the CRS for each fund portfolio as a weighted sum of the CRS values for individual companies, with weights determined by the share of each company in the mutual fund portfolio. For a fund to be rated, the carbon risk of at least 67% of the assets in its portfolio must be under evaluation by Sustainalytics.[2] The Morningstar score is a number between 0 and 100, with lower scores indicating lower carbon risk. The portfolio score along with the percentile category rank information have been made available to investors since the second quarter of 2018, although Morningstar also provides backdated information from the first quarter of 2017 on the basis of historical fund portfolio composition. Morningstar also reports information on the FFI of the fund portfolio, computed as the portfolio's asset-weighted exposure to fossil fuel companies (thermal coal extraction, thermal coal power generation, oil and gas production, oil and gas power generation and oil and gas products and services). A mutual fund is labelled *low-carbon* when its CRS is below 10 and its FFI is less than 7% of assets. Figure 1 shows how the Morningstar's website displays carbon risk information to investors.

[1] In fact, the correlation coefficient between the values of the CRS and sustsainability ratings based on ESG is low, reflecting thus that both measures embedded different pieces of information.
[2] Further details about the CRS computation procedure for mutual funds can be found at https://www.morningstar.com/lp/measuring-transition-risk.

[INSERT FIGURE 1 ABOUT HERE]

3.2 Data

We sourced mutual funds data from Morningstar Direct, assembling data for all US-domiciled open-end equity mutual funds and covering quarterly periods from 30 June 2018 — when CRS information was made available to investors — to December 2019. The sample also includes information for the five previous quarters, as the transition risk for fund portfolios was backdated to the first quarter of 2017. The survivor-bias-free database includes mutual funds within the main retail share classes,[3] which — to avoid Evans' (2010) incubation bias — are older than two years. Funds in the database are categorized into one of the following nine Morningstar equity fund categories: large blend (LB), large growth (LG), large value (LV), mid-cap blend (MB), mid-cap growth (MG), mid-cap value (MV), small blend (SB), small growth (SG) and small value (SV). Excluded are equity funds such as bond funds, money market funds, funds of funds, index funds and real estate funds (note that those funds lack CRS values because they cannot be computed). The final sample comprises 1,526 equity mutual funds, with 1,280 mutual funds quarterly rated with a CRS and 246 mutual funds with no information on low-carbon transition risks.

We measure fund flows at the fund level as quarterly USD flows divided by total net assets (TNA) at the end of the previous quarter:

$$Flows_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1}(1 + r_{i,t})}{TNA_{i,t-1}},$$

[3] Some mutual funds offer multiple share classes, which usually differ in fee structure and clientele (e.g., retail funds, institutional funds, etc). We consider a homogenous share class given that considering different classes for the same fund as separate funds is misleading as they offer the same gross return before expenses.

where $TNA_{i,t}$ and $TNA_{i,t-1}$ are the total net assets of fund *i* at the end of quarters *t* and *t-1*, respectively, and $r_{i,t}$ is the return of fund *i* at quarter *t*. As flows may differ across funds according to different fund features such as size, we additionally consider normalized flows as in Hartzmark and Sussman (2019). For each quarter, normalized flows are given by the flow percentile in that quarter and are robust to differences in flows due to fund size and to outliers.

We also retrieve specific mutual fund information from Morningstar as follows. We obtain sustainability ratings, computed based on the ESG factors of the fund. For the last month of each quarter, sustainability ratings are reported by Morningstar to investors in the form of icons representing globes, where one and five represent the worst and best rating, respectively. Hartzmark and Sussman (2019) document that sustainability information, as reflected in a ranking based on a system of one to five globes, has a significant impact on fund flows, whereas information embedded in sustainability scores has a negligible effect on flows. We also take information on the SRI policy of the fund (a dummy variable equal to 1 if the fund declares that it applies an SRI policy and 0 otherwise) as it may influence fund flows (El Ghoul and Karoi, 2017; Riedl and Smeets, 2017). In addition, we take information on fund size (measured as the log of TNA), age (years in existence at the end of the quarter calculated from the fund's inception date) and quarterly expense ratios. Our database also includes information on Morningstar fund analysts star ratings, a backward-looking measure of fund past performance that identifies the potential best (five stars) and worst (one star) fund performers. We also include quarterly fund returns, calculated as the first difference of the log of fund prices. Continuous variables (with the exception of ratings) are winsorized at the 1% and 99% levels to control for the effect of outliers.

3.3 Descriptive statistics

Table 1 presents summary statistics for CRS-rated funds from the second quarter of 2018 (when ratings were first published) through to the last quarter of 2019. After CRS publication, mutual funds experience quarterly outflows of -1.99% on average, whereas fund flow dispersion is reduced. This evidence — which differs across mutual funds as indicated by the percentiles — is consistent with the fall in average mutual fund returns. The CRS score is 10.55 per quarter on average, with high dispersion around the mean and across percentiles.

Figure 2 depicts CRS distribution across mutual funds in the periods after CRS publication, displaying asymmetries with a large (small) proportion of funds in the lowest (highest) quantiles, with most funds attaining CRS values between 7 and 13 and with only a small percentage reaching CRS values above 20. Descriptive statistics for the FFI, for an average value of 10.32, reflect wide dispersion between fund portfolios; the sample contains funds with zero FFI and funds with FFI with a maximum value of 97.7. The globe sustainability rating on average is 3.09 and SRI funds account for 19% of total funds. Average size (log of TNA) is 18 and displays low dispersion, while average age is 16.7 years. As for the star rating, most funds have three or more stars. Average quarterly expenses are 0.3, with low variability between mutual funds.

[INSERT TABLE 1 ABOUT HERE]

[INSERT FIGURE 2 ABOUT HERE]

4. Are investors aware of low-carbon transition risks?

Arguably, a rise (fall) in portfolio low-carbon transition risk, *ceteris paribus*, should discourage both environmentally conscious investors and risk-averse investors with positions in that fund, with the result that this fund should experience outflows (inflows). Contrarily, changes in carbon metrics are expected to have little or no impact on fund flows when investors are environmentally unaware or risk neutral.

In this section, we examine whether investors are aware of the low-carbon transition risk embedded in their mutual fund portfolios by focusing on the sensitivity of fund flows to carbon risk information. We use information on the CRS, the percentile rank of the CRS within the Morningstar category, the low-carbon label of the fund portfolio, the portfolio FFI and other control variables. Graphical visualization of carbon risk information is available to investors since the second quarter of 2018, as shown in Figure 1. The CRS is more informative regarding the low-carbon transition risk of mutual fund portfolios considering the overall market, whereas the percentile rank yields a relative continuous measure of the transition risk within a Morningstar category. As for the carbon label, this qualitative measure offers investors intuitive information based on percentile rank cutoffs for the portfolio CRS and FFI. While FFI does not inform investors on carbon risk, it does provide useful information on fund portfolio exposure to carbon emissions. All carbon metrics are displayed to investors along with the sustainability rating (computed based on ESG scores).

