Staff memo

Taking their temperature: Swedish mutual funds and the Paris Agreement.

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Summary[1]

In this staff memo, I study how close a sample of 122 Swedish equity mutual funds is to meeting the targets set by the Paris Agreement. I document that, on average, the funds in the study are aligned with a temperature increase of 2.77°C which is *well-above the upper bound* of 2°C target set by the Paris Agreement. I also show that there is no significant difference, on average, between funds whose investment management companies have joined leading climate initiatives and those whose management companies have not. There is also no difference between funds that have and have not received a "Low Carbon Designation" label from Morningstar. On the other hand, I document that index funds are associated with slightly lower temperature increases than non-index funds, and that fund size and the geographic location of the firms the funds invest in are key determinants to understand their alignment with the Paris Agreement. To better assess the implications of the results for financial stability, I also look more directly at the funds' exposure to firms with different transition risk profiles. I find that funds collectively invest considerably in securities issued by firms that have significant work to do to green their operations. I also document that, over the period 2019-2022, the funds' exposure to the firms with the worst transition risk profiles has somewhat decreased. However, because of a lack of time-series data at the firm level, I am unable to fully understand whether this result is driven by firms themselves becoming more aligned with net zero or, absent any improvement on the firms' side, by funds actively choosing to reduce their exposure to firms more exposed to transition risks.

Keywords: Equity mutual funds, climate-related risks, greenhouse gases (GHG) emissions, Paris Agreement, Net Zero Asset Managers Initiative, UN Principles for Responsible Investment, financial stability.

[1] Cristina Cella is an advisor at the Systemic Risk Division of the Financial Stability Department. She would like to thank Thomas Jansson, Samantha Myers, Jenny Rosenblad, Olof Sandstedt, Ulf Stejmar, Annika Svensson, Jan Wolter, and the participants at the AFS FORUM in January 2023. She is also very thankful to Isabelle Holmberg, Dominika Krygier and Gary Watson for their help. Please note that the views expressed in this paper are solely those of the author and do not necessarily reflect the views of the Riksbank.

Sammanfattning på svenska

Detta staff memo undersöker 122 svenska aktiefonders temperaturanpassningar i slutet av detta århundrade. Resultaten tyder på att fonderna i urvalet i genomsnitt gör anpassningar som motsvarar en temperaturökning på 2,77 °C, vilket är långt över den övre gränsen på 2 °C som anges i Parisavtalet. Resultaten visar också att det i genomsnitt inte finns någon signifikant skillnad mellan fonder som anslutit sig till ledande klimatinitiativ och fonder som inte har gjort det. Det finns inte heller någon skillnad mellan fonder som har en ”Low Carbon Designation”-beteckning från Morningstar och de som inte har det. Å andra visar resultaten att indexfonder är förknippade med lägre temperaturökningar än icke-indexfonder, och att fondernas storlek och det geografiska läget för de företag som fonderna investerar i utgör viktiga faktorer för att förstå deras anpassningsförmåga till Parisavtalet. För att bättre förstå konsekvenserna av resultaten för den finansiella stabiliteten tittar jag också mer direkt på fondernas exponering mot företag med olika profiler i termer av övergångsrisk. Jag hittar att fonderna i betydande utsträckning kollektivt investerar i värdepapper som emitteras av företag som fortfarande har en lång väg att gå gällande deras klimatanpassning. I memot dokumenteras också att den genomsnittliga mängden aktier som fonderna äger i företag med de sämsta profilerna när det kommer till övergångsrisk, har minskat under perioden 2019-2022. På grund av brist på tidsseriedata på företagsnivå kan det dock inte fullt ut bedömas om detta resultat drivs av att företagen själva blir mer inriktade på ett nettonollutsläpp eller, om man antar att det inte sker någon förbättring från företagens sida, av att fonderna aktivt väljer att minska sin exponering mot företag som är mer utsatta för övergångsrisker.

1 Introduction

This paper builds on existing studies (Cella 2020, 2022) and tries to better understand the exposure of Swedish mutual funds (and more in general the Swedish financial system) to transition risks. To develop this exercise, I use proprietary portfolio data for a sample of 122 Swedish equity mutual funds in September 2022 and the forward-looking analysis (at fund and at firm level) provided by Carbon4Finance Carbon Impact Analytics (CIA) Platform.

In the paper, I assume that the more a fund is aligned with the Paris agreement, the less it is exposed to transition risks. For each fund in the sample, I then calculate the temperature increase it is aligned with by the end of this century using the CIA Platform and I compare this result with the Paris agreement's long-term goal to hold the increase in the global average temperature to well-below 2°C above pre-industrial levels.[2] Furthermore, to better assess potential consequences for financial stability, I employ firm-level information provided by Carbon4Finance to study the funds' aggregate exposure to firms with different transition risk profiles and how this exposure has changed over the period 2019-2022.

I document that the 122 Swedish equity funds (semi-randomly) selected for this study are still quite far from the well-below 2°C target by the end of this century. Actually, no fund is even close to the more ambitious 1.5°C target: the average fund in the sample is aligned with a temperature increase of 2.77°C and only five funds are aligned with an increase below 2°C. Therefore, the majority of the mutual funds in the sample are exposed to substantial transition risks.

These results hold for funds with different characteristics. I find no difference between the temperature alignment of funds whose investment management companies have joined both the Net Zero Asset Managers Initiative *and* the UN Principles for Responsible Investment (initiative funds) and those whose investment management companies have not publically joined either of these two initiatives (non-initiative funds). Also funds that have received a Low Carbon Designation (LCD) from Morningstar have a temperature alignment similar to the sample average. Interestingly, index funds are, on average, associated with a lower temperature increase than non-index funds. Yet, the average increase in the sub-sample of index funds is 2.58°C while in the sample of non-index fund it is 2.89°C, which still indicates a large exposure to transition risks in both samples. I also find that fund size explains a lot of the variation in the funds' average temperature alignment. Small funds are aligned on average with a temperature increase of almost 2.89°C, while the average in the sub-sample of large funds is close to the sample average (2.75°C). Again, these results suggest that transition risks are quite substantial in both sub-samples.

Finally, I document that investment in securities issued by firms located in countries with low or very low climate-mitigation profiles, calculated by the Climate Change

[2] United Nations Climate Change (2015).

Performance Index (CCPI), is associated, on average, with statistically higher temperature alignments than investment in countries with high CCPI scores. Yet, even funds with more than 62% (the sample median) exposure to countries with high CCPI scores are aligned, on average, with a temperature increase of 2.69°C which again indicates that these funds are also far from meeting the Paris Agreement's target. Nevertheless, this result suggests that, although firms' specific plans to green their operations is a key element in the transition to a greener economy, countries must also set ambitious climate agendas to help finance it. Yet, countries also need to invest more in adaptation since the (economic and human) costs of climate change will be substantial if greenhouse gases (henceforth GHG)[3] emissions are not cut nearly in half by 2030 (IPCC, 2023).

Carbon4Finance also provides information at the issuer level. This information allows me to make a more general assessment of the exposure of the funds to securities classified (from A+ to E-) based on their issuers' *contribution to mitigating climate change:* the more a firm contributes to mitigating climate change, the less exposed the firm is to transition risks.

I document that the exposure of equity mutual funds to firms with a positive contribution to *mitigating climate* change (firms with a CIA score above B-) is relatively small with respect to exposure to other firms. In September 2022, it represented approximately 8% of the market capitalization of all equity mutual funds in the sample and has been quite stable over the period 2019-2022. Investment in securities issued by firms with a CIA score between C+ and C- is significant, but the average exposure of funds to securities issued by firms with a CIA score below D+ has decreased (although slightly) over the period 2019-2022. This result is particularly strong for firms in the fund's portfolio with the highest carbon intensities. Yet, I do not have data to study whether this decrease is driven by firms improving their efforts to green their operations or, absent such efforts, by funds' deliberate decisions to decrease their exposure.

By and large, the results in this paper confirm those documented by Cella (2022) which employed data from Substainalytics to study the carbon footprint of a sample of Swedish *home biased* equity mutual funds and their trading in securities with different carbon intensities. The main conclusion of that paper is that funds have still substantial work to do to align their portfolios to net zero, and this paper, using a broader set of funds with exposures not only to Swedish firms, confirms that conclusion.[4]

[3] The carbon-dioxide (CO_2) equivalent is the unit of measure that expresses the climate impact from emissions of different greenhouse gases by converting amounts of other gases into the equivalent amount of carbon dioxide with the same global warming potential. Emissions are converted into CO_2 emissions using a methodology provided by the UN climate panel, the IPCC. In the text, I use the words CO_2 equivalents (CO_2e) and greenhouse gases (GHG) interchangeably. This is because carbon-dioxide equivalents (CO_2e) describe different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact (Brander et.al, 2012)

[4] I actually find that the 28 equity mutual funds in both studies are aligned with an average temperature rise of 2.73°C.

Unfortunately, as in Cella (2022), I still cannot understand whether funds are just waiting for firms to make the transition a reality or whether they are more actively trying to green their portfolios. This is a significant limitation. In fact, although I document that the funds' investment in some of the firms with the largest exposure to transition risk has somewhat decreased, this change is (economically) small and therefore it is not clear whether funds are greening their portfolios rapidly or effectively enough.

Finally, as in Cella (2022), relying on a single data provider is a conspicuous limitation for this study since temperature alignments and firms' climate-mitigation ratings are based on specific scenarios, key assumptions and methodological choices. Yet, the fact that both papers, using different sources of data, point toward the same result is reassuring. Still, keeping all the short-comings in mind, results have to be interpreted with caution and should be used as a general indication that *more has to be done* both by firms and funds to help reach net zero.

