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Climate risk, ESG ratings, and the flow-performance relationship in mutual funds[☆]

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ABSTRACT

We extend the burgeoning literature on climate finance by examining the informational role of mutual fund sustainability ratings on the asset allocation decisions by investors when faced with climate risks. Utilizing data on a large sample of equity mutual funds in Australasia (Australia and New Zealand), we find that climate risk plays a significant role on the sensitivity of fund flows to past performance. We find that the sensitivity is stronger for mutual funds that enjoy high sustainability ratings, and we show that the informational value of past performance over subsequent fund flows becomes more important when investors face greater climate risks. We argue that sustainability ratings of managed funds not only complement performance but also help improve the efficiency of asset allocation decisions, more so during a heightened climate risk environment.

1. Introduction

The growing importance of environmental and social implications of investment decisions has fuelled a remarkable boom in socially responsible investments over the past decade (Krueger, Sautner, & Starks, 2020). Despite the mixed evidence on the performance of investment tools with high sustainability ratings compared to their conventional alternatives, investor interest in sustainable investments has been quite resilient (Albuquerque, Koskinen, Yang, & Zhang, 2020), suggesting that investors increasingly view sustainability as a necessity rather than a luxury (Pastor & Vorsatz, 2020; Yousaf, Suleman, & Demirer, 2022). Naturally, this has led to a rapidly growing literature that focuses on the impact of climate risk on financial markets. Interestingly, the majority of works in the burgeoning climate finance literature have focused on the pricing implications and risk management of climate risks in financial markets. One topic that is relatively understudied in this literature, however, is the role played by climate concerns over the investment decisions towards managed funds.

The potential impact of climate concerns over asset allocation decisions towards managed funds is indeed of high importance as the growing public demand for sustainable investments has left portfolio managers under pressure to tilt their portfolios towards such assets. As a result, an increasing number of institutional investors have signed up on responsible investment principles over the last

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decade (Edmans, 2023) to attract investor flows, despite the evidence that investing in socially responsible mutual funds incurs a significant penalty in certainty-equivalent returns compared to their conventional counterparts (Geczy, Stambaugh, & Levin, 2005). In this study, we contribute to the literature from a unique perspective by examining the effect of climate risk and sustainability ratings (or ESG ratings) on the flows allocated by investors to managed funds.[1] By doing so, we explore the role of climate risk from a new perspective by relating it to asset allocation decisions towards managed funds.

Our work primarily builds on the argument that investment flows in the managed funds industry often serve as an indicator of investor sentiment (e.g., Ben-Rephael, Kandel, & Wohl, 2012; Frazzini & Lamont, 2008). Indeed, a growing number of studies suggest that investors use signals from past performance of funds to infer managerial skills (Huang, Wei, & Yan, 2022) which paves the way to a predictive relationship between fund flows and past performance that is well documented in the literature (e.g., Berk & Green, 2004; Franzoni & Schmalz, 2017; Huang et al., 2022). Offering a theoretical insight, Berk and Green (2004) argue that the flow-performance relationship reflects Bayesian (rational) investor learning about the skill of mutual fund managers such that past performance provides signals to investors, which in turn creates an informational channel. While a handful number of studies have expanded the fund flow-performance analysis to sustainable funds (e.g., Benson & Humphrey, 2008; Renneboog, Ter Horst, & Zhang, 2011) and show that flows into sustainable funds do not follow past performance, however, the extant empirical evidence on the flow-performance relationship is mixed and tend to depend on the measure of sustainability, time horizon, and asset universe. Also, the current literature has yet to explore the role of climate risk as a determinant of the predictive relationship between fund flows and past performance.