We explore the response of fund flows to low-carbon transition risk by regressing fund flows on a carbon risk measure and a set of control variables using the following panel regression model:

$$Flows_{i,t} = \omega + \beta CRS_{i,t\text{-}1} + \theta Controls_{i,t\text{-}1} + \varepsilon_{i,t}\,, \tag{1}$$

where sub-indexes *i* and *t* denote fund *i* and quarter *t*, respectively, and where CRS is the carbon risk score (or an alternative carbon risk measure). As control variables we include variables that have been considered in the literature to examine the flow-performance relationship (see, e.g., El Ghoul and Karouri, 2017; Spiegel and Zhang 2013). Specifically, we control for flow persistence by considering lagged flow values (e.g., Del Guercio and Tkac, 2001; Fant and O'Neal, 2000); we also include lagged values of fund return performance, given that investor decisions largely depend on past performance, for which reason past performance and future flows are likely to be positively linked. We also control for the effect of fund ratings, as this information might be used by investors in their investment decisions. Specifically, we include star rating information to account for the effect of potential fund performance on flows and also consider information on fund expenses, size and age, as these are expected to affect future net fund flows (Spiegel and Zhang 2013). We also include information on the SRI nature of the fund, as the corresponding flows are less sensitive to performance than conventional funds (Renneborg Ter Horst and Zhang, 2011; El Ghoul and Karouri, 2017). Likewise, we also take into account the effect of the five-globe sustainability rating in order to capture the effects of fund portfolio sustainability on fund flows, as in Hartzmark and Sussman (2019); the carbon rating metric thus captures specific effects related to transition risks that go beyond information embedded in sustainability ratings. In addition, we control for the FFI of the fund portfolio, as investors may associate FFI with profitability and may not fully disregard funds with relatively high FFI for given particular levels of climate-related transition risk; empirical support for this tradeoff — with potential effects on fund flows — has very recently been provided by Monasterolo and Angelis (2020). Finally, we control for unobserved heterogeneity by cross-section and over time by including fixed-effects investment-style dummies (defined according to the nine Morningstar equity fund categories described above) and year-by-quarter fixed effects. To mitigate potential reverse causality concerns, control variables are lagged by one quarter. Standard errors are clustered by fund and time.

Table 2 shows the impact of low-carbon transition risk measures on fund flows of the fund portfolio. Panel A columns (1) and (2) show the effects of the CRS on fund flows in the next quarter. Independently of the inclusion of control variables in the regression equation with one lag for funds, fund flows react negatively to the fund portfolio CRS, with estimated coefficients of -0.13 and of -0.19 for ignoring and considering the effects of control variables, respectively, and with respective t-statistic values of -4.40 and -2.47 clustered by quarter and fund. Those parameter estimates imply that an increase in the low-carbon transition risk exposure of the fund portfolio by one standard deviation has a detrimental effect on fund flows of around -0.74% and -1.09%, respectively. Our evidence of the negative impact of low-carbon transition risk on fund flows is consistent with previous research on the role of risk in fund flows (e.g., Spiegel and Zhang, 2013), even though our analysis focuses specifically on low-carbon transition risk. Contrarily, evidence in columns (3) and (4) reveals that the effect of information on the CRS percentile category rank significantly explains fund flows only when the effect of control variables is not accounted for; however, this effect dissipates as we include control variables in the regression. Similar evidence is reported in columns (5) and (6) for the low-carbon label effect, which is significant at the 5% level, for a double-clustered t-statistic of 2.43; however, that significance disappears as control variables are included in the regression. Regression estimates in column (7), covering all carbon risk measures and control variables, reveal that the CRS is the only carbon risk metric that remains significant for fund flows, while the CRS percentile category rank and the low-carbon label have no impact. Overall, results in Table 2 columns (1)-(7) — which are robust to the inclusion of a wide set of control variables — suggest that investors respond to low-carbon transition risk information, although their reaction depends on the CRS values and not on the CRS percentile category rank or carbon label, suggesting that investors consider the CRS to be more informative.

[INSERT TABLE 2 ABOUT HERE]

As for the control variables, our results in Table 2 panel A indicate that fund flows are persistent, as shown by the statistically significant coefficients of the lagged flows, which remain similar through different specifications. For funds within the five-globe category, we find that flows increase with respect to less sustainable funds, i.e., investors value sustainability — as already reported by Hartzmark and Sussman (2019) and corroborating the evidence in favour of greater stability of sustainable fund flows as informed by Benson and Humphrey (2008), Renneboog et al. (2011) and Duran et al. (2019). Remarkably, our evidence documents that the CRS conveys specific information that goes beyond information embedded in sustainability information and that CRS information, more so than sustainability information, has a particular and additional negative effect on fund flows.

Our evidence further indicates that SRI fund flows benefit from their policy orientation, with quarterly flows increasing roughly 0.6% at the 10% level of significance. We also find that a fund's star rating has a positive and significant impact on flows: the better ranked a fund is in terms of the number of stars, the larger the next-quarter fund flows. This result is in line with the evidence reported by Blake and Morey (2000) and Del Guercio and Tkac (2008), who have showed that the star rating positively influences fund flows in more highly rated funds. Consistent with previous empirical results (Chevalier and Ellison, 1997), our empirical evidence confirms the flow-performance relationship, as fund returns have a positive and significant impact on next-quarter fund flows.[4] Contrarily, we find that fund size and age have no significant impact on flows, while unsurprisingly, expense ratio has a negative and significant impact. Finally, our regressions, as reflected in Table 2 Panel A, include specific fund and year-by-quarter fixed-effect dummies, controlling for time and mutual fund impacts on the low-carbon transition risk effects on fund flows.

Table 2 Panel B presents evidence on the impact of the low-carbon transition risk on normalized flows. Empirical results confirm the evidence reported in Panel A on the relevance of CRS information in explaining flows. Specifically, before and after considering all controls, the CRS has a significant and negative impact on the normalized flows, with t-statistic values clustered by time and fund above 3. Thus, reducing noise in flows by normalizing them has no impact on the significance of our evidence on low-carbon transition risk. Our results indicate that raising the CRS by one standard deviation reduces the fund flow percentile by -0.005 after considering the effect of all control variables. Consistent with the evidence reported in Panel A, results in Panel B columns (5)-(7) confirm that the low-carbon label has a negligible or no impact on normalized flows, while the negative effect of the CRS remains after taking into consideration the effect of other carbon metrics.

4.1. Low-carbon transition risk score quantiles and fund flows

Empirical evidence reported in Table 2 suggests that investors are sensitive to carbon risk information, so any increase in the low-carbon transition risk score will discourage investors, a fact reflected in a reduction in fund flows. However, not all CRS levels are perceived equally by investors; funds with low-carbon transition risk ratings are arguably

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[4] We have also checked for the effect of asymmetries in past performance, finding no significant effects in terms of past returns and finding asymmetric effects in past fund flows, which have negligible impact on the parameter estimates of the CRS variable.

perceived more favourably by environmentally aware and risk-averse investors, while the opposite occurs for funds with high low-carbon transition risk ratings. Consistently, therefore, low-carbon rated funds should experience inflows, whereas high-carbon rated funds should experience outflows.

We further explore whether fund flows differ across CRS percentile ranks. Figure 3 shows average percentage fund flows for each CRS decile rank after controlling for year-by-quarter fixed effects. In examining all deciles of the CRS distribution, the graphical evidence suggests that the behaviour of average funds in the first deciles remarkably differs from the behaviour of average funds in the last deciles, the former experiencing inflows and the latter outflows. Furthermore, visual inspection of Figure 3 reveals that dynamics for funds with a CRS below and above the median CRS value (10.10) radically differ, as the former experience inflows and the latter outflows. This evidence suggests that investors do indeed respond to CRS differently depending on level, increasing (reducing) their exposure to funds with low (high) CRS levels.

[INSERT FIGURE 3 ABOUT HERE]

We formally test for the potential asymmetric effect of the CRS on fund flows, as displayed in Figure 3, by considering quantile effects of the CRS in the flows regression in Eq. (1) as follows:

$$Flows_{i,t} = \omega + \beta 1_{i,t\text{-}1}(q_\alpha) + \theta Controls_{i,t\text{-}1} + \varepsilon_{i,t} , \qquad (2)$$

where $1_{i,t\text{-}1}(q)$ is an indicator variable equal to 1 if the CRS of fund *i* at time *t-1* belongs to the α-quantile q_α of the CRS distribution and 0 otherwise. We estimate Eq. (2) by considering the median quantile of the CRS distribution as well as extreme quantiles as given by the first and fifth quintiles, which include funds with a CRS below 6.7 and above 13.3, respectively. We also consider the product of the quantile dummies and the CRS values in order to account for the potentially different impact of the CRS on flows depending on level. All regressions include the same set of control variables as in Eq. (1), while standard errors are computed by clustering at the fund and time levels.