2 Data

2.1 Carbon4Finance Carbon Impact Analytics (CIA) Platform

In the spring 2022, the Eurosystem Procurement Coordination Office (EPCO) procured granular data on climate-related risks. As part of this procurement, Sveriges Riksbank obtained access to the Carbon4Finance Carbon Impact Analytics (CIA) Platform. Since 2016, Carbon4Finance has been using the CIA methodology to measure the footprint of financial portfolios, thus building a database of GHG emissions for a large number of companies (Euronext Indices, 2022).[5]

In brief, the CIA methodology allows the user to identify the temperature trajectory of an investment portfolio based on its constituents' current and future climate performance. The CIA platform performs a "bottom-up" analysis (for firms in approximately 50 sub-sectors) of a portfolio's carbon performance. Each issuer in the database is attributed a score that is a function of its induced emissions (scope 1, scope 2 and scope 3),[6] avoided emissions[7] and forward-looking strategy. These scores are aggregated (using the security's weight) at portfolio-level before the temperature alignment assessment is performed (Raynaud et. al, 2020).

Results rely on different climate scenarios that lead to a specific amount of GHG emissions into the atmosphere, which in turn leads to specific temperature rise by the end of this century. Therefore, a portfolio's alignment can be seen as its contribution to the transition towards a certain economy, defined by a specific climate scenario, and leading to an implied temperature rise by the end of this century.

Since CIA analyses securities' issuers (about 7,764 issuers of which around 6,000 are corporates), I also have access to information about how each issuer is classified by Carbon4Finance in terms of its *contribution to mitigating climate change*. This information is synthesized with an issuer-level score (i.e. *Overall Rating)*, ranging from A+ to E-.

To calculate an entity's overall rating, Carbon4Finance employs past, current, and forward-looking scores of all underlying activities of the company. The overall rating

[5] Carbon4 Finance has a worldwide coverage with more than 124,000 ISINs for a total of 7,584 entities (of which 7,041 are unique entities) and circa 4,500 emission emitters for the year 2020. To analyse each firm, Carbon4 Finance collects data from various reports published by each company. In case physical data is not available, estimations based on financial data are used.

[6] Scope 1 are direct emissions from the activities of an organization from sources it controls. These would include company vehicles and fuel combustion on site, like gas boilers. Scope 2 are indirect emissions from the generation of electricity and heat used by an organization. Scope 3 are emissions generated within the production/consumption chain.

[7] Carbon4Finance defines avoided emissions as the differences between induced emissions and a reference situation. For example, it can be emissions avoided thanks to the use of an entity's products compared to other products available on the market (e.g., EVs compared to thermal engines, or biofuel compared to conventional fossil fuels). It can also be emissions avoided by a company's performance against a sectoral benchmark (e.g., comparison of power producers' carbon intensity against IEA's 2DS scenario).

should provide a comprehensive measure of the entity's carbon performance and its transition risk exposure. This rating is then expressed as a letter in a range from A+ (best in class) to E- (worst in class). Briefly, firms with a score between A+ and A- make the biggest contribution to climate mitigation, followed by firms with a score between B+ and B-. These are followed by firms with a score between C+ and C- which, by and large, make an insignificant contribution to climate mitigation and are therefore more exposed to transition risks than the firms with a score between A+ and B-. Finally, firms with a score below D+ make a poor or (worse) negative contribution to climate mitigation and therefore are even more exposed to transitions risks than firms with a score between C+ and C-.

For a full review of the CIA methodology (including its strength and weaknesses with respect to other data providers), I refer the reader to Raynaud et al. (2020) and Anquetin et al. (2022). For more details about the methodology and data employed, I refer the reader directly to Carbon4Finance documentation available on the company webpage.[8]

2.2 Fund selection

Funds' holdings information was collected from VINN in September 2022. VINN is a proprietary database that contains quarterly information on the securities holdings of all institutional investors registered in Sweden.[9] In VINN, funds report a rich set of information, however I focus on a few key variables: (a) each fund's main identifier (RIAD code), (b) each security's main identifier (ISIN), (c) each security's market value in the fund's portfolio, (d) the total number of shares owned, and (e) the country of the issuer.

I can identify a total of 367 equity mutual funds reporting to VINN in September 2022. However, as in Cella (2022), I assume that funds have different commitments to meeting the net zero target. To capture this commitment, I focus on funds belonging to investment management companies that have joined the *Net Zero Asset Managers Initiative*[10] and those that have not. However, in this paper, I am more restrictive and to

[8] https://www.carbon4finance.com/our-latest-carbon-impact-analytics-methodological-guide2

[9] VINN collects information from Pension Funds, Insurance Corporations, Mutual Funds, Central banks, Monetary Financial Institutions, Money Market Funds, Social Security funds and Foreign Branches. A definition of these institutions can be found in the Handbook on Securities Statistics (IMF, 2015). Institutional investors need to be registered in Sweden to be covered in VINN. If an institutional investor operates on Swedish markets but is registered elsewhere, in Luxemburg for example, it is not covered in VINN. This is also the case for individual funds registered abroad but that belong to an investment management company registered in Sweden. VINN has a high coverage but does not cover 100% of the institutional investors registered in Sweden. Data is collected directly from the institutional investors and then custodian data is employed to fill in additional information for smaller holdings and sectors for which information cannot be collected directly. For mutual funds, special funds and synthetic mutual funds the coverage is in principle 100%. The data is originally collected each quarter by the Swedish Financial Authority (Finansinspektionen) and then used by Statistics Sweden (SCB) to create VINN on behalf of the Riksbank.

[10] The Net Zero Asset Managers Initiative, launched in December 2020 had, in May 2022, 273 signatories with a total of $ 61.3 trillion in assets under management (Netzeroassetmanagers, 2022). In a nutshell, the signatory's commitment to this initiative implies that "asset managers will have to work with their clients and are expected to ratchet up the proportion of assets managed in line with net zero goals." Information about what signatories commit to can be found on the Net Zero Asset Managers Initiative's website.

better identify funds that are publically committed to the net zero target, I also discriminate between funds whose investment management company has or has not joined the *Principal of Responsible Investment.*[11]

The *Net Zero Asset Managers Initiative* (NZAMI) gathers together an international group of asset managers committed to supporting the goal of net zero GHG emissions by 2050 or sooner. The UN Principles for Responsible Investment (PRI) has a more general focus and makes up an international organization promoting the incorporation of environmental, social, and corporate governance factors (ESG) into investment decision-making. In Sweden, the largest investment management companies have joined *both* the PRI and the NZAMI, but there is also a group of investment management companies that have not signed up to either of them.

I identify as *initiative funds* those funds that belong to investment management companies that are signatory of **both initiatives** and as *non-initiative funds* the funds that belong to investment management companies that are **not signatory to either** initiative, a total of 150 funds.

Next, I only include funds for which the CIA platform covers at least 60% of the portfolio to calculate the fund's temperature alignment. This screening leaves me with a total sample of 122[12] funds (of which 78 initiative funds) that represent a total market capitalization of circa SEK 2,218 billion, which, in turn, is about 66% of the total market capitalization reported by all of the 364 funds in VINN in September 2022 (SEK 3,369 billion).

To further exploit the cross-sectional variation between funds and to study which fund's characteristics may be relevant to explain differences between funds' temperature alignment, I collect additional fund characteristics from Morningstar and built additional fund level variables using the information provided by VINN. I describe these variables in the next section when I describe the results.

[11] The United Nations-backed Principles for Responsible Investment Initiative (PRI), launched in 2006, is a network of international investors working together to integrate ESG factors into their investment decisions and contribute to the development of sustainable capital markets by putting the six Principles for Responsible Investment into practice. Signatories include many of the world's largest pension funds, foundations, leading investment managers and their service providers that, in March 2021, were responsible for over $121 trillion in assets worldwide (Unpri, 2023).

[12] Out of the 122 funds, 110 are UCITS funds. An Undertaking for Collective Investment in Transferable Securities (UCITS) is an investment fund that invests in liquid assets and can be distributed publicly to retail investors across the EU.

3 Funds' temperature alignment

3.1 Descriptive statistics

In this section, I employ descriptive statistics, reported in Table 1, and figures to provide main facts about variation in the funds' temperature alignment produced by the CIA methodology. In the next section, instead, I employ multivariate analysis to study more in depth what funds' characteristics may be associated with the temperature increase a fund is aligned with. For the sake of brevity, funds' additional descriptive statistics are provided in Table 1.A in Appendix A.