This paper presents a unique view on the relationship between climate risk and financial market dynamics by investigating the interplay between the environmental, social, and governance (ESG) ratings of a fund and the predictive power of past returns over subsequent fund flows when investors face greater uncertainty regarding the transitional and physical implications of climate change. To do so, we utilize a large sample of equity mutual funds domiciled in the Australasia region (Australia and New Zealand) and examine the effect of the recently developed climate risk index on the fund flow-performance relationship using Morningstar ESG ratings. We contribute to the literature from two aspects. First, we extend the burgeoning literature on climate finance in a unique direction by examining the informational role of sustainability ratings on the asset allocation decisions by investors towards mutual funds when faced with greater uncertainty regarding the regulatory and physical risks caused by climate change. Furthermore, the investor learning literature in the context of mutual funds highlights that higher uncertainty hinders investor learning about managerial skills (e.g., Ali, Badshah, Demirer, & Hegde, 2023; Starks & Sun, 2016), thus leading to an inefficient capital allocation by investors.[2] The role of uncertainty is further emphasized by Franzoni and Schmalz (2017), who show that uncertainty regarding the risk loadings on benchmark factors affects investors' capital allocation decisions, thus reducing the flow-performance sensitivity in extreme market states. Although the previous empirical works on the US mutual fund industry document that investors reward funds in an asymmetric fashion based on their past performance. That is, investors prefer to invest in outperforming funds more aggressively than they sell underperforming funds (see, for example, Sirri & Tufano, 1998; Del Guercio & Tkac, 2002, among others).

Despite the large literature on the fund flow-performance relationship in different contexts, previous studies do not investigate the issue in the context of climate uncertainty, which has been shown in recent studies to be a significant concern when making investment decisions (Ceccarelli, Ramelli, & Wagner, 2024, Krueger et al., 2020). The role of climate risk is particularly important in the context of funds with a responsible investment focus because the perceived risks associated with the physical and transitional aspects of climate change might shift investor preferences from performance to ESG values, thus distorting the informational role of past performance over fund flows. The literature on the fund flow-performance relationship in the context of sustainable funds is relatively less developed and mostly focuses on the comparison of sustainable funds against their conventional counterparts. For example, Bollen (2007) shows that flows to socially responsible investment (SRI) funds are positively (negatively) related to positive (negative) past performance. Similarly, Renneboog et al. (2011) show that SRI funds are generally less concerned about negative returns compared to non-SRI funds (or conventional funds) based on the flow-performance sensitivity for such funds. The authors further argue that SRI funds care less (more) about the financial (non-financial) attributes of the investment. Similarly, Benson and Humphrey (2008) through their sample of U.S. mutual funds with SRI focus, argue that investors who prefer sustainability face difficulty in finding alternative SRI assets to divert their funds into, thus such flows to SRI funds are less sensitive to past performance compared to a conventional fund (i.e., non-SRI fund). In contrast, we argue that the information reflected by the ESG rating of a fund can help to alleviate some of the informational asymmetries that may arise between the fund managers and investors in terms of their adherence to responsible corporate practices, thus strengthening the flow-performance relationship among high ESG-rated (or sustainable) funds. In that regard, our analysis adds another dimension to the informational value captured by ESG ratings in a novel context. To the best of our knowledge, ours is the first study that examines the informational value of sustainability ratings in the climate risk context via the fund flow performance relationship analysis.

Second, we develop two indexes of climate risk for Australasia via textual analysis of an extensive list of news articles from *The Australian* and *The New Zealand Herald* newspapers associated with the region over the period January 2018 through December 2022. Our procedure can capture the distinction between physical and transition risks associated with climate change prompted by physical climate events or the regulatory or operational impact of climate risks. To the best of our knowledge, this is the first study in the

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[1] Since environmental, social and governance (ESG) measure broadly captures the sustainability of a mutual fund we use sustainable or high ESG rated funds synonymously throughout the paper.

[2] These recent works, add a new perspective to the relationship between stock market dynamics and uncertainty that is shown to drive return and volatility dynamics in financial markets (see Ali, Badshah, Demirer, & Hegde, 2022; Kelly, Pástor, & Veronesi, 2016; Liu & Zhang, 2015; Pástor & Veronesi, 2013; You, Guo, Zhu, & Tang, 2017; among others).

literature to propose measures of physical and transitional climate risk for Australasia. Considering the growing evidence that climate concerns play a significant role in asset allocation decisions (Ceccarelli et al., 2024; Krueger et al., 2020), our work aims to enlarge our understanding of the changing dynamics in investor preferences towards this growing asset class and the role of climate concerns in the process.