Estimation results for Eq. (2) are reported in Table 3. In column (1), the coefficient of the median quantile dummy variable is 0.83, for a t-statistic of 1.81, which can be interpreted as a gain of about 0.83% in flows of funds with a CRS lower than the median over funds with a CRS higher than the median. This result is consistent with the graphical evidence displayed in Figure 3. Reported in column (2) is evidence for the first quintile dummy variable; the estimated coefficient is not significant, indicating that there is no gain in flows of this category of funds compared with fund flows for the remaining quintiles. Contrarily, the coefficient for the fifth quintile dummy, as presented in column (3), points to losses in flows for funds in that quintile with respect to the remaining quantiles. Column (4) jointly addresses the effect of the first and fifth quintiles, reporting that fifth quintile funds, but not first quintile funds to a significant degree, experience outflows with respect to second, third and fourth quintile funds. Taken together, the empirical evidence in columns (1)-(4) is fully consistent with the graphical evidence in that funds with a high low-carbon transition risk value (above the median or higher) experience outflows while funds with a low-carbon transition risk value see inflows. Finally, columns (5)-(7) report additional empirical evidence on the CRS impact on flows in considering the interaction between the dummy quintile variables and CRS values. Empirical results indicate that the CRS has a neutral effect on flows for funds with low ratings, and a negative and significant effect for funds with high ratings, for an average effect of -0.12%.

The robustness of our results in Table 3 are confirmed by considering different quantile levels ($\alpha = 0.10, 0.20$), with the empirical results from those tests leading to the same conclusions as reported here.

[INSERT TABLE 3 ABOUT HERE]

Overall, the empirical evidence in Table 3 suggests that CRS publication has led to higher rated funds becoming less attractive for investors and consistently experiencing money outflows; furthermore, lower rated funds remain insensitive to the low-carbon transition risk and, as graphically evidenced in Figure 3, experience flow improvements relative to funds with higher ratings. This evidence is consistent with the fact that investors are concerned with the CRS when this is abnormally high, but are less worried when the CRS is low. Strikingly, our evidence is consistent with the effect of sustainability ratings on flow dynamics between funds rated as highly sustainable and as non-sustainable, as reported by Hartzmark and Sussman (2019), even though the low-carbon transition risk has an additional and particular negative effect on flows.

4.2. The labelling effect of low-carbon transition risk on fund flows

The previous subsection shows that only funds rated low-carbon experience improvements in fund flows. However, among those funds there are differences in terms of portfolio FFI; some funds are awarded a low carbon label when the CRS is under 10 and the FFI is under 7% of assets, whereas this distinction is not awarded to other low-carbon funds. We examine whether the label has any effect on fund flows by conducting a regression discontinuity test of mutual funds around the CRS and FFI cutoffs, using the regression discontinuity design proposed by Choi and Lee (2018) that considers the treatment effect of two forcing variables in the mean-regression function.

Let $\delta_{CRS} = 1(CRS < 10)$ and $\delta_{FFI} = 1(FI < 7\%)$ be indicator variables that take the value 1 when the CRS is below 10 and the FFI is below 7%, respectively. Those two indicator variables allow the introduction of four potential responses corresponding to δ_{CRS} and δ_{FFI} of (0,0), (1,0), (0,1) and (1,1), where the treatment or labelling effect is given by $\delta_{CRS}\delta_{FFI}$. Thus, in examining the effect of the interaction $\delta_{CRS}\delta_{FFI}$, we also consider the impact of δ_{CRS} and δ_{FFI} separately — as in Choi and Lee (2018) — i.e., the effect on flows of a CRS below (above) 10 and FFI above (below) 7%, called partial treatment effects. Hence, the net effect of carbon labelling can be estimated using the following regression equation:

$$Flows_{i,t} = \omega + \gamma\, \delta_{CRS,t\text{-}1} + \eta\, \delta_{FFI,t\text{-}1} + \beta\, \delta_{CRS,t\text{-}1}\delta_{FFI,t\text{-}1} + \theta\, Controls_{i,t\text{-}1} + \varepsilon_{i,t}, \qquad (3)$$

where the labelling effect is given by $\omega + \gamma + \eta + \beta$, the partial effects of the CRS and FFI are given by $\omega + \gamma$ and by $\omega + \eta$, respectively, and the net effect of low-carbon labelling is given by β $((\omega + \gamma + \eta + \beta - \omega) - (\omega + \gamma - \omega) - (\omega + \eta - \omega))$. We estimate Eq. (3) in the local neighbourhood of the two running variables using a single bandwidth $T^{-1/6}\sigma$, where T is the number of observations and σ is the standard deviation of the CRS or the FFI variable, with respective values of 1.30 and 2.98. The set of controls in Eq. (3) includes the same variables as in Eq. (1) and standard errors are computed by clustering at the fund and time levels.

Figure 4 plots fund observations around the two cutoffs, considering only funds with CRS and FFI values lower than 40 and 40%, respectively. This figure illustrates the fact that there are unlabelled funds that meet one labelling criteria and not the other. Table 4 shows the average percentage fund flows for different combinations of CRS and FFI values in the areas surrounding cutoffs after controlling for year-by-quarter fixed effects. The shaded area in Table 4 shows average flows for funds labelled low carbon, with values for both CRS and FFI below the reference breakpoints. Cells located below the shaded area report information on average flows for funds that meet the CRS requirement for labelling but have portfolios with FFI higher than 7% ($\delta_{CRS} = 1,\ \delta_{FFI} = 0$); those funds experience greater average inflows than funds with similar CRS values and lower FFI values. Contrarily, in cells located to the right of the shaded area, which report information on average flows for funds that do not meet the CRS requirement but have FFI lower than 7% ($\delta_{CRS} = 0,\ \delta_{FFI} = 1$), average flows are lower than those in the shaded area. These data reveal that increasing the CRS level negatively impacts fund flows, independently of the known CRS threshold of 10, whereas increasing the FFI of the fund portfolio over the reference level of 7% has a favourable effect on fund inflows for CRS values below 10. Finally, considering the area for CRS and FFI above their cutoffs ($\delta_{CRS} = 0,\ \delta_{FFI} = 0$), average fund flows become increasingly negative as the value of the CRS increases, consistent with the graphical evidence reported in Figure 3. Overall, the evidence in Table 4 points to the fact that, in the area surrounding the cutoffs, there is no major difference between labelled and unlabelled fund flows, while moderate increases in the FFI have favourable effects on flows that offset the negative impact of higher CRS values on flows. In general, the results in Table 4 show that, although investors prefer mutual funds with lower CRS values (preferably less than 9), the FFI acts as a counterforce by stimulating greater exposure to fossil fuels. This evidence is consistent with the negative and positive parameter estimates of the CRS and FFI reported in Table 2.

[INSERT FIGURE 4 ABOUT HERE]

[INSERT TABLE 4 ABOUT HERE]

Table 5 presents estimates of the discontinuities surrounding the CRS and FFI cutoffs in the local neighbourhoods of the two forcing variables, using uniform weights within each neighbourhood. The evidence in Table 5 indicates that, in the areas surrounding the CRS and FFI cutoffs, fund flows are not especially responsive to low-carbon labelling. Estimates of both partial effects and the net labelling effect are not significant for any of the specifications presented in Table 5.