Table 1. Funds' descriptive statistics

	(1)	(2)	(3)	(4)
	No	Mean	Median	SD
Portfolio Temp. °C	122	2.77	2.70	0.46
CIA Coverage	122	88%	90%	9%
Carbon Footprint (WACI)	122	459	438	238

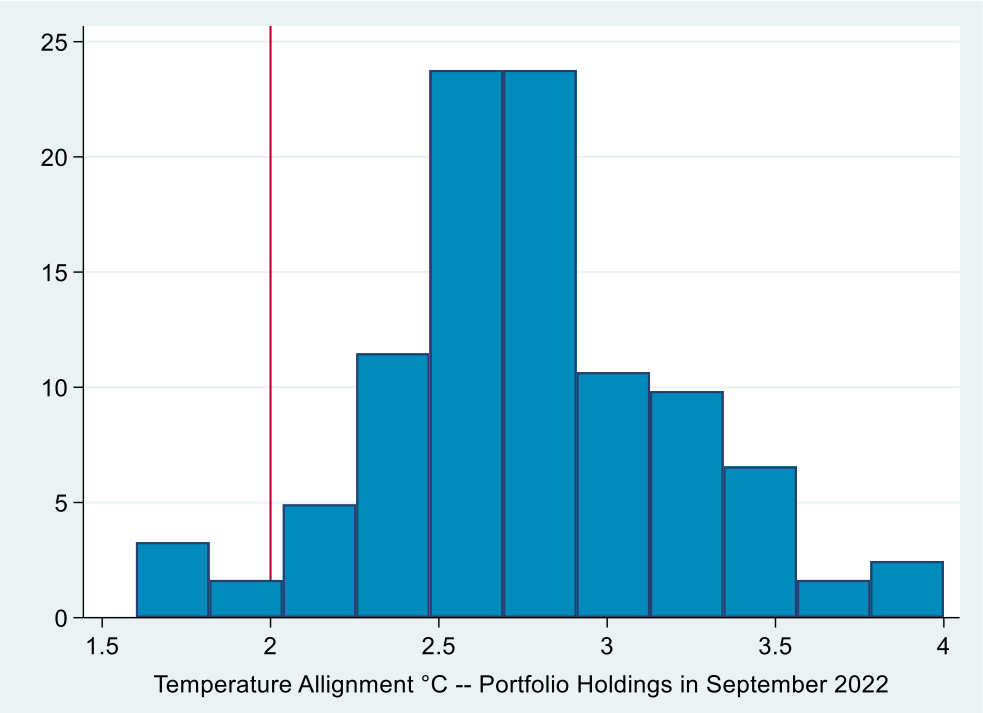
Note: Descriptive statistics for the main variables of interest. All characteristics are calculated using data for September 2022.

Sources: VINN and Carbon4Finance.

Table 1 shows that the average fund in the study is aligned with a temperature increase of 2.77°C (with a median of 2.70°C). Importantly, this result is based on a very large coverage of the assets in the funds' portfolio. The average CIA coverage in the sample is 88% (much above the threshold of 60% I had imposed to begin with). Figure 1 below shows how funds are distributed in different brackets of temperatures.

Figure 1. Distribution of funds' temperature alignment by the end of this century

Percent of funds



Note. Distribution of temperature increases with which the funds in the study are aligned by the end of this century.

Sources: VINN and Carbon4Finance.

Figure 1 clearly shows that for the large majority of the funds in this study, the CIA methodology predicts a temperature alignment by the end of this century above the 2°C *maximum* target set by the Paris Agreement. The graph also shows that dispersion is large: five funds are aligned with a temperature rise below or equal to 2°C, eighty-five funds are currently aligned with a temperature between 2.1°C and 3°C, and thirty-two funds are aligned with an increase of between 3°C and 4°C.

Next, to understand how the temperature increase a fund is aligned with is related to its current carbon footprint, Table 1 reports descriptive statistics for each fund's "weighted average carbon intensity" (i.e. WACI).[13] A fund carbon footprint is calculated as recommended by the Task Force on Climate-Related Financial Disclosures (TCFD 2017 and 2020) employing each firm's carbon intensity (total scope 1, scope 2 and scope 3 emissions normalized by the firm's revenues) provided by Carbon4Finance.

[13] I want to note that, as suggested by Bolton et al. (2022), the net-zero goals are expressed as levels and not relative terms. Therefore, while funds, for comparability reasons and because of the easiness of the measure, report WACI, one has to acknowledge that this synthetic measure may actually tell us very little about the ability of a fund to help in the transition to net zero. Moreover, a fund's WACI is based on backward-looking information (i.e. past emissions) while the net zero target relies on the ability of firms to innovate and/or compensate for their emissions.

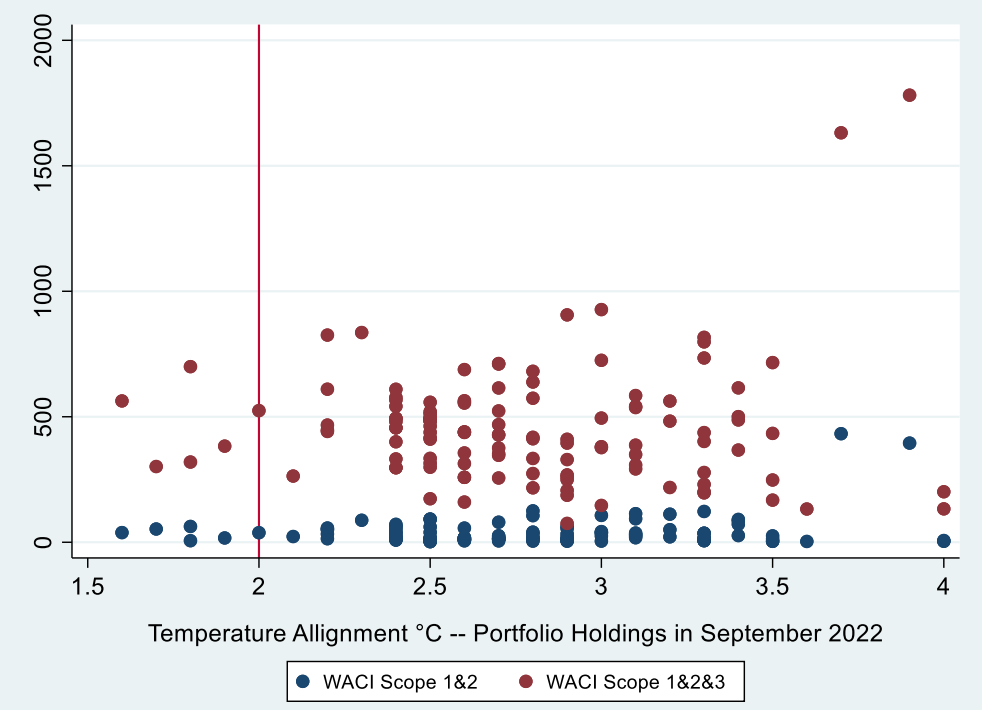
For each fund *j* at time *t* (September 2022), using each stock *i*'s weight in the fund's portfolio and the latest stock carbon intensity (CI), I calculate the fund carbon footprint (WACI) as the following weighted average:

Eq.1 $$WACI_{j,t} = \sum_{i=1}^{n} \frac{Market\ Value_{i,j,t}}{Total\ Portfolio\ Value_{j,t}} * CI_i$$

In September 2022, the average WACI in the sample was about 459, which means that the average firm in the average fund emitted 459 tonnes of carbon dioxide (henceforth, CO_2eq) per million euro of company revenues at the time the emissions were calculated.

Figure 2. Funds' carbon footprint (WACI)

Tonnes of CO2eq per million euro (tCO2e/M€)



Note. Funds' carbon footprint (i.e. WACI). The blue dots represent the fund's WACI calculated using scope 1 and scope 2 emissions, while the red dots represent a fund's WACI calculated using scope 1, 2 and 3 emissions. See Eq.1 for details about how WACI is calculated and footnote 6 for a definition of scope 1, 2 and 3 emissions.

Sources: VINN and Carbon4Finance.

For each fund's temperature alignment calculated using the CIA methodology, Figure 2 shows the fund's WACI calculated using scope 1 and 2 emissions (blue dots) and scope 1, 2 and 3 emissions (the red dots).

To begin with, Figure 2 clearly shows the importance of including scope 3 emissions when calculating a fund's carbon footprint since including scope 3 emissions (see footnote 6 for an explanation) gives more accurate information about the emissions of firms (especially for those that given their operation tend to have little scope 1 and scope 2 emissions) and consistently leads to much higher carbon footprints.

Figure 2, though, not only illustrates that scope 3 emissions have a large impact on a fund's carbon footprint, but also that there is very little connection between the carbon footprint of a fund and its temperature alignment: two funds with similar carbon footprints can be aligned with very different temperatures by the end of this century.

In unreported analyses, I test the statistical significance of this result employing cross-sectional OLS regressions in which the dependent variable is the temperature increase a fund is aligned with by the end of the century (Portfolio Temp. °C) and the independent variable is the fund carbon footprint (WACI). Independent of the control variables included, the coefficient of the independent variable is always statistically insignificant.

This should not come as a surprise since emissions are backword-looking and, in isolation,[14] provide little information about a firm's future path to net zero. Nevertheless, firms with large emissions are those that will need to put more effort into greening their operation. As a consequence, the carbon footprint of a fund still gives an indication of how much effort a fund needs to put in to green its portfolio with respect to other funds. Yet, using the temperature increase a fund is aligned with allows us to better grasp the amount of effort really necessary to green the portfolio so that it is aligned with the Paris Agreement and also allows to better understand differences between funds.

To give an example, Figure 2 clearly shows that the funds aligned with a temperature increase of around 4 °C have about the same WACI as those aligned with a temperature increase below 2 °C. This result is driven by the fact that the composition of a fund portfolio (by industry and geographic location, for example) affects the fund temperature alignment but is not captured by its carbon footprint. Therefore, even though a fund carbon footprint gives a rough estimate of how much effort funds need to put in to green their portfolios, because of the characteristics of the firms issuing the securities in their portfolios, some funds will have to work more intensively to reach net zero than other funds with similar carbon footprints.

Therefore, although the aim is to reach the same target, a fund carbon footprint and the temperature increase it is aligned with provide a different type of insight for investors. The only way to reconcile these measures is to have access to firms' transition plans. Yet, such plans should be transparent and firms' goals should be concrete and verifiable to really allow investors and authorities to fully understand the significance of a fund's carbon footprint without more complex analyses such as those provided by Carbon4Finance. Results in Table 2 in the next section will stress the importance of this issue even more.