Our main findings show that rational investors use past returns as a signal to form their posterior expectations about the ability of a fund manager, more so when a fund enjoys high ESG ratings. In essence, our results show the ESG rating of a fund serves as a performance complement, confirming the dual role of such ratings not only as an indicator of the investment principles adopted by the fund manager but also as a performance complement to managerial skills. This supports the argument by Pedersen, Fitzgibbons, and Pomorski (2021) and Van der Beck (2023), where ESG scores play a dual role as they not only provide valuable information regarding firm fundamentals but also affect investors' preferences. For example, Van der Beck (2023) argues that sustainable funds outperform and have higher flows, contrary to the findings in earlier research. The author, in his 2012–2022 sample, shows that investors favoring ESG portfolios have a significant alpha compared to those favoring a non-ESG portfolio, suggesting that fund ESG ratings positively affect the flow and performance. We also find that the nature of climate uncertainty, in terms of transition or physical risk, plays a significant role on the sensitivity of fund flows to past performance such that the response of fund flows to past performance is particularly stronger for 'sustainable' funds. This finding further highlights the informational value of sustainability ratings for a fund, more so during market states when investors are more concerned about climate risk both from physical and regulatory perspectives.

We explain our findings in light of earlier research, which has broadly classified sustainable finance under one umbrella of ESG that involves both pecuniary and non-pecuniary investor preferences. However, recent research has attempted to disentangle the investor motivation from a pecuniary to non-pecuniary. For example, Starks (2021, 2023) argues that the investors' and fund managers' preference significantly regulates the meaning of ESG or SRI because the ESG qualities of an investment are as important as financial quality (i.e., performance). Furthermore, the author argues that investment decision-making is highly driven by either the financial quality (i.e., risk and return) or ESG quality (i.e., non-pecuniary preferences such as sustainability or carbon footprints, among others), or a combination of both. The underlying intuition from Starks (2023) is that sustainable investments can be important to both investors focused on traditional value (return and risk) and socially driven investors who focus on ESG non-pecuniary values. We further argue that the relationship between performance or risk and ESG investing depends on investor preference. There is a notion that ESG investing can lead to better risk management (Hoepner, Oikonomou, Sautner, Starks, & Zhou, 2024) or can identify higher return opportunities (Albuquerque, Koskinen, & Zhang, 2019; Giglio, Kelly, & Stroebel, 2021; Krueger et al., 2020). Therefore, the research is inconclusive yet about the over-arching effects of ESG investing on the fund flows, performance, and risk. More importantly, our research question does not contribute to the debate of whether ESG affects the return or not; rather, we argue that investor flows are driven by both pecuniary and non-pecuniary preferences. Thus, we argue that investors prefer to tilt their investments towards funds that value both ESG quality and financial quality.

Our findings show that climate uncertainty has a significant impact on the informational role of past performance over managerial skills conditional on the ESG ratings and the nature of climate risk. From a practical perspective, our findings highlight the importance of developing and actively monitoring various aspects of climate risks that affect investors' decision-making towards sustainable assets. Professional money managers should not only monitor these risks to develop market timing strategies in their investments but also strive to alleviate any informational asymmetries that may arise between them and their investors, particularly when investors face greater risks due to the effects of climate change.

The rest of the paper is organized as follows. Section 2 describes the data and the methodology for constructing climate risk indexes. Section 3 presents the empirical results on the fund flow-performance relationship in ESG-rated funds and the role of climate uncertainty along with the economic implications of our findings. Finally, Section 4 provides our concluding remarks with suggestions for future research.

2. Data and methodology

2.1. Data

We employ a survivorship bias-free mutual fund dataset that includes all available open-end equity mutual funds from Morningstar Direct, domiciled in Australia and New Zealand. Since Morningstar provides the fund-level sustainability (ESG) rating data for Australia and New Zealand, our sample period starts in August 2018. Globally, Morningstar launched the Sustainability Ratings of over 40,000 mutual funds into a simple rating scale between one and five globes, as depicted in Fig. A1 in the Appendix. The rating system was designed to provide "a reliable, objective way" to evaluate how investments are meeting environmental, social, and governance challenges wherein funds are classified based on the underlying holdings.[3] In this setting, each holding is assigned a sustainability score based on the research of public documents undertaken by Sustainalytics, an independent Morningstar company that provides ESG ratings and analytics for listed companies. The ratings are based on how a firm scores on ESG issues, and at the end of each month, Morningstar takes the weighted average of this measure based on the fund's holdings to form a fund-specific sustainability score. Each fund in a Morningstar category is then ranked based on its sustainability score and this ranking serves as the basis of the Morningstar globe ranking depicted in Fig. A1. It must, however, be noted that Morningstar provides ESG ratings for only a subset of the funds from