For the robustness check of this result, we use the square-neighbour and oval-neighbour kernels and linear and quadratic specifications of the two forcing variables (Choi and Lee, 2018). We also run a regression discontinuity analysis that only focuses on the first time that funds are awarded the low-carbon label, in order to account for the surprise effect of labelling in next-quarter flows. Evidence from those analyses leads to a similar conclusion as derived from Table 5 and our regression discontinuity result is fully consistent with the behaviour of average flows across the CRS and FFI values reported in Table 4. To sum up, evidence in Tables 4 and 5 points to the non-labelling causal effect on flows

[INSERT TABLE 5 ABOUT HERE]

4.3. Before and after analyses of the low-carbon transition risk information disclosure

Previous evidence suggests that investors are aware of the fund portfolio’s low-carbon transition risk, since next-quarter fund flows are negatively impacted by the CRS. However, those effects may simply capture differences in fund flows already reflected in flow dynamics in the period before CRS publication. In this section we explore the effect of the CRS on flows before and after CRS publication using information on CRS backdated by Morningstar to the first quarter of 2017 (but not released to investors until the second quarter of 2018). If the response of flows to the (hidden) low-carbon transition risk in the pre-period were similar to the above reported results, then the CRS effect reported above would have captured pre-period effects and not the low-carbon transition risk information released to investors; however, this was not the case, as explained below.

We consider rated equity funds (1280) and unrated equity funds (246) one quarter before and one quarter after CRS publication and use a DiD approach to test for the impact of the carbon rating on fund flows. Specifically, we estimate the following equation:

$$Flows_{i,t} = \omega + \gamma_0\, time + \gamma_1\, R_{i,t-1} \cdot CRS_{i,t-1} + \gamma_2\, time \cdot R_{i,t-1} \cdot CRS_{i,t-1} + \theta\, Controls_{i,t-1} + \varepsilon_{i,t}, \quad (4)$$

where *time* is a dummy variable that takes the value 1 for the post-period and 0 for the pre-period and where $R_{i,t}$ is a binary variable that takes the value 1 if fund *i* is rated at quarter *t* and 0 otherwise. The rating dummy variable $R_{i,t}$ is multiplied by the CRS since important for investors is not only whether or not the fund portfolio is rated but also the size or the information content of the rating assigned to the fund portfolio. The parameters γ_1 and $\gamma_1 + \gamma_2$ capture differences in the effect of the carbon risk measure between rated and unrated funds in the pre-period and the post-period, respectively, γ_0 reflects changes in the unrated fund flows in the post-period and $\gamma_0 + \gamma_2$ captures differences in the effect of carbon risk information in the pre- and post-period for rated funds; finally, γ_2 is the DiD estimator reporting information on how the CRS impacts on relative fund flows. Included in Eq. (4) is the same set of control variables as for the regression in Eq. (1).

Table 6 presents DiD estimates for the pre- and post-periods. Results for the CRS measure reported in column (1) suggest that there is no significant difference between the two periods for unrated fund flows, whereas the CRS impact for rated funds is significant and negative in the post-period, i.e., hidden or pre-publication CRS had no impact on flows of rated funds, whereas the post-publication impact was negative and significant. Consistently, DiD estimators are significant, confirming that the release of CRS information had a negative impact on fund flows, a result that is consistent with the evidence reported in Table 2 for the quarters after CRS publication. This result is also consistent with the response of investors to the exposure of the fund portfolio to low-carbon transition risk. Table 6 column (2) reports DiD evidence on the impact of the carbon transition rating when considering CRS percentile category information. As found for Table 2, this information has no significant effect on flows. Similarly, the evidence in column (3) for the effect of the low-carbon label points to no labelling effect, as the estimate for γ_2 is non-significant. Regarding normalized flows, the empirical evidence in columns (4)-(6) point to similar conclusions as for columns (1)-(3). Finally, the DiD regression in Eq. (4), which considers the carbon rating for the five pre-publication quarters and the six post-publication quarters, results in regression estimates leading to the same conclusions as derived from Table 6.

[INSERT TABLE 6 ABOUT HERE]

We further explore whether the loss of flows for mutual funds in the fifth quintile versus the first quintile of the CRS distribution is exacerbated with CRS publication. Figure 3 and Table 3 reveal that funds with high CRS values lose funds with respect to funds with low CRS values. The question is whether differences between high- and low-carbon rated fund flows intensify with the release of CRS information to investors, as the answer provides information on investors' reactions to that information and on their concerns regarding this kind of risk, as reflected in changes in flows. Taking the fifth and first quantile funds in the pre- and post-period, for this set of funds we run the following DiD regression for fund flows:

$$Flows_{i,t} = \omega + \gamma_0\, time + \gamma_1\, q5_{i,t-1} + \gamma_2\, time \cdot q5_{i,t-1} + \theta\, Controls_{i,t-1} + \varepsilon_{i,t}\ , \qquad (5)$$

where $q5$ is a dummy variable that takes the value 1 or 0 if fund *i* at quarter *t* is in the fifth quantile or first quintile of the CRS distribution, respectively, and where the remaining variables are defined as in Eq. (4). The parameters γ_1 and $\gamma_1 + \gamma_2$ capture the difference in fund flows between the fifth and first quintile funds in the pre- and post-period, respectively, γ_0 and $\gamma_0 + \gamma_2$ reflect changes after CRS publication in the first and fifth quintile funds, respectively, and, finally, the parameter γ_2 is the DiD estimator reporting information on the impact of the release of CRS information on relative fund flows (a negative value indicates a loss of flows to the fifth with respect to the first quintile funds).

Estimates of Eq. (5) are presented in Table 7. Flow differences between the fifth and first quintile funds widen with the release of CRS information: the DiD parameter estimate is -1.58 with a t-statistic of -2.23 clustered by quarter and fund. For normalized flows, estimates in Table 7 column (2) lead to similar conclusions. Results in Table 7 are consistent with the graphical evidence displayed in Figure 3 regarding the role of CRS publication in the enhanced dynamics of fund flows.

Specifically, our evidence is consistent with the fact that investors flee from funds with high climate-related transition risk, so funds with high CRS levels experience outflows. This finding highlights the importance of information dissemination to nudge the channelling of financial resources to more climate-friendly investments. Our findings are also consistent with the fact that investors focus on extreme outcomes in making their investment decisions (e.g., Hartzmark, 2015).

[INSERT TABLE 7 ABOUT HERE]

5. Fund flows, low-carbon transition risk and investment focus

The sensitivity of investors to climate-related transition risks may differ across investors, who may focus on either or both performance and environmental/social outcomes in decision-making processes. Under these circumstances the possible tradeoff between objectives that is demarcated by investor's preferences may have an impact on the sensitivity of fund flows to low-carbon risk ratings.

In this section we analyse whether the impact of low-carbon transition risk on flows differs according to the investment focus of the fund. To that end, we consider how the impact of low-carbon transition risk differs considering, as a proxy of future fund performance, the star performance rating, SRI policy and the globe sustainability rating. Our empirical analysis relies on the same regression setup as given by Eq. (1), but we now include the interaction of the carbon risk measure with: (a) the five-star performance category dummies; (b) the SRI variable; and (c) the five-globe sustainability category dummies. As carbon risk measures, we consider the CRS and the low-carbon label.

Table 8 columns (1) and (2) contain empirical results for star-rated fund flow responses to the low-carbon transition risk. The empirical evidence suggests that the impact of the CRS on fund flows differs across star-rating categories; more specifically, the impact is negative and significant for funds rated with three, two or one stars (intensifying as the star rating declines) and, contrarily, is neutral for funds with four or five stars. This evidence is consistent with the notion that investors are aware of the tradeoff between performance and environmental risk. Investors not particularly focused on performance — those who invest in funds with low star ratings — are more sensitive to low-carbon transition risks and will withdraw investments if a fund portfolio's exposure to low-carbon transition risk is impaired, while investors more focused on performance tend to do the opposite as the low-carbon transition risk is offset by greater expected profitability.

As for the low-carbon label indicator, our results indicate that this label has a positive effect at the 1% level for one-star funds, a less intense positive but significant impact at the 5% level for two-star and four-star funds and no evidence in favour of labelling for the five-star and three-star funds.