3.2 Multivariate analyses

In this section, I employ cross-sectional OLS regression to study what funds' characteristics are associated with their temperature alignments. Results are reported in Table

[14] If a firm has been substantially decreasing its emissions over time, one could then infer the firm's trajectory to net zero. This information is, in fact, considered by Carbon4Finance when estimating a firm's overall rating.

2. Descriptive statistics for the main variables of interest are reported in Table 1.A in Appendix A.

For the sake of space, I briefly describe the explanatory variables employed in Table 2 and their descriptive statistics while discussing the results. Notice that the results in Table 2 do not include all the variables in Table 1.A. This is because the omitted variables were statistically insignificant when included as explanatory variables. So, for the sake of brevity, I only report and discuss variables that are statistically significant or those I am particularly interested in studying.

Again for the sake of keeping the information easily accessible, I also divide the discussion of Table 2 into sub-sections based on the main variable of interest.

Table 2. Cross-sectional OLS regressions

	Portfolio Temperature Alignment in °C			
	(1)	**(2)**	**(3)**	**(4)**
Initiative Funds	0.06		0.01	
	(0.174)		(0.919)	
Low Carbon Funds	-0.04		-0.01	
	(0.685)		(0.933)	
Index Funds		-0.15*	-0.23**	
		(0.089)	(0.024)	
High CCPI				0.90***
				(0.001)
Low-Very Low CCPI				1.13*
				(0.051)
Nr of Securities (ln)			0.07	
			(0.261)	
SE Firms' Targets	-1.27**	-1.25*	-0.92***	-1.44
	(0.031)	(0.050)	(0.005)	(0.119)
Medium	-0.21**	-0.20***	-0.21**	-0.13***
	(0.012)	(0.001)	(0.031)	(0.007)
Large	-0.14**	-0.07***	-0.12*	-0.15***
	(0.033)	(0.009)	(0.095)	(0.010)
Constant	2.96***	2.97***	2.67***	2.16***
	(0.000)	(0.000)	(0.006)	(0.003)
Observations	122	108	108	122
Adjusted R^2	0.064	0.104	0.093	0.218

Note: Cross-sectional OLS regressions. Standard errors are robust and clustered at the fund size category level. Robust p-values are reported in the parentheses underneath the coefficients and should be interpreted as follows *** p<0.01, ** p<0.05, * p<0.1.

Sources: VINN, Carbon4Finance and Morningstar.

3.2.1 Initiative funds, funds with a low-carbon designation

To begin with, closely following Cella (2022), I explore the hypothesis that funds belonging to investment management companies and having joined the *Net Zero Asset Managers Initiative* AND the *Principal of Responsible Investment* (initiative funds) may work more aggressively to green their portfolios than funds whose investment management companies have not openly joined either of these initiatives (non-initiative funds).[15] However, whether initiative funds are currently aligned, on average, with a lower temperature increase than non-initiative funds is an empirical questions that I take directly to the data.

I also further exploit the variation in the cross-section of mutual funds to try and identify funds that should be less exposed to realizations of transition risks. To do so, I employ the information content of the "Low Carbon Designation" (i.e. LDC label) assigned by Morningstar since 2018.[16] Funds that receive the LCD label should be more likely to select, to begin with, firms that are more aligned with reaching net zero and therefore may be aligned with lower temperature rises than funds that do not receive the label. In the final sample, I create the variable "Low Carbon Funds" equal one if a fund has received the LDC label from Morningstar and zero otherwise.

Table 1.A in the Appendix shows that, in total, 64% of the funds in this study can be classified as initiative funds and 66% of the total set of funds have received the LCD label; 45% of the funds are initiative funds with an LDC label.[17]

Results in Table 2, Column (1) show that there is no difference, on average, between the temperature alignment of initiative and non-initiative funds, and funds that have or have not received the LCD label.[18] In additional un-tabulated analyses, I also look more directly at initiative funds with a low-carbon label, but neither are these funds, on average, any different from the rest of the funds in the sample. This result is particularly interesting since Ceccarelli, Ramelli and Wagner (2021) show that low-carbon funds are likely to have lower exposure to future potential climate change risks. Yet,

[15] This hypothesis is in line with the results documented by Gibson, Krueger, Matos, and Steffen (2020) who study funds that have joined the Principles for Responsible Investing (PRI). Although they document large heterogeneity, Gibson and her co-authors suggest that European funds that have joined the PRI have better ESG score footprints (a value weighted average of the ESG scores in the fund's portfolio). Besides, studying initiative funds is also important since it is documented that responsible investors attract more investor flow: Humphrey and Li (2021) document this result for PRI signatories, Hartzmark and Sussman (2019) for funds with high sustainability ratings, and Ceccarelli, Ramelli and Wagner (2021) for funds that have received a "Low Carbon Designation" (i.e. LDC label) from Morningstar. The latter results corroborate the idea that a fund joining a climate initiative conveys a valuable signal to its investors about the type of strategy it intends to employ.

[16] While the aim of this study is not to comment on the quality of this label, it is important to consider that investors have limited information about funds' climate strategy and therefore the information conveyed by such a label becomes an important communication tool.

[17] The information about whether a fund's investment management company has joined the Net Zero Asset Managers Initiative and the PRI is obtained from the "Race to Zero" and the Principal of Responsible Investment websites. The information of whether a fund in September 2022 has obtained a low carbon designations (i.e. a LCD label) is collected from Morningstar.

[18] These results are robust to different specifications and sets of control variables. And, even when interacted with size dummies, both the Initiative and Low Carbon Fund variables and their interactions with size dummies remain statistically insignificant.

the results in Table 2 may be driven by the fact that the firms selected by these funds may not focus primarily on cutting emissions, which is consistent with the other result documented by Ceccarelli et al. that low-carbon funds display higher idiosyncratic volatility relative to the current market portfolio, mostly because they usually underweight carbon-intensive sectors.[19]

This first set of results largely confirms the results reported in Cella (2022), yet since the way firms are working to green their operations is now accounted for by the CIA methodology, more emphasis may be given to the option that funds most likely need to work more to green their portfolios.

One potential reason why we do not observe any statistical difference between initiative and non-initiative funds, nor between low-carbon and non-low carbon funds, could be that these funds, which tend to be big and usually belong to the biggest investment management companies, are leading the way while smaller funds, maybe due to a lack of resources, are lagging behind and try to mimic the behaviour of the largest funds. To explore this hypothesis, I include in the analysis dummies for terciles of fund size.

3.2.2 Fund size

Table 1.A in the Appendix shows that the portfolio of the average fund has a size of circa SEK 18 billion calculated as the total market value of all securities in the fund's portfolio in September 2022. Yet, variation is high: the standard deviation of this variable is SEK 68 billion and the median is around SEK 8 billion. Because of the large difference in fund size, instead of using this variable as a continuous one, I divide the funds in bins based on size and I also assume that errors could be correlated between the funds of a similar size. Hence, using the fund size distribution, I divide funds into terciles of size. Each tercile contains about 40 funds.

Results in Table 2 show that large (average size around SEK 46 billion) and medium-sized (average size around SEK 8 billion) funds are associated with a lower temperature increase than small funds (average size around SEK 1 billion). These results are statistically and economically strong and stay invariant in all regressions, independent of the other explanatory variables included in the analyses.

In Table 2.A in Appendix A, I further investigate how fund size is correlated with its temperature alignment and instead of using terciles of size, I employ a finer definition and include dummies for quintiles of fund size. Results show again that with respect to very small funds (with an average size of around SEK 0.46 billion), all of the other categories are associated with lower temperature rises, especially funds in the third quintile for which the magnitude of the coefficient and the statistical significance are the strongest.

[19] In Cella (2022), I document that initiative funds with a low-carbon label in December 2021 had amongst their largest emitters (scope 1 and scope 2) firms that had transition plans in place and firms working to make their existing production processes or products less polluting and more energy-efficient.

These results suggest that small funds (and very small ones in particular) are those further away from the Paris Agreement's target and also beg the question of why this is the case. If the problem is a lack of resources to acquire the necessary information and at the same time deliver competitive performance, one may wonder whether making firm-level, forward-looking climate data (like that employed in this study) a public good could drastically shorten the way to the net zero.

3.2.3 Index funds

Next, Table 2, Column (2) documents that funds labelled by Morningstar as Index Funds (which represent 20% of the 108 funds for which this information is available) tend to be associated, on average, with lower temperatures by the end of this century.

With respect to non-index funds, index funds tend to be classified as medium-sized funds, have larger investment in firms located in Sweden, Norway and Denmark, and, on average, double the amount invested in Swedish firms with science-based emissions reduction targets (more details about these firms can be found in section 3.2.4). They also, on average, have three times the number of securities in the portfolios than non-index funds and therefore are much more diversified. Finally, only 45% of the index funds are initiative funds, and a staggering 90% of them have received a low-carbon designation. I include the latter variables as controls in Column (3).

Including these variables improves dramatically the statistical significance of the variable index funds, while none of the additional control variables has any significance. Hence, the index funds in the sample are on average associated with lower temperature rises than non-index funds also after controlling for specific characteristics that distinguish these two sub-samples of funds.

3.2.4 Firms geographic location

Next, I study whether funds' investment in firms located in different geographic areas is associated with different temperature alignments. In particular, I follow the results provided by CCPI (Climate Change Performance Index, CCPI.org) to identify countries with a similar "climate-mitigation" profiles.