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[3] For details, see http://news.morningstar.com/articlenet/article.aspx?id=745467.

the overall universe of funds because their rating system requires that a large portion of the fund's portfolio component holdings be rated by the corporate or sovereign risk rating frameworks. However, not all funds meet this criterion; therefore, within the Morningstar database, a considerable number of funds remain unrated. Since our focus is specifically on the role of ESG ratings on investor learning in the context of climate uncertainty, in our analysis, we use only the funds that meet Morningstar's ESG rating requirement.

After excluding funds with missing ESG ratings and other information such as returns and total net assets (TNA), our final sample yields an average of 2724 funds per month across the two countries; among them, on average 2050 are alive (surviving) and 674 are defunct or dead (liquidated/merged), resulting in a total of 59,743 fund-month observations for our analyses.[4] Fig. 1 presents the distribution of the mutual funds in the sample across the five sustainability ratings over the period 2018–2022. The sustainability globe ratings stand for funds in high risk (Globe 1 or G1), above average risk (Globe 2), average risk (Globe 3), below average risk (Globe 4) and low risk (Globe 5 or G5). Thus, Morningstar assigns a fund with high (low) ESG risk relative to its Morningstar Global Category as 1 (5) globe. To enrich our inferences, we further distinguish between the domestic funds (funds that invest primarily in stocks of the country of domicile) and international funds (funds that invest primarily in stocks of countries different from the country of domicile). To classify the funds based on their international or domestic focus, we use the fund investment category from Morningstar, which results in 1004 (1720) funds classified as domestic (international), on average. Overall, our final dataset includes a large sample of equity mutual funds covering two significant markets with a total net asset value of $533 billion, representing a sizeable chunk of the mutual fund population and unique set of panel data (when aggregated at the country level) for each month.

Table 1 presents the descriptive statistics for the sample of funds used in the multivariate tests. Panel A presents the monthly average each year and Panel B reports the monthly fund statistics across the ESG ratings. We observe in Panel A that the average annual fund flow is consistently negative during the sample period. In Panel B, while the funds in each ESG category experience net outflows, we observe that Globe 1 funds significantly outperform those in the low-risk category by a 0.34 % per month margin, possibly reflecting the compensation investors place on high ESG-risk funds. On the other hand, we find no significant difference in fund flows between the high and low-risk funds.

Table 2 provides further details about fund characteristics for the whole sample (Panel A) and Globe 5 and Globe 1 funds (Panels B and C, respectively). On average, we observe net outflows in all panels, suggesting that funds in Australasia on average had investor outflows during the sample period. While Globe 1 funds (high ESG risk) outperform Globe 5 funds (low ESG risk) based on raw returns, the opposite holds when we adjust fund returns for risk based on the four-factor model of Carhart (1997). This could be as the more sustainable a fund is, the less prone the fund becomes to market-wide risks in the long run. This is further supported by the lower return volatility experienced by Globe 5 funds (5.927 %) compared to Globe 1 funds (6.391 %), along with lower idiosyncratic volatility. Further categorizing the funds based on their domestic and international focus, i.e., whether they primarily invest in domestic or foreign securities, we observe in Table A1 in the Appendix that international funds, on average, experience outflows to a lesser extent, while these funds outperform their domestic counterparts on a risk-adjusted basis. At the same time, domestic funds are more volatile and smaller in size. Finally, the pairwise correlations presented in Panel F in Table A1 show a positive correlation between risk-adjusted returns and fund flows, while flows are negatively correlated with fund age, volatility, and idiosyncratic volatility.