Overall, our evidence suggests that investors' pecuniary or non-pecuniary motives are crucial in determining the impact of the low-carbon transition risk on fund flows. Investors with more altruistic motivations (Stern et al., 1999; Døskeland and Pedersen, 2016) are more likely to maintain positions in low star-rated funds and, consequently, those funds are more susceptible to gain inflows when the fund portfolio reduces its exposure to carbon risk. In contrast, investors with more egoistic criteria, mainly based on fund performance (Brodback, Guenster & Mezger, 2019), are more tolerant of carbon risk, given that this risk may be offset by greater portfolio returns. Therefore, in this latter case, the disclosure of carbon risk information is not enough to shift the investment focus of egoistic investors. Given that four-star and five-star funds experience the greatest flows, other policies that force companies to reduce carbon risk are needed, as the evidence suggests that an information-based policy on CRS is insufficient to change investor decision-making.

[INSERT TABLE 8 ABOUT HERE]

Regarding SRI funds, which clearly delimit the social purposes of investments, our empirical evidence in Table 8 (in accordance with the above-reported evidence) indicates that the CRS has a negative and significant impact on all funds; however, the negative impact is more pervasive for mutual funds that apply SRI policies. This evidence is consistent with the notion that investors with positions in SRI funds are more aware of climate-related risks and so are more sensitive to fund exposure to that risk. The low-carbon label consistently has a positive and significant effect on SRI funds, but no significant effect on funds that do not explicitly apply SRI policies. These results are consistent with the value-belief-norm theory, whereby altruistic personal values lead to a pro-environmental attitude that reduces carbon emissions.

The last two columns of Table 8 present evidence on the CRS impact on flows considering the five-globe sustainability categories, with more globes indicating greater sustainability. The impact of the CRS on fund flows varies across sustainability categories, with a significant negative impact for funds in the two-globe, three-globe and four-globe categories and with no significant impact on funds in the remaining categories. The lack of significance of the CRS for the five-globe funds is consistent with the evidence presented in Table 3, where the CRS impact for funds with low exposure to carbon risk is insignificant. As for the carbon label effect, our evidence points to a significant and positive effect only for the most sustainable funds, i.e., in the five-globe category and no evidence for the funds in the remaining sustainability categories.

6. Economic impact

Empirical results in the previous sections indicate that the CRS has a negative and robust effect on fund flows and that high- and low-rated carbon funds experience outflows and inflows, respectively. But what is the economic impact of the CRS?

To answer this question, we conduct a back-of-the-envelope analysis on overall impact that uses information on quarterly TNA, the CRS regression coefficient and the quarterly CRS of the fund portfolio. Thus, for each fund we estimate the next-quarter funds by multiplying TNA, the CRS of the fund portfolio and the overall estimated CRS coefficient (-0.195). From these estimates, we find that, for an average TNA of 4.57 billion USD over the period 2018Q2 to 2019Q3, an increase of one point in the CRS leads to next-quarter outflows of 481.5 million USD. We also evaluate the economic impact of the CRS by comparing quarterly estimated flows for funds located below the median and in the first and fifth quintiles of the CRS distribution for the period 2018Q2 to 2019Q3. The parameter estimates presented in column (1) of Table 3 indicate that average gains in flows to funds with a portfolio CRS below the median are 2.43 billion USD. The parameter estimates in column (4) of Table 3 used to compute flow differences between funds in the fifth and first quintiles of the CRS distribution result in a relative loss of 3.12 billion USD to funds with high exposure to carbon risk. We further evaluate the magnitude of the impact of carbon risk by considering performance expectations as given by the star rating. From estimates in Table 8, five-star funds gain average flows of 1.87 billion USD with respect to one-star funds.

We finally conduct a what-if analysis by estimating what the fund flows would be if the fund had a CRS of 0. Given the parameter estimates from Eq. (2), for each fund and time period we compute next-quarter flows and multiply these estimates by the TNA of the quarter in order to obtain next-quarter monetary flows and, in a similar way, we estimate monetary flows under the assumption that the fund is not exposed to low-carbon transition risk. We then compare fund flows with the real level of carbon risk with what fund flows would be if carbon risk was negligible, finding a loss of 228.8 million USD, reflecting a quantitative assessment of the importance of the impact of the low-carbon transition risk.

Although previous monetary estimates of funds show that the economic magnitude of exposure to low-carbon transition risk is considerable, it is difficult to assess how this risk exposure of the fund portfolio impacts on the number of investors, given that we have no information on the number of investors who enter a fund on the basis of the CRS. Likewise, it is difficult to determine whether the economic impact is permanent or transitory. We may expect that the sensitivity of flows to CRS continues to hold over longer periods, but may also expect the monetary impact to change as fund managers alter the exposure of the fund portfolio to the low-carbon transition risk.

7. Conclusions

Transition to a low-carbon economy to mitigate the adverse effects of climate change entails specific risks for the value of firms. In this paper we have explored whether investors are aware of climate-related transition risks by analysing how fund flows react to the disclosure of climate-related transition risk information embedded in US mutual fund portfolios.

Using information on the vulnerability of the value of firms to the transition to a low-carbon economy as measured by the CRS score, we present evidence on the effect on fund flows of the publication of information on the low-carbon transition risk embedded in US equity mutual fund portfolios. The evidence suggests that investors are aware of the low-carbon transition risk embedded in their fund portfolios, as reflected by the negative impact of climate-related transition risk on fund flows, and so allocate more money to funds with low CRS values and less money to funds with high CRS values. Moreover, we document that information regarding climate-related transition risk has a particular impact on flows beyond the information contained in sustainability ratings or the SRI focus of the fund and other control variables. We also show that, before the disclosure of CRS information, there was no difference in fund flows according to low-carbon transition risk, whereas after the disclosure of CRS information, flow differences between funds in the first and the fifth quintiles increased. Furthermore, our results on the positive effects of FFI on flows point to the existence of a tradeoff between low-carbon transition risk and FFI, consistent with the fact that investors appreciate funds with lower climate-related transition risk without fully disregarding fund portfolios with higher FFI. We also confirm that alternative carbon metrics such as the CRS percentile rank by category and the Morningstar low-carbon label (awarded to funds with CRS<10 and FFI<7%) have no impact on investment decisions given that those measures have significant effects on fund flows.

We additionally explore whether the impact of climate-related transition risk information differs based on the pecuniary or non-pecuniary motives of investors. We find that low star-rated fund flows are sensitive to climate-related transition risk, whereas flows for four-star and five-star funds occur independently of carbon risk. We also find that flows of SRI funds and of high-sustainability funds are more sensitive to climate-related transition risk than other funds.

All in all, our evidence on the impact of climate-related transition risks on fund flows highlights the salience of releasing information on climate-related risk so as to redirect investment efforts to more climate-friendly assets, as a strategy that is particularly effective when the information internalizes the cost of climate externalities, as is the case of the CRS rating. Whether the sensitivity and the response of investors to low-carbon transition risks information differ across different countries is an interesting and open question for future research.

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Figure 1

Information on mutual fund portfolio carbon metrics displayed on the Morningstar website

This figure shows how Morningstar's website displays information on carbon risk score and on fossil fuel involvement to investors. A label indicating the low carbon feature of the fund (on the extreme left) is shown when the carbon risk score is below 10 and fossil fuel involvement is less than 7% of the (weighted) assets in the fund portfolio.