CCPI index[20] evaluates and compares the climate protection performance of 60 countries and the European Union (EU), which collectively account for more than 92% of global greenhouse gas (GHG) emissions. Countries are ranked using quantitative data from internationally recognized institutions that are synthesized in a score. The variables composing the score are the following: GHG Emissions (40% of overall score); Renewable Energy (20% of overall score); Energy Use (20% of overall score) and Climate Policy (20% of overall score). Using the CCPI countries are classified in different brackets, from the best (high CCPI score) to the worst (low and very low CCPI score).

[20] See CCPI (2023a)

I look at funds' investments in all the countries that have received a high score from CCPI and a low and very low score.[21] The average equity fund in the analysis has circa 56% of its total market value invested in countries with a high CCPI score, and most of this exposure is driven by exposure to firms located in Sweden, Norway and Denmark. However, the average fund has an exposure of circa 27% to countries that have received a low and very low CCPI score. US and Canada also are in this group of countries and account for most of the investment in countries with a low and very low CCPI score. The rest of the countries represent an average share of 17%.

The OLS regressions in Table 1 column (4) shows clearly that funds investing in countries with better policies to mitigate climate change are aligned with lower temperature rises by the end of this century. The coefficient of the variable capturing the funds' investment in countries with a High CCPI score is positive and statistically significant (0.90) but smaller than the one of the funds investing in countries with a low CCPI score (1.13).

Overall, results show that, as is the case for firms, investment in countries working more consistently on climate-mitigation policies is one potential way for funds to green their portfolios and create a "race" between firms and countries to improve their polices. Importantly, one has to keep in mind that firms within the same countries can have completely different alignments to the Paris Agreement, and that not even the countries with a high CCPI score are still fully aligned with the Paris Agreement. For example, according to the CCPI analysis: "To become aligned with a well-below-2°C trajectory, Sweden needs to improve its transport, reduce waste incineration, and improve energy efficiency for buildings." So, even for the best-in-class countries, the work is far from complete, yet this is a valuable investment because it supports not only the country green's transition but also the transition of its financial actors.

3.2.5 Swedish firms with a set scientific target

In the analyses, I also control for the percentage of fund market capitalization invested in Swedish firms with a scientific target. To identify firms with a scientific target, I collect information from the website of the Science Based Targets initiative (SBTi)[22] about Swedish firms with set science-based emissions reduction targets. SBTi provides a list of these firms, their set targets (which are usually based on scope 1 and scope 2 emissions reduction) and also checks on how well the firm is doing to meet their commitment.

[21] The following countries have received a high overall score from CCPI: SE, DK, NO, PT, DE, GB, MA, IN, PH, CL. The following countries have received either a low or a very low overall score from CCPI: US, CA, AU, RU, CN, KZ, IR, SA, PO, HU, JP, MY, BR, AR, ZA, DZ, TR, BG, RO, BY, CZ, IE, BI, SI, TH, VN. More details can be found on the CCPI's project webpage (CCPI, 2023b). All of the countries that are in VINN but are not in the high CCPI score group nor in the low and very Low CCPI score group, are classified as "medium" countries and labelled as "Other Countries" in the Descriptive statistics reported in Table 1.A.

[22] The SBTi is a partnership between CDP, the United Nations Global Compact, World Resources Institute (WRI) and the World Wide Fund for Nature (WWF) (Sciencebasedtargets, 2023).

I identify the list of Swedish firms followed by SBTi (a total of only 18 firms) and match them with the funds' portfolio holdings in September 2022. Then for each fund, I calculate the variable "SE Firms with Targets" which is obtained as the total amount of market value invested in these firms by the fund divided by the total fund market value. Although the set of firms is small to begin with, Table 1.A in Appendix A shows that, on average, funds are largely invested in them since the average total investment in this firm is about 7% (with a median of 4%).

This latter result is not surprising since, on average, the firms that voluntarily set science based targets for themselves tend to be among the largest firms in the economy and issue a variety of securities, including green bonds. Table 2, columns (1)-(4), as expected, show that funds that have larger investment in these firms tend to be aligned with lower temperature, even though results are statistically weaker in column 4 when I include investment in countries with different CCPI scores.

By and large, the main results in this section are consistent with the recent finding of Gupta et al. (2022) who suggests that the fastest way to accelerate the transition may be for investors to choose to only invest in companies that are already greening their operations. Their argument is that, although investors will need to pay a premium for such firms, the current owners of the firms are incentivized to reform the firm immediately, preventing any delays and generating impact quickly. This paper shows that this may be also the fastest way for funds to drastically green their portfolios; yet, while this approach may incentivize other firms to become green (as also suggested by Bolton et al. 2022), the overall (social) success of this strategy depends not only on firms to set scientific targets, but, most importantly, to provide relevant information, or like meeting specific emissions milestones within a certain period of time, to allow investors to verify the work done to meet such targets. If targets are not met, firms *should not be* rewarded.

This section shows that medium and large funds tend to be aligned with lower temperature rises, this is also the case for funds that invest in Swedish firms that have set scientific targets for themselves to reach and for index funds. I also studied whether the rest of the funds' characteristics reported in Table 1.A may be associated with funds' temperature alignment, but I found that basically no fund's characteristics, besides whether the fund is an index fund or not and the fund's geographical investment and size, has any association with the fund's temperature alignment.

In the next section, to better understand the implication for financial stability of fund's exposure to transition risks, I look more directly at how firms are themselves classified by Carbon4Finance in terms of contribution to climate change mitigation. I show how the investment of the funds in this study has changed over time in firms with different climate-mitigation classifications and, in Appendix B, also provide broader statistics for the entire set of institutional investors in VINN.

4 Financial stability consideration

Results so far show that the average fund in the sample is aligned with a temperature rise well above the Paris Agreement targets. In particular, Figure 1 documents that only five of the 122 funds in this study are aligned with a temperature rise below or equal to 2°C, while most of the funds is well above this threshold suggesting that the majority of the funds in this study is significantly exposed to realizations of transition risks. While these results clearly support the conclusion that funds have a lot more to do to green their portfolios, from a financial stability perspective it is important to try to quantify the actual exposures to firms with different climate mitigations profiles. By identifying the firms that contribute the most to a fund's exposure to transition risks, it is easier to understand the potential for decarbonization and further discuss the importance of specific risk management plans.

In this section then, I further exploit the information provided by Carbon4Finance at the issuer level. This information allows me to classify securities based on their issuer's contribution to mitigating climate change. Using this information, I study the exposure of all funds to firms with different transition risk profiles to understand potential consequences for financial stability and then I look at how their ownership in these firms has changed.

Immediately I want to point out that results need to be interpreted with caution. To study how investment in firms with different CIA scores has changed over time, I employ the latest score for each firm provided by carbon4Finance (the only one I have access to) and keep it constant over the period 2019-2022. Of course, if firms have been reclassified over this period, this will introduce a bias in the results that, unfortunately, I cannot control for. In other words, I cannot figure out whether results are driven by the action of the funds or by firms working more consistently on their transition plans. Yet, from a monitoring perspective, I can study general trends to understand how the exposure of the funds to transition risks has been changing even at the expense of the significant limitation of not being able to understand what is driving these changes. I discuss this issue further while illustrating the results.

Also notice that consistent with the labelling assigned by Carbon4Finance, when I do not directly employ the CIA scores to describe results, I refer to firms with a CIA score between A+ and B- as firms with a *significant* climate-mitigation profile or firms with smaller exposure to transition risks, interchangeably. By the same token, I refer to firms with a CIA score between C+ and C- as firms with an *insignificant* climate-mitigation profile (these are also more exposed to transition risks than firms with a CIA score between A+ and B-) and firms with a CIA score below D+ as firms with a *poor/negative* climate-mitigation profile (these firms are the most exposed to transition risks). In the description and discussion of the results, I employ interchangeably the scores and the labels.

4.1 Total investment

In this section, I look at how much of the funds' total market capitalization is allocated to firms with different climate-mitigation profiles. Results are reported in Table 3. In Appendix B, Table 3.1B extends the results in Table 3 by reporting funds' total exposure to Swedish firms only and firms in carbon-intensive industries.

Table 3. Mutual funds' total investment by firm contribution to climate change mitigation

Percent of Total Market Value

	(1)	(2)	(3)	(4)	(6)
Year	**A+,A,A-**	**B+, B, B-**	**C+, C, C-**	**Below D+**	**No Match**
2019	0.79%	6.53%	63.86%	15.57%	13.25%
2020	0.95%	6.80%	63.86%	14.75%	13.59%
2021	1.09%	6.59%	58.40%	14.39%	19.53%
2022	1.08%	7.35%	58.72%	12.48%	20.37%

Note: Results refer to September each year. The CIA overall scores are the latest available and are kept constant over the entire time period.

Sources: VINN and Carbon4Finance.

Table 3 compiles results for the total investment of the 122 equity funds in the analyses, independent of the characteristics of the issuers. Figure 1.B in Appendix A shows that the majority of the firms in the sample have received a score between C+ and C, and therefore are labelled as firms with an insignificant contribution to climate mitigation. Reflecting this pattern, Table 3 shows that, half of the total market capitalization of Swedish equity funds (including index funds) in this study was, in September 2022, invested in firms with a score of C+, C, C- .

Firms with a score of C+, C, C- have substantial work to do to green their operations and firms with a score below D have even more work to do. In September 2022, these latter firms represented investments for about 12% of the funds' total market capitalization. Looking more closely at the firms within the same category of transition risk exposure, there are unquestionably firms that are in better shape than others. Then, I isolate how much of the total portfolio value invested in firms with a score of C+, C, C- (below D+) is invested in the firms with a score of C+ (D+) which, by consistently working on their transition plans, may be the most likely to switch to a better group in the near future.