2.2. *Measuring climate risk*

To examine the role of climate risk in the fund flow-performance relationship across the ESG-rated funds in our sample, we construct measures of physical and transition climate risk for Australasia.[5] Following the approach adopted by Bua, Kapp, Ramella, and Rognone (2024), we perform a detailed textual analysis of an extensive list of news articles from *The Australian and The New Zealand Herald* associated with the region for the 2018–2022 period, as *these newspapers* are popular sources of news for the finance industry to update investment decisions.[6] To this end, we adopt the physical and transition climate risk-weighted vocabularies of Bua et al. (2024), which are constructed based on a list of authoritative and scientific texts on climate change published by governmental

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[4] It is noteworthy that Morningstar provides the data in US dollars, so we use fund returns and fund size (total net assets) denominated in US dollars for all the funds in our analyses. The rationale to use USD-denominated data is as follows: 1) Morningstar converts the fund returns and fund size (or net assets) from local currency to the US dollar using the unhedged existing exchange rate as on the fund reporting date. This conversion ensures the comparability of funds across multiple economies (Australia and New Zealand). 2) A significant portion of managed funds in Australia and New Zealand invest in overseas assets that are denominated in local currency. For example, an average fund in Australia and New Zealand holds about 15 %–22 % and 40 % respectively in overseas assets (see Ali et al., 2022) 3) Several previous multi-country studies use common currency-denominated values as opposed to local currency (for example, Renneboog et al., 2011 use Euros for comparability across funds in different countries, similarly, Caglayan and Ulutas, 2014 use USD denominated values for emerging market hedge funds).

[5] The Intergovernmental Panel on Climate Change (IPCC)'s sixth Assessment Report (Reisinger, Howden, Vera, et al., 2020) defines physical climate risk as those risks resulting from dynamic interactions between climate-related hazards, either acute like floods or chronic like sea level rise, with the exposure and vulnerability of the affected elements, e.g., societies or ecological systems, to the hazards. Transition risks are instead defined as risks associated with transitioning to a low-carbon economy that can entail policy, technology, and market changes to combat climate change.

[6] Our newspaper selection choice is primarily driven by the volume of readership considerations. As per Statista a popular database that gathers publicly available information, "The Australian" newspaper is the leading newspaper in Australia in 2021–2022, with 3.05 million readerships. Similarly, "The New Zealand Herald is a premier newspaper in New Zealand. We retain English language news with a maximum length of 5000 words sourced from the Factiva database for *The Australian* (all sources) and *The New Zealand Herald* newspapers with a regional focus on Australia and New Zealand. We then apply a one-day novelty filter to remove repetitive news and redundancy in the data.