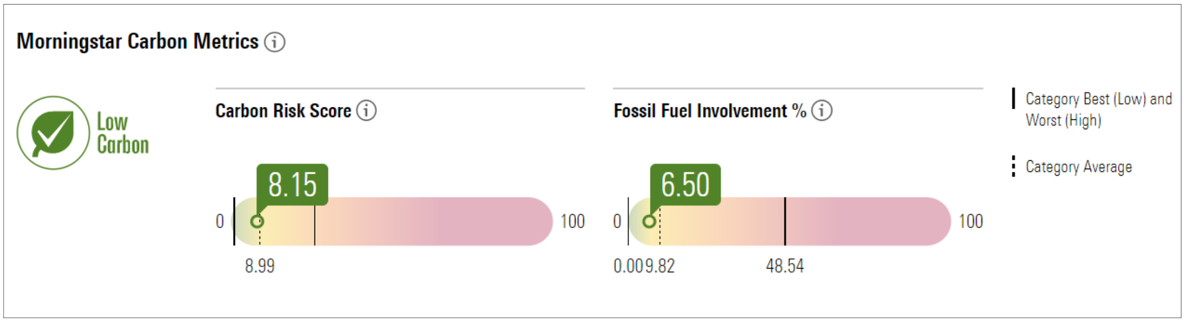

Figure 2

Carbon risk score distribution for US equity mutual funds

This graph depicts the carbon risk score distribution for US fund portfolios for quarterly periods between 2018Q2 and 2019Q4.

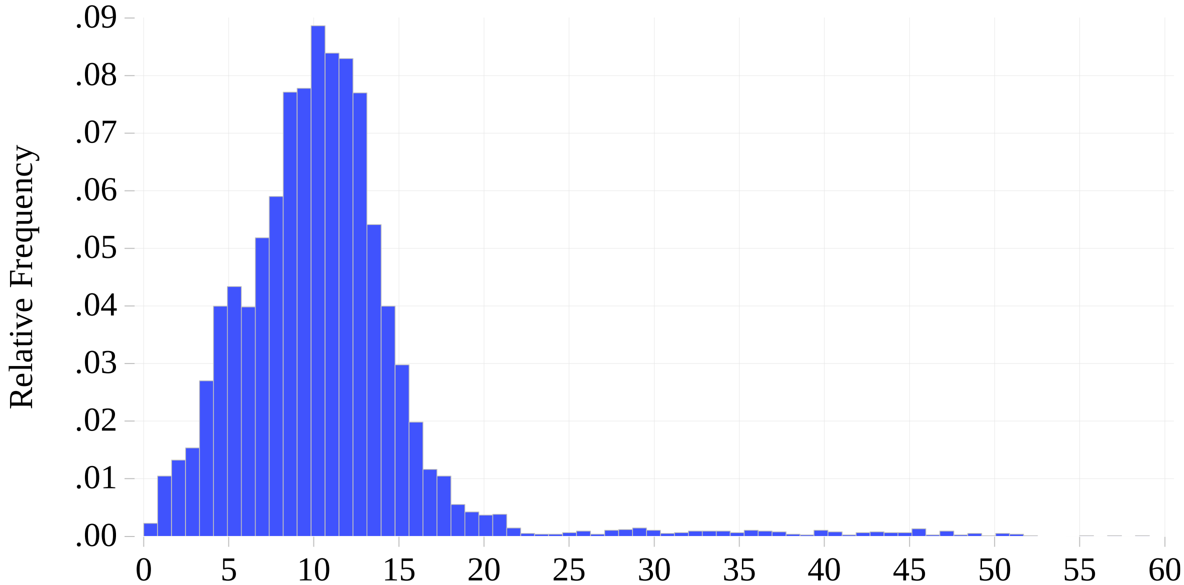

Figure 3

Average fund flows by carbon risk score deciles

This figure shows average percentage flows by deciles of the carbon risk score distribution, controlling for quarter x year fixed effects, for US equity fund portfolios for quarterly periods between 2018Q2 and 2019Q4. The upper threshold values of the carbon risk score from the first to the tenth deciles are 4.7, 6.7, 8.2, 9.3, 10.2, 11.2, 12.2, 13.3, 15.2 and 58.4, respectively.

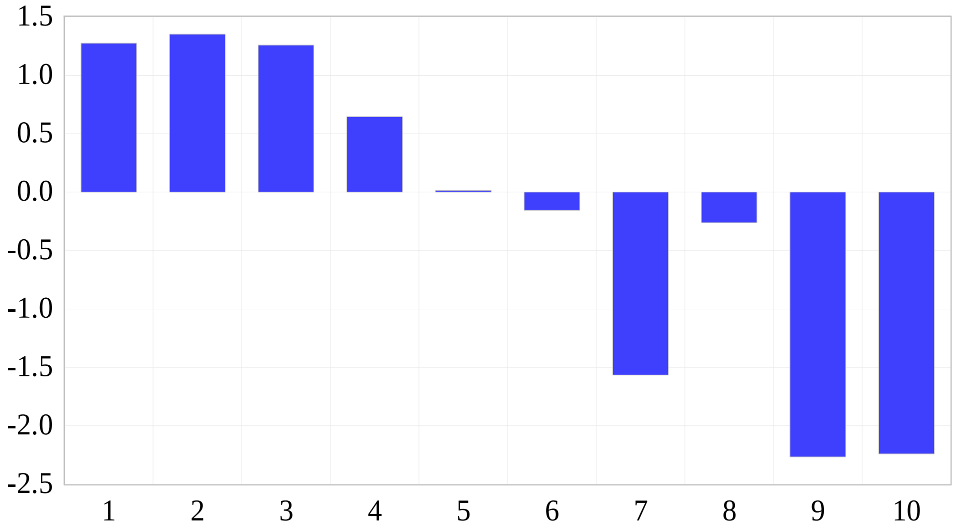

Figure 4

Fund flow observations around the carbon risk score (CRS) and fossil fuel involvement (FFI) cutoffs

This graph depicts fund flows around the carbon risk score (CRS) and fossil fuel involvement (FFI) cutoffs (both trimmed at the value of 40) for US equity fund portfolios for quarterly periods between 2018Q2 and 2019Q4.

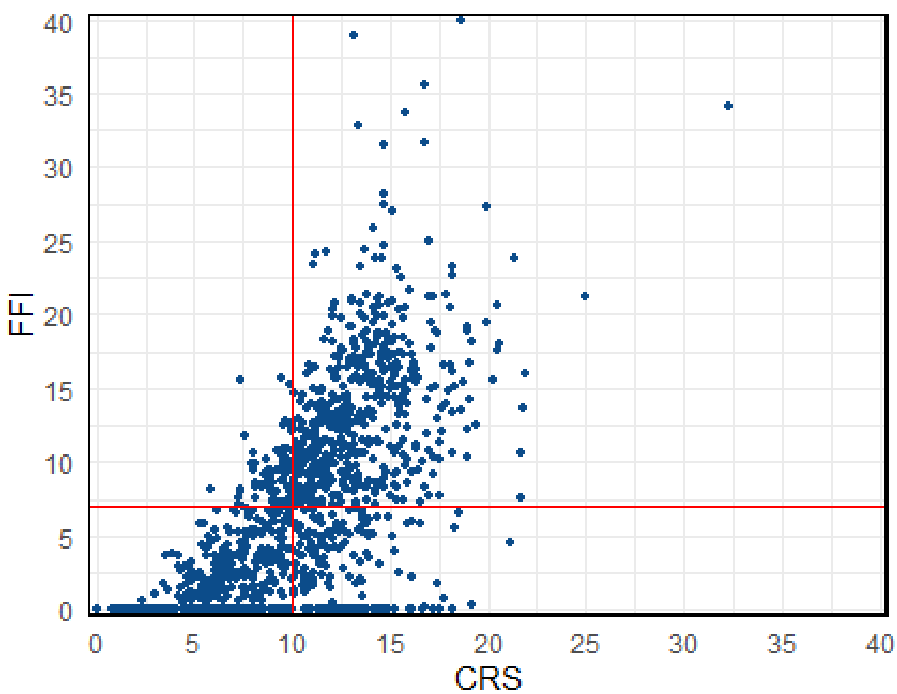

Table 1

Summary statistics

	Mean	SD	p10	p25	p50	p75	p90
Flows (%)	-1.99	14.47	-9.53	-4.66	-2.20	0.52	6.71
CRS	10.55	5.75	4.65	7.35	10.10	12.61	15.05
FFI	10.32	13.32	0	2.27	8.03	13.32	18.31
Sustainability	3.09	1.05	2	2	3	4	4
SRI	0.19	0.39	0.00	0.00	0.00	0.00	1.00
Size	18.00	2.39	14.78	16.26	18.14	19.74	21.02
Age	16.75	11.35	5.01	8.51	14.92	21.84	27.38
Star rating	2.84	1.07	1.00	2.00	3.00	4.00	4.00
Expenses	0.30	0.07	0.21	0.26	0.30	0.34	0.39
Return (%)	-0.13	11.58	-17.76	-1.81	2.17	6.14	11.01

This table presents summary statistics for the variables in the sample for the period 2018Q2 to 2019Q4. The sample includes 1,280 equity mutual funds with low-carbon transition scores, following carbon risk score (CRS) publication by Morningstar, for a total of 7,680 quarterly observations. CRS: carbon risk score; FFI: fossil fuel involvement; SRI: socially responsible investment.