I find that, in 2022, 15% (46%) of the total investment in securities issued by firms with a score of C+, C, C- (below D+) was allocated to firms with a score of C+ (D+). In particular, investment in firms with a score of C+ represented about 9% of the total portfolio value in 2022. Yet, even assuming that these latter firms may have the most chance to be soon classified in the above B- sub-sample, the remaining exposure to firms with a score of C+, C, C- remains quite high unless firms collectively make major efforts to green their operations in a timely fashion. The same can be said for firms with a score of D+, which even if they move to the sub-set of firms with a score between C+ and C- still will be quite far from having completed their transition.

Panel C of Table 3.1B looks at the funds' exposure to firms in very carbon intensive industries: Oil & Gas Midstream, Oil & Gas Exploration & Production, Mining, Construction, Agriculture & Fisheries, Metals, Refineries, Chemicals and Materials. Clearly, the exposure of Swedish equity funds to these industries (at least regarding the firms for which data is available) is very limited (between 1% and 2% of the total market capitalization) and quite constant over time suggesting that the funds have most likely not changed their exposures to these type of industries very much.

The result above could be driven not only by the fact that, at the fund level, investment in firms in high emitting industries is usually quite small, but also by the fact that funds may find it difficult to replace these investments. It is also important to point out that some of the conglomerates conducting the most polluting activities are sometimes classified as "financial firms" because of their holdings structure. This, of course, biases the results toward identifying less exposure to carbon-intensive industries. Fortunately, part of this problem is resolved by looking at the total scope 1, 2 and 3 emissions at the conglomerate level rather than at the firm's industry classification per se.

Table 3.2B in Appendix B extends some of the results in Table 3 showing aggregated figures for all equity mutual funds (those in the main study and those excluded because of the selection rules described in section 2.2) and all institutional investors (mutual funds, pension funds, insurance companies, etc.) reporting to VINN in September 2022. Moreover, the last part of Table 3.2B shows the exposure of the monetary financial institutions (MFI) reporting to the Swedish credit registry (KRITA) to firms they lend to and for which Carbon4Finance provides the CIA score.

Of the results reported in Table 3.2B, in this section, I want to emphasize the results for the entire universe of equity mutual funds in VINN reported in Panel B. Consistent with what I show more granularly for the 122 funds in this memo (that represent more than 66% of the total market value of all equity funds in VINN in September 2022). While when I look at all institutional investors and at MFI, I can only match a small part of their portfolios, this is not the case for Swedish equity mutual equity funds. For these funds I can match the large majority of the firms issuing the securities in their portfolios and I can clearly see that these funds are exposed to substantial transition risk: investment in firms with a score below C+ is large, a total of SEK 2,258 billion out of a total of SEK 3,367 billion. This confirms the need for attentive monitoring to insure that funds have dedicated risk management plans.

To conclude, in this sub-section I show that Swedish equity mutual funds appear to have large exposure toward firms with a CIA score below C+, which substantially need to green their operations to align themselves to net zero, although their exposure (i.e. the total market value of these investments) to these firms has slightly decreased over time. Yet, given the large market movements in the last three years, this decrease could be driven, at least partly, by valuation effects rather than actual disinvestments. In the next section then, I look directly at changes in the shares owned by funds in firms with different exposures to transition risks.

4.2 Changes in the composition of funds' portfolios

In this section, I study how the amount of shares owned by funds in firms with different transition risk profiles has changed over time. The analyses focus on non-index funds only since index funds follow a specific benchmark and adjust their portfolio to minimize their tracking errors. Also in this section, the CIA scores are the latest available and are kept constant over time. Again, this means that I cannot distinguish whether the results are driven by changes in CIA scores that I cannot control for (a firm moving from A to B for example) or by active decisions by the funds.

In Table 4 below, I study relative changes, with respect to stocks issued by firms with a score between A+ and B-, in the amount of securities owned in stocks issued by firms with a score of C+, C and C- and those with a score below D+, respectively. The full table is reported in Appendix B (Table 4.1B), and results employing portfolio weights as dependent variable are available in Table 4.B also in Appendix B.

Table 4. Investment in stocks issued by firms with different CIA score

Panel OLS regressions with fixed effects.

	Amount of Shares Owned after Passive Rebalancing			
	All firms	**1st tercile CI**	**2nd tercile CI**	**3th tercile CI**
	(1)	(2)	(3)	(4)
C+	-0.00	0.02	-0.02	-0.02
	(0.737)	(0.177)	(0.338)	(0.206)
C	-0.01	-0.00	-0.02	-0.04**
	(0.126)	(0.957)	(0.506)	(0.030)
C-	-0.02**	-0.00	-0.02	-0.04**
	(0.035)	(0.953)	(0.360)	(0.032)
Below D+	-0.02**	0.01	-0.03	-0.05**
	(0.048)	(0.338)	(0.369)	(0.012)
Observations	103,780	34,219	35,213	34,348
Adjusted R^2	0.068	0.188	0.130	0.061

Note: Panel OLS regressions over the period Q12019-Q32022. Column (1) shows results for all shares in the funds' portfolios. Columns (2), (3) and (4) show results for sub-sets of in different terciles of scope 1, 2 and 3 of carbon intensity in September 2022. Terciles of carbon intensity are calculated for each fund in each quarter to be able to capture the most polluting firms in the fund portfolio. The dependent variable is the amount of shares owned after passive rebalancing (percentage) calculated as in section 3.3 of Cella (2022). Regressions include industry dummies, year-quarter dummies and fund-year-quarter dummies. Index funds are excluded. Standard errors are robust and clustered at fund-year-quarter level. Robust p-values are reported in the parentheses underneath the coefficients and should be interpreted as follows *** p<0.01, ** p<0.05, * p<0.1. The full table is shown in Appendix B, Table 4.1B.

Sources: VINN, Carbon4Finance and Morningstar.

Table 4 reports quarterly panel OLS regressions over the period Q1/2019-Q3/2022. The dependent variable is the percentage amount of shares held by each fund after passive rebalancing. This variable is calculated as the difference between (a) the amount of shares held by a fund at time *t* and (b) the amount of shares the fund would have held at time *t* if it had reinvested all the proceeds it made from this stock

in the stock itself (see Cella 2022 for details). Therefore, the difference between (a) and (b) represents the change in the amount of shares not driven by passively reinvesting the proceeds from the stock in the stock itself (i.e. passive rebalancing). Using this variable it is easier to interpret whether changes in a stock's portfolio weight is driven by changes in its price rather than changes in the number of shares. Importantly, at the end of each quarter, the amount of shares owned and the price are obtained directly by the funds.

Independent of their CIA score, firms with a large carbon footprint are those that need to put in the largest effort to green their operations. Therefore, absent further information about firms' transition plans, if funds want to reduce their carbon footprints quickly, they could target changes in the firms in their portfolios with the largest carbon footprint. Therefore, each quarter, I divide all of the securities in each of the fund's portfolios into terciles of emissions intensity and combine this information with the CIA score. Again, in September 2022, I have the emissions intensities calculated by carbon4Finance using the latest emissions estimates available to them, so the problem remains and I cannot really distinguish whether it is firms' actions or funds' choices behind the results, but I can at least investigate whether there have been any changes in amount of shares funds own in the most polluting firms in their portfolios as of September 2022.

Results for firms classified by terciles of carbon intensity are reported in columns (2), (3) and (4) respectively. All columns show results that include industry dummies, year-quarter dummies and fund-year-quarter dummies. In each column, I also control for stock level main characteristics (market capitalization, returns, volatility, whether the stock paid a dividend of not, liquidity). Standard errors are robust and clustered at fund-year-quarter level.

The first column in Table 4 looks at how, over the period 2019-2022, the average stake of a fund has changed in firms with a CIA score of C+, C, C- and below D+ with respect to the change in the amount of shares in stocks issued by firms with a CIA score above B-. Results clearly show that, after accounting for passive rebalancing, the average amount of shares in stocks issued by firms with a score of C- and below D+ has significantly decreased over the period 2019-2022, although the magnitude of the coefficients is small. This means that with respect to stocks issued by firms with the best climate-mitigation profiles, the amount of shares held in firms with the poorest climate-mitigation profile has on average slightly decreased over time.

Looking at the rest of the columns in Table 4, it appears that this result is mostly driven by a decrease in the amount of shares owned in the most polluting firms in the funds' portfolios. In fact, when splitting the sample into firms' carbon intensity terciles, calculated at the fund level each quarter, results are only statistically significant for the sub-sample of firms in the third terciles of carbon intensity and are particularly strong, both economically and econometrically, for firms with a CIA score below D+.

Interestingly, in the sub-sample of firms with the highest carbon intensity, high stock returns over the past quarter and high stock return volatility are also associated with a lower average amount of shares, as shown in Table 4.1B in the appendix. This suggest that within the sub-set of stocks issued by firms with the highest contribution to the funds' carbon footprints, funds may be reducing their exposure to more volatile stocks and stocks that have yielded a higher return in the past.

The results in Table 4 suggest that, absent additional information about the firms' transition plans, funds may be trying to reduce their carbon footprint and align themselves with net zero by reducing their exposure to firms with high carbon intensities. Yet, I cannot exclude that results are purely driven by firms decreasing their emissions and changing score category. Yet, for the very polluting firms with a very low CIA score, it may be unlikely that the entire result is solely driven by unobservable changes at the firm level rather than funds actively trading away from these firms.

In fact, unless a very polluting firm has, in the last 4 years, made a very ambitious transition plan to reach net zero in a timely fashion and has consistently worked hard on greening its operations, it may be unlikely that a firm with a score of D+ or less in 2019, for example, may have obtained a score of A in 2022. However, I cannot exclude that this may be the case for at least a sub-set of firms with a score below D+ and above C-. And, if this were to be the case, it would be an extremely positive sign that the transition can be made quickly even by the most polluting firms.

Finally, even though funds may not possess the same information I employ or any specific information about firms' contribution to climate mitigation, one possibility behind the results documented above is that, over the time period 2019-2022, many firms have put considerable effort into obtaining an ESG score (and/or have issued green securities). Obtaining an ESG score or issuing green securities should allow a firm to have a higher climate-mitigation profile. Therefore, since Carbon4Finance employs a very large set of data that should overlap with most of the data employed to calculate ESG scores, CIA score should be highly correlated with the potential ESG score firms would receive. It would be important then to control whether firms obtaining an ESG score or issuing green securities are also more likely to obtain a CIA score above B-, but unfortunately I do not have access to this information.

In conclusion, given the lack of data, more monitoring and direct communication with the funds themselves is necessary in order to make sure that funds consistently continue to reduce their exposure to transition risks.

5 Discussion and conclusions

On March 20, 2023 the IPCC (Intergovernmental Panel on Climate Change) presented its 6th comprehensive Assessment Report (IPCC, 2023). This report, like other reports published before,[23] states very clearly that climate change is induced by human activity and illustrates very alarming facts about the state of the world today. Moreover, the report is quite open about the (economic and human) costs of climate change if GHG emissions are not reduced in nearly half by 2030 and more investment in adaptation is not promptly funded.

From the financial industry perspective, the results of the report make it clear that investing in line with the green transition is a risk management tool that allows institutional investors to protect themselves against transition risks. Importantly though, as people become more engaged in the collective effort to mitigate global warming, responsible investing will continue to attract a substantial amount of flow (Humphrey and Li 2021, Hartzmark and Sussman 2019 and Ceccarelli, Ramelli and Wagner 2021), giving institutional investors a substantial incentive to green their portfolios.

In Sweden, mutual funds appear to be aware of the importance of investing in a more responsible way. In May 2021, for example, the majority of the Swedish funds members of the Swedish Investment Funds Association (Fondbolagens Förening) were shown to promote sustainable practices, even though these do not only refer to alignment to the net zero target (Fondbolagens Förening, 2021). Swedish firms also seem to be aware of the importance of investing in greening their operations (Sveriges Riksbank 2023a, p.3). Yet, while firms meet the time-consuming and costly challenge to *measure and manage* their emissions,[24] funds need this (accurate and verifiable) information *promptly* to be able to *measure and manage* their own carbon footprint in a cost-effective way. These data limitations are not trivial and are also a major obstacle for public institutions trying to assess the potential consequences of climate-related risks for economic growth and financial stability (Cella 2020, 2022; Sveriges Riksbank 2023b).

Fortunately though, at least for public institutions, things are moving at a fast pace. In spring 2022, the central bank members of the Eurosystem Procurement Coordination Office (EPCO), among them Sveriges Riksbank, were able to jointly procure forward-looking data from Carbon4Finance. Even if one needs to keep in mind that the results obtained using this data are driven by specific scenarios, key assumptions and methodological choices made by Carbon4Finance, data can be exploited to monitor the pace of the transition and at the same time provide relevant information to the financial industry. Absent additional firm-level information, combining their detailed portfolio information with this additional information, institutional investors should be

[23] The IPCC report from April 2022, for example, assessed that limiting warming to around 1.5°C required global greenhouse gas emissions to be reduced by a staggering 43% by 2030 (IPCC 2022).
[24] Fortunately, a new regulation (CSRD and ESRS, European Commission, 2021b) has been approved so that large non-listed firms and all listed firms will need to report carbon emissions data from 2023. For more details see European Commission (2023a) and Brightest (2023).

able to better understand where they stand and how much more work they should put in, on average, to green their portfolios.

Unfortunately, the message of this memo is not one that should make anyone happy yet. The fact that in September 2022, the average fund in the sample was aligned with a temperature of 2.77°C and only 5 funds out of a total of 122 are aligned with a temperature increase below 2°C makes it clear that funds are still far from meeting the goal of well-below 2°. This is a clear risk to financial stability since the analyses also show that most of the firms in the funds' portfolios have substantial exposure to transition risks. If this risk is not managed adequately, the potential consequences for the stability of the Swedish financial system could be serious.

By and large, the results in this study are consistent with those provided in a related memo published in 2022 (Cella 2022). This latter study employed completely different data but came to similar conclusions: mutual funds are currently exposed to substantial transition risks and, unless they are very confident that firms in their portfolios will make a swift transition, they need to work substantially more to manage this risk. This does not mean that there are no positive signs; things are, at least partially, moving in the right direction.

As a matter of fact, I document that the average amount of shares owned by funds (after rebalancing) in firms with high emissions and large exposure to transition risks (both unfortunately only available in September 2022) has slightly decreased over the period 2019-2022. Unfortunately, because of data limitations, I cannot distinguish whether this is driven by firms reducing their emissions, and therefore their exposure to transition risks, or, absent this improvement, to funds actively trading away from these firms.

In conclusion, my studies show that monitoring is necessary to make sure that transition risks are managed correctly so as not to have consequences for financial stability. Fortunately, the more information becomes accurate, verifiable and accessible to all parties in need of it, the less costly the green transition will become.

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APPENDIX A. Temperature alignments, additional material

Table 1.A Funds' additional descriptive statistics

	(1)	(2)	(3)	(4)
		Characteristics in September 2022		
	N	**Mean**	**Median**	**SD**
Initiative Funds	122	64%	100%	48%
Low Carbon Funds	122	66%	100%	48%
No of Securities	122	144	52	341
Portfolio Weight	122	1.98%	1.64%	1.51%
Fund Size (SEK billion)	122	18.19	7.86	68.38
SE Firms with (Scientific) Targets	122	7.15%	3.73%	8.25%
High CCPI Countries	122	55.89%	62.28%	36.94%
Low and Very Low CCPI Countries	122	27.12%	1.59%	33.70%
Other Countries	122	16.99%	11.39%	17.80%
		Characteristics in December 2021		
Churn Ratio	122	0.14	0.10	0.12
Net Flow	105	0.03	0.00	0.16
3 Years Ann. Return	107	15.42%	15.00%	5.68%
High Sustainability	107	47%	0%	50%
Morningstar Rating	101	3.52	4.00	0.99
Management Fees	88	0.98	1.25	0.56
Index Fund Dummy	108	20%	0%	40%

Note: Table 1 shows descriptive statistics for the main variables of interest. The churn ratio, calculated as in Gaspar, Massa and Matos (2005) and Cella, Ellul and Giannetti (2013), captures how much of their portfolios funds turn over every quarter (see Cella, Ellul and Giannetti (2013) p. 1612 for the full discussion). High Sustainability is calculated as a dummy variable XXX. The Morningstar Rating for funds, often called the star rating, is a purely quantitative, backward-looking measure of a fund's past performance, measured from one to five stars.

Sources: VINN, Carbon4Finance and Morningstar.

Table 2.A Cross-sectional OLS regressions with quintiles of size

	Portfolio Temp. °C			
	(1)	**(2)**	**(3)**	**(4)**
Initiative Funds	0.07		0.08	
	(0.460)		(0.365)	
Low Carbon Funds	-0.03		-0.05	
	(0.753)		(0.669)	
Index Funds		-0.19*		
		(0.092)		
High CCPI				0.89***
				(0.000)
Low-Very Low CCPI				1.11***
				(0.003)
Nr of Securities (ln)			0.03	
			(0.555)	
SEFirmsTargets	-1.39**	-1.33**	-1.27*	-1.53***
	(0.031)	(0.017)	(0.072)	(0.009)
Size quintiles:				
Q2: Av. size SEK 3 billion	-0.16*	-0.16***	-0.15*	-0.14***
	(0.064)	(0.000)	(0.083)	(0.000)
Q3: Av. size SEK 8 billion	-0.34***	-0.39***	-0.35***	-0.21***
	(0.003)	(0.000)	(0.001)	(0.000)
Q4: Av. size SEK 14 billion	-0.18**	-0.11***	-0.20**	-0.17***
	(0.041)	(0.000)	(0.014)	(0.000)
Q5: Av. size SEK 66 billion	-0.17*	-0.11***	-0.21**	-0.19***
	(0.089)	(0.000)	(0.022)	(0.000)
Constant	3.02***	3.05***	2.88***	2.22***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	122	108	122	122
Adjusted R^2	0.065	0.136	0.061	0.212

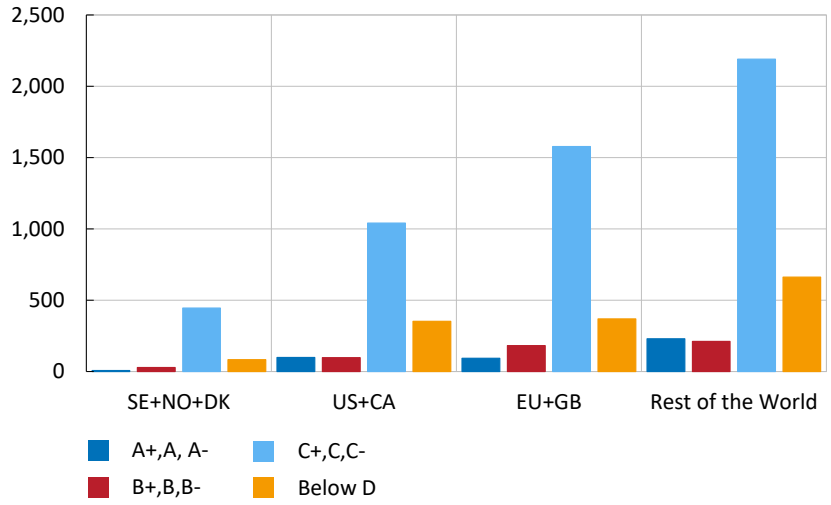
Note: Cross-sectional OLS regressions. Standard errors are robust and clustered by quintiles of fund size. Robust p-values are reported in the parentheses underneath the coefficients and should be interpreted as follows *** p<0.01, ** p<0.05, * p<0.1.