Table 2

Impact of low-carbon transition risk rating on fund flows

Panel A. Fund flow regressions							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	5.491	14.162**	2.772	11.531**	2.103	11.472*	13.668**
	(1.25)	(2.39)	(0.53)	(2.02)	(0.39)	(1.94)	(2.29)
CRS	-0.133***	-0.195**					-0.212**
	(-4.40)	(-2.47)					(-2.31)
CRS category percentile			-0.011***	0.001			0.010
			(-2.78)	(0.14)			(1.56)
Low carbon label					1.557**	1.058	0.698
					(2.43)	(1.37)	(0.92)
Control variables							
Lagged flows	0.339***	0.314***	0.341***	0.316***	0.339***	0.315***	0.314***
	(3.10)	(2.76)	(3.11)	(2.77)	(3.11)	(2.78)	(2.75)
FFI		0.062**		0.000		0.005	0.066**
		(2.29)		(-0.04)		(0.71)	(2.26)
One globe		0.550		0.806		0.119	0.175
		(0.50)		(0.71)		(0.14)	(0.21)
Two globes		1.266		1.546*		0.860	0.903
		(1.37)		(1.64)		(0.87)	(0.92)
Four globes		0.038		0.368		-0.350	-0.282
		(0.09)		(0.91)		(-0.74)	(-0.58)
Five globes		1.482***		1.798***		1.041	1.236*
		(2.67)		(4.30)		(1.31)	(1.68)
SRI		0.574		0.597*		0.611*	1.236*
		(1.62)		(1.65)		(1.70)	(1.68)
Star rating		1.202***		1.195***		1.181***	1.240***
		(2.82)		(2.72)		(2.75)	(2.81)
Return		0.138*		0.147*		0.146*	0.137*
		(1.78)		(1.70)		(1.77)	(1.84)
Size		-0.217		-0.207		-0.209	-0.219
		(-0.77)		(-0.74)		(-0.75)	(-0.78)

Panel A. (cont.)

Age		0.020		0.022		0.021	0.019
		(1.42)		(1.52)		(1.47)	(1.39)
Expenses		-14.610***		-15.812***		-15.842***	-14.156***
		(-3.10)		(-3.43)		(-3.37)	(-3.09)
Quarter-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund style FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.124	0.146	0.123	0.145	0.124	0.145	0.147
Observations	7,560	7,560	7,560	7,560	7,560	7,560	7,560

Panel B. Normalized fund flow regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.369***	0.743***	2.288**	0.664***	0.272*	0.671***	0.736***
	(2.90)	(5.74)	(1.93)	(4.80)	(1.74)	(4.78)	(5.65)
CRS	-0.003***	-0.005***					-0.006***
	(-4.07)	(-3.29)					(-4.19)
CRS category percentile			-0.000**	0.000			0.000***
			(-2.25)	(1.24)			(3.98)
Low-carbon label					0.024	0.008	-0.002
					(1.43)	(0.50)	(-0.11)
Control variables							
Lagged flows	0.356***	0.288***	0.361***	0.292***	0.360***	0.292***	0.286***
	(15.57)	(12.97)	(15.66)	(12.93)	(15.44)	(13.01)	(12.64)
FFI		0.001***		0.000		0.000	0.002***
		(2.67)		(-1.36)		(-0.90)	(3.07)
One globe		0.024		0.032		0.026	0.028
		(0.82)		(1.10)		(0.79)	(0.87)
Two globes		0.030**		0.038**		0.032***	0.033***
		(2.09)		(2.53)		(3.60)	(3.98)
Four globes		-0.013		-0.002		-0.009	-0.007
		(-1.17)		(-0.19)		(-1.10)	(-0.84)
Five globes		0.007		0.018		0.009	0.016
		(0.50)		(1.46)		(0.48)	(0.86)

Panel B. (cont.)

SRI		0.019*		0.020*		0.020*	0.021*
		(1.71)		(1.85)		(1.75)	(1.88)
Star rating		0.045***		0.045***		0.045***	0.047***
		(7.84)		(7.71)		(7.56)	(8.33)
Return		0.005***		0.005***		0.005***	0.005***
		(3.14)		(2.84)		(2.87)	(3.27)
Size		-0.011***		-0.011***		-0.011***	-0.011***
		(-3.85)		(-3.78)		(-3.77)	(-3.86)
Age		0.000		0.000		0.000	0.000
		(0.97)		(1.15)		(1.14)	(0.96)
Expense		-0.467***		-0.494***		-0.498***	-0.448***
		(-6.13)		(-6.49)		(-6.50)	(-5.86)
Quarter-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund style FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.148	0.208	0.145	0.205	0.145	0.205	0.209
Observations	7,560	7,560	7,560	7,560	7,560	7,560	7,560

This table presents the results for the response of fund flows to low-carbon transition risks as measured by the carbon risk score (CRS), CRS percentile category and the low-carbon label. Columns (2), (4) and (6) present the result for each measure along with different control variables, including lagged value of fund flows, fossil fuel involvement (FFI), sustainability globe rating, fund socially responsible investment (SRI) focus, Morningstar star rating, return, size (log of TNA), age and expenses. Column (7) present estimates including all carbon risk measures and control variables, whereas Columns (1), (3) and (5) present results for the three carbon risk measures excluding control variables. All columns include year x quarter fixed-effect (FE) dummies and Morningstar fund investment style FE. Data covers quarterly periods from June 2018, when the CRS became available to investors, to December 2019. T-statistics — reported in parentheses — are computed using clustered standard errors by time and fund. The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 3

Response of fund flows to low-carbon transition risk ratings by carbon risk score (CRS) quantiles

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	10.920**	11.632**	11.740**	11.804**	11.584**	12.098**	12.124**
	(1.93)	(1.98)	(2.03)	(2.03)	(1.98)	(2.16)	(2.16)
Median quantile	0.832*						
	(1.81)						
First quintile		0.381		0.401			
		(0.63)		(0.67)			
Fifth quintile			-1.734***	-1.739***			
			(-2.85)	(-2.86)			
First quintile x CRS					0.031		0.054
					(0.36)		(0.62)
Fifth quintile x CRS						-0.122***	-0.123***
						(-2.97))	(-2.99)
Quarter-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund style FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.145	0.145	0.146	0.146	0.145	0.147	0.147
Observations	7,560	7,560	7,560	7,560	7,560	7,560	7,560

This table presents estimation results of the response of fund flows to low-carbon transition risk rating by carbon risk score (CRS) quantiles as per Eq. (2). The median quantile is a dummy variable that takes the value 1 when the CRS of the fund is below the median value (10.1) of the CRS distribution and 0 otherwise. The first quintile and fifth quintile are dummy variables that take the value 1 when the CRS of the fund is in the first and in the fifth quintile of the CRS distribution, respectively, and 0 otherwise. Columns (1) through (4) present results by considering different dummy percentile ranks of the CRS distribution, using as control variables the lagged value of fund flows, fossil fuel involvement (FFI), sustainability globe rating, fund socially responsible investment (SRI) focus, Morningstar star rating, return, size (log of TNA), age and expenses. Columns (5)-(7) report results for the interaction between quantile dummy variables and the CRS. T-statistics — reported in parentheses — are computed using clustered standard errors by time and fund. The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. FE: fixed effects.