Sources: VINN, Carbon4Finance and Morningstar.

APPENDIX B. Financial stability considerations, additional material

Figure 1.B Carbon4Finance CIA coverage by geographical regions

Number of firms



Note. Total number of firms and sovereign is 7,764; 92 firms have no ISIN and therefore can't be geographically located.

Sources: Carbon4Finance and Riksbank.

Table 3.1B Mutual funds' total investment by firms' contribution to climate change mitigation

Market Value in SEK billion

	(1)	(2)	(3)	(4)	(6)	(7)
Year	**A+,A,A-**	**B+, B, B-**	**C+, C, C-**	**Below D+**	**No Match**	**Total**
Panel A:			**All Issuers**			
2019	13	107	1,046	255	217	1,638
2020	18	129	1,212	280	258	1,898
2021	27	164	1,453	358	486	2,488
2022	24	163	1,303	277	452	2,219
Panel B:			**Swedish Entities Only**			
2019	11	25	336	39	79	489
2020	13	33	403	49	114	612
2021	13	34	370	65	288	770
2022	12	22	258	40	268	600
Panel C:			**Investment in very-carbon-intensive industries**			
2019	0	16	38	39	0	93
2020	1	20	36	26	0	84
2021	2	16	51	34	0	102
2022	2	17	43	38	0	100

Note: Results refer to September each year. I define as very carbon-intensive the following industries: Oil & Gas Midstream, Oil & Gas Exploration & Production, Mining, Construction, Agriculture & Fisheries, Metals, Refineries, Chemicals and Materials. Industries classifications are provided by Carbon4Finnace so only firms that are covered by their analyses are included in each industry. The CIA overall scores are the latest available and are kept constant over the entire time period.

Sources: VINN and Carbon4Finance.

Table 3.2B Institutional investors' investment by contribution to climate-change mitigation

Market Value in SEK billion

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	A+,A,A-	**B+, B, B-**	**C+,C,C-**	**D+,D,D-**	**E+,E,E-**	**No Match**	**Total**
Panel A:				**All Institutional Investors in VINN**			
2019	157	322	2,929	683	21	10,156	14,269
2020	194	377	3,250	740	11	10,681	15,254
2021	238	469	3,832	952	13	12,823	18,325
2022	196	437	3,255	730	11	12,401	17,031
Panel B:				**All Equity Funds in VINN**			
2019	19	144	1,507	363	11	472	2,516
2020	25	171	1,746	408	5	553	2,907
2021	37	223	2,105	529	6	958	3,859
2022	31	215	1,852	400	6	863	3,368
Panel C:				**Banks Total Lending – Data from KRITA**			
2019	7	30	217	19	2	1,928	2,203
2020	7	32	261	19	2	1,991	2,312
2021	7	29	218	21	1	2,066	2,341
2022	5	47	325	40	0	2,327	2,744

Note: Results refer to September each year. The CIA overall scores are the latest available and are kept constant over the entire time period.

Sources: VINN, KRITA and Carbon4Finance.

Table 4.1B Change in stocks issued by firms with different CIA Scores

Panel OLS regressions with fixed effects. Dependent variable is the amount of shares owned after passive rebalancing (percentage).

	All firms	1st tercile CI	2nd tercile CI	3th tercile CI
	(1)	(2)	(3)	(4)
CIA Score:				
C+	-0.00	0.02	-0.02	-0.02
	(0.737)	(0.177)	(0.338)	(0.206)
C	-0.01	-0.00	-0.02	-0.04**
	(0.126)	(0.957)	(0.506)	(0.030)
C-	-0.02**	-0.00	-0.02	-0.04**
	(0.035)	(0.953)	(0.360)	(0.032)
Below D+	-0.02**	0.01	-0.03	-0.05**
	(0.048)	(0.338)	(0.369)	(0.012)
Country CCPI Score:				
Medium	-0.01	0.02*	-0.02	-0.01
	(0.404)	(0.077)	(0.459)	(0.668)
Other	-0.01	0.02	-0.02	0.01
	(0.440)	(0.137)	(0.286)	(0.643)
Stock Characteristics:				
Market Cap (ln)	0.00	0.00	0.01**	-0.00
	(0.126)	(0.370)	(0.022)	(0.943)
Stock Returns	-0.70***	-0.68***	-0.66***	-0.69***
	(0.000)	(0.000)	(0.000)	(0.000)
Stock Returns Lag	0.14***	0.18***	0.07	0.15
	(0.001)	(0.002)	(0.183)	(0.114)
30 Days Volatility	-0.00***	-0.00**	-0.00**	-0.00*
	(0.002)	(0.022)	(0.039)	(0.067)
30 Days Volatility Lag	0.00***	0.00*	0.00**	0.00
	(0.010)	(0.076)	(0.034)	(0.226)
Dividend Paying Lag	0.01	-0.00	0.02	0.01
	(0.125)	(0.622)	(0.118)	(0.433)
Bid-Ask Spread Lag	-0.04	-0.03	-0.06**	-0.03
	(0.217)	(0.464)	(0.031)	(0.762)
Constant	-0.03	-0.07	-0.13	0.09
	(0.690)	(0.327)	(0.197)	(0.541)
Observations	103,780	34,219	35,213	34,348
Adjusted R^2	0.068	0.188	0.130	0.061

Note: Panel OLS regressions over the period Q12019-Q32022. Column (1) shows results for all shares in the funds' portfolios. Columns (2), (3) and (4) show results for sub-sets of in different terciles of scope 1, 2 and 3 of carbon intensity in September 2022. Terciles of carbon intensity are calculated for each fund in each quarter to be able to capture the most polluting firms in the fund portfolio. The dependent variable is the amount of shares owned after passive rebalancing (percentage) calculated as in section 3.3 of Cella (2022). Regressions include industry dummies, year-quarter dummies and fund-year-quarter dummies. Index funds are excluded. Standard errors are robust and clustered at fund-year-quarter level. Robust p-values are reported in the parentheses underneath the coefficients and should be interpreted as follows *** p<0.01, ** p<0.05, * p<0.1. The full table is shown in Appendix B, Table 4.1B.

Sources: VINN, Carbon4Finance and Morningstar.

Table 4.2B Portfolio weights – Active funds only

Panel OLS regressions with fixed effects.

	All firms	1st tercile CI	2nd tercile CI	3th tercile CI
	(1)	(2)	(3)	(4)
CIA Score:				
C+	-0.11***	-0.34***	0.05**	0.04*
	(0.000)	(0.000)	(0.043)	(0.056)
C	-0.22***	-0.40***	-0.13***	-0.08***
	(0.000)	(0.000)	(0.000)	(0.000)
C-	-0.02	-0.20***	-0.04*	0.15***
	(0.318)	(0.000)	(0.063)	(0.000)
Below D+	-0.13***	-0.25***	-0.06**	-0.05**
	(0.000)	(0.000)	(0.011)	(0.013)
Country CCPI Score:				
Medium	0.03**	0.07***	0.09***	-0.03**
	(0.024)	(0.000)	(0.000)	(0.025)
Other	0.07***	0.09***	0.13***	0.01
	(0.000)	(0.000)	(0.000)	(0.414)
Stock Characteristics:				
Market Cap (ln)	0.00	0.00	0.01**	-0.00
	(0.126)	(0.370)	(0.022)	(0.943)
Stock Returns	-0.70***	-0.68***	-0.66***	-0.69***
	(0.000)	(0.000)	(0.000)	(0.000)
Stock Returns Lag	0.14***	0.18***	0.07	0.15
	(0.001)	(0.002)	(0.183)	(0.114)
30 Days Volatility	-0.00***	-0.00**	-0.00**	-0.00*
	(0.002)	(0.022)	(0.039)	(0.067)
30 Days Volatility Lag	0.00***	0.00*	0.00**	0.00
	(0.010)	(0.076)	(0.034)	(0.226)
Dividend Paying Lag	0.01	-0.00	0.02	0.01
	(0.125)	(0.622)	(0.118)	(0.433)
Bid-Ask Spread Lag	-0.04	-0.03	-0.06**	-0.03
	(0.217)	(0.464)	(0.031)	(0.762)
Constant	-1.26***	-1.33***	-1.52***	-0.91***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	110,978	36,782	37,461	36,735
Adjusted R^2	0.577	0.537	0.653	0.678

Note: Panel OLS regressions over the period Q12019-Q32022. Column (1) shows results for all shares in the funds' portfolios. Columns (2), (3) and (4) show results for firms grouped by terciles of scope 1, 2 and 3 of carbon intensity in September 2022. At the end of each quarter and for each fund, the dependent variables are calculated as the total amount of shares owned in a stock times the price of the stock, as reported by the fund. Regressions also include industry dummies, year-quarter dummies and fund-year-quarter dummies. Index funds are excluded. Standard errors are robust and clustered at fund-year-quarter level. Robust p-values are reported in the parentheses underneath the coefficients and should be interpreted as follows *** p<0.01, ** p<0.05, * p<0.1.

Sources: VINN, Carbon4Finance and Morningstar.

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