Table 4

Average fund flows by carbon risk score (CRS) and fossil fuel involvement (FFI) values

		CRS values							
		4-5	6-7	7-8	8-9	9-10	10-11	11-12	12-13
FFI values	2-3	0.953	1.481	1.563	1.212	0.370	0.031	-0.159	-0.026
	3-4	0.760	-0.093	0.318	-0.318	-1.175	-1.021	-1.189	-0.879
	4-5	1.487	0.428	1.636	0.404	-0.494	-0.437	-0.576	-0.310
	5-6	1.753	0.529	1.799	1.089	-0.745	-0.822	-0.967	-1.108
	6-7	1.565	0.440	1.427	0.954	-0.851	-0.441	-0.641	-0.449
	7-8	1.553	0.592	1.831	1.656	-0.157	-0.100	-0.361	-0.415
	8-9	1.708	0.555	1.770	1.325	-0.467	-0.153	-0.398	-0.350
	9-10	1.572	0.426	1.776	0.869	-0.661	-0.615	-1.043	-0.832

This table presents average percentage flows by CRS and FFI after controlling for quarter x year fixed effects for quarterly periods between 2018Q2 and 2019Q4. Each cell reports information on average flows for funds with both a CRS greater than or equal to and lower than the numbers indicated at the head of the column, and FFI greater than or equal to and lower than the numbers indicated at the beginning of the row. The shaded area indicates average flows of funds labelled as low-carbon, with the watershed for CRS and FFI indicated with vertical and horizontal lines, respectively.

Table 5

Regression discontinuity for fund flows around the carbon risk score (CRS) and fossil fuel involvement (FFI) cutoffs

	(1)	(2)	(3)	(4)
Constant	-1.623	-0.173	2.719	7.554
	(-0.98)	(-0.17)	(1.05)	(0.53)
δ_{CRS}	0.625	1.299	1.360	0.191
	(0.39)	(0.72)	(0.80)	(0.15)
δ_{FFI}	-2.533	-1.574	-1.954	-2.437
	(-1.13)	(-0.62)	(-0.44)	(-1.24)
$\delta_{CRS}\delta_{FFI}$	-1.691	-1.021	-1.020	-4.047
	(-0.82)	(-0.52)	(-0.54)	(-1.42)
Control variables	No	No	No	Yes
Quarter-year FE	No	Yes	Yes	Yes
Fund style FE	No	No	Yes	Yes
R^2	0.007	0.024	0.007	0.138
Observations in (0,0)	216	216	216	216
Observations in (0,1)	261	261	261	261
Observations in (1,0)	125	125	125	125
Observations in (1,1)	161	161	161	161

This table presents parameter estimates of the regression discontinuity as per Eq. (3) for fund flows around the CRS and FFI around cutoffs of 10 and 7%, respectively. Estimates were conducted in the local neighbourhood of the two running variables using the bandwidth $T^{-1/6}\sigma$. T-statistics — reported in parentheses — were computed using clustered standard errors by time and fund. The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. FE: fixed effects.

Table 6

Difference-in-differences effect of the low-carbon transition risk rating on fund flows

	Fund flows			Normalized fund flows		
	(1)	(2)	(3)	(4)	(5)	(6)
Time	1.095	-1.214	-1.151	0.045	-0.005	-0.016
	(1.19)	(-1.14)	(-1.77)	(2.65)	(-0.27)	(-1.39)
CRS	0.085			0.001		
	(1.36)			(0.35)		
Time x CRS	-0.207***			-0.004***		
	(-2.67)			(-3.41)		
CRS category percentile		0.007			0.000	
		(0.54)			(0.86)	
Time x CRS category percentile		-0.002			-0.000	
		(-0.12)			(-0.74)	
Low-carbon label			0.507			0.021
			(0.52)			(1.19)
Time x low-carbon label			-0.517			0.000
			(-0.43)			(0.01)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Fund style FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.151	0.148	0.241	0.258	0.247	0.246
Observations	2,999	2,999	2,999	2,999	2,999	2,999

This table presents estimation results of the difference-in-differences regression in Eq. (4) for fund flows, using the carbon risk score (CRS), CRS percentile category and the low-carbon label as measures of carbon-related transition risks. Columns (1) to (3) present results for the effect of each measure on fund flows using as control variables the lagged value of fund flows, fund portfolio sustainability, fund socially responsible investment focus, Morningstar star rating, return, size (log of TNA), age and expenses. Similarly, Columns (4) to (6) present results for the normalized fund flows. The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. FE: fixed effects.

Table 7

Difference-in-differences estimates of flows for funds in the fifth and first quintiles of the carbon risk score (CRS) distribution

	Fund flows	Normalized fund flows
Time	-6.341***	-0.091***
	(4.53)	(-5.93)
q5	-0.588	-0.003
	(-0.51)	(-0.15)
Time x q5	-1.585**	-0.030***
	(-2.23)	(-3.35)
Control variables	Yes	Yes
Quarter-year FE	Yes	Yes
Fund style FE	Yes	Yes
R^2	0.161	0.224
Observations	5,817	5,817

This table presents estimation results for the difference-in-differences regression in Eq. (5) for fund flows and normalized fund flows, considering funds in the fifth and first quintiles of the CRS distribution. Control variables include lagged value of fund flows, fund portfolio sustainability, fund socially responsible investment focus, Morningstar star rating, return, size (log of TNA), age and expenses. The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. FE: fixed effects.

Table 8

Response of fund flows to low-carbon transition risk by five-star rating, socially responsible investment (SRI) policy and sustainability five-globe rating

	Five-star rating		SRI funds		Sustainability five-globe rating	
	CRS	Low-carbon label	CRS	Low-carbon label	CRS	Low-carbon label
Constant	19.080***	11.495*	13.999**	11.332*	28.649***	27.002***
	(3.37)	(1.92)	(2.34)	(1.92)	(2.93)	(2.76)
One star/globe rating	-0.349***	2.647***			-0.105	0.488
	(-4.27)	(4.49)			(-1.37)	(0.33)
Two stars/globes rating	-0.243***	1.088*			-0.073***	1.506
	(-2.83)	(1.65)			(-3.10)	(1.49)
Three stars/globes rating	-0.199**	0.732			-0.108***	0.964
	(-2.36)	(0.85)			(-3.99)	(1.20)
Four stars/globes rating	-0.040	1.310*			-0.161**	0.867
	(-0.40)	(1.74)			(-2.52)	(1.34)
Five stars/globes rating	0.063	1.104			-0.108	2.402***
	(0.38)	(0.43)			(-0.87)	(4.66)
SRI funds			-0.305**	2.229**		
			(-2.08)	(1.96)		
Non-SRI funds			-0.189**	0.774		
			(-2.39)	(1.01)		
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund style FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.146	0.146	0.147	0.146	0.155	0.154
Observations	7,560	7,560	7,560	7,560	7,560	7,560

This table presents estimation results for fund flow response to the CRS and low-carbon label measures, considering effects by five-star rating (columns (1) and (2)), fund SRI policy (columns (3) and (4)) and sustainability five-globe rating (columns (5) and (6)). Flow regressions include as control variables the lagged value of fund flows, fossil fuel involvement (FFI), fund portfolio sustainability, fund SRI focus, Morningstar star rating, return, size (log of TNA), age and expenses. T-statistics — reported in parentheses — are computed using clustered standard errors by time and fund. The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. FE: fixed effects.