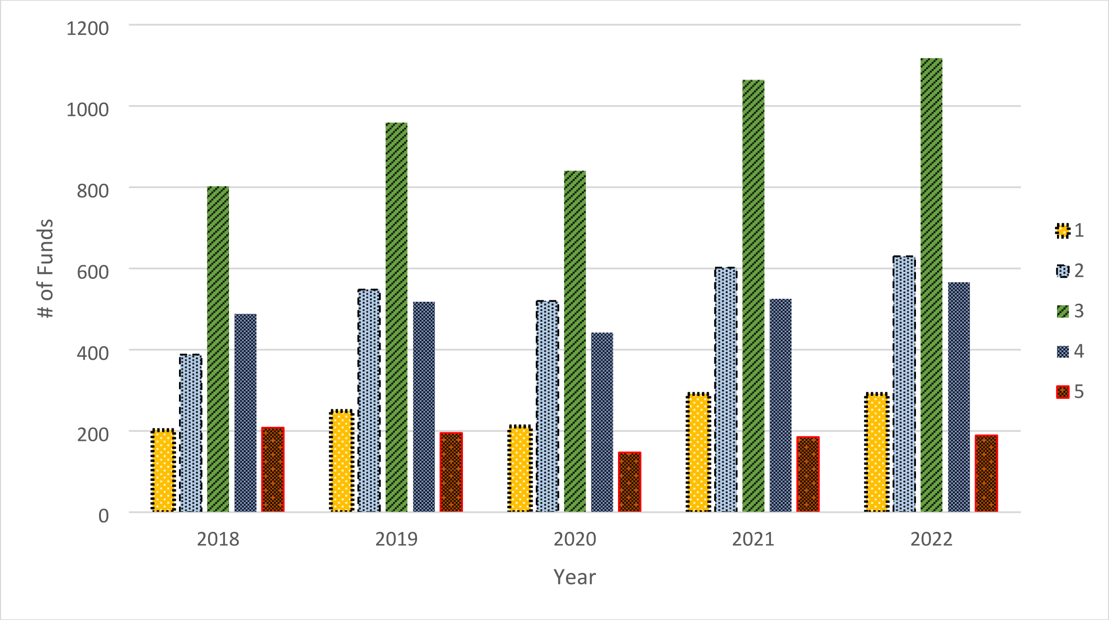

Fig. 1. The distribution of mutual funds across the Morningstar sustainability (ESG) ratings.
The figure presents the distribution of mutual funds in the sample across the five ESG ratings over the period 2018–2022. The sustainability globe ratings represent funds with high ESG risk (Globe 1 or G1), above average risk (G2), average risk (G3), below average risk (G4), and low risk (Globe 5 or G5). As shown in Fig. A1 in the Appendix, a fund with high (low) ESG risk relative to its Morningstar Global Category receives 1 (5) globe.

Table 1
Descriptive statistics for fund performance, fund size, and flows.

Panel A: Fund performance and flows over time

Year	Monthly Raw returns (%) $_{(t)}$	Fund Flow (%) $_{(t)}$	Size (Mn) $_{(t)}$
2018	−2.72	−0.17	168.14
2019	1.73	−0.65	170.21
2020	1.94	−0.52	156.10
2021	0.52	−1.31	212.44
2022	−1.15	−0.93	192.91
All years	0.06	−0.72	179.96

Panel B: Fund performance and flows across the five sustainability ratings

Ratings	Monthly Raw returns (%) $_{(t)}$	Fund Flow (%) $_{(t)}$	Size Mn $_{(t)}$
Globe 1	0.68	−0.63	148.87
G2	0.40	−0.81	179.35
G3	0.50	−0.93	204.93
G4	0.45	−0.66	160.43
Globe 5	0.34	−0.70	172.53
G1 - G5	0.34***	0.08	−23.67**
t-stat	(2.90)	(0.72)	(−2.47)

This table presents the monthly averages of fund performance (raw returns), fund size, and fund flow each year for the full sample (Panel A) and the monthly fund statistics across the five Morningstar sustainability ratings (Panel B). Monthly fund flows (%) are computed based on Franzoni and Schmalz (2017) as $FLOW_{i,c,t} = \frac{TNA_{i,t} - TNA_{i,t-1}\left(1 + R_{i,t}\right)}{TNA_{i,t-1}}\, x\, 100$ where $TNA_{i,t}$ is the total net assets (Size) in USD of fund i at the end of month t, and $R_{i,t}$ is the return of fund i in month t. Panel B presents the average fund performance (monthly raw returns (%) $_{(t)}$), monthly fund flows, and fund size for funds across the five sustainability ratings. The sustainability globe ratings represent funds with high ESG risk (Globe 1 or G1), above average risk (G2), average risk (G3), below average risk (G4), and low risk (Globe 5 or G5). The last column in the panel shows the difference between Globe 1 and Globe 5 funds, along with the corresponding t-statistics in parenthesis. Values for raw returns, size, and fund flow are winsorized at 1 % and 99 %. ***, **, and * indicate statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 2
Descriptive statistics of mutual funds in the sample.

	Mean	Std. Dev.	Min.	p25	Median	p75	Max.
Panel A: Full sample							
FLOW	−0.797***	5.874	−20.986	−1.687	−0.374	0.499	17.51
CH-4 Alpha	0.339***	0.446	−0.639	0.08	0.352	0.615	1.255
Raw returns	0.537***	7.042	−22.38	−2.95	1.11	4.74	17.58
Volatility	5.935***	2.738	2.383	4.014	5.181	7.007	14.449
Fund Size	3.033***	2.415	−2.761	1.327	3.183	4.854	7.786
Fund Age (Months)	5.014***	0.602	3.466	4.691	5.124	5.434	6.035
Idiosyncratic Volatility	2.689***	1.079	1.167	1.911	2.416	3.162	5.548
Size Beta	−0.018***	0.251	−0.663	−0.162	−0.021	0.131	0.594
MKT Beta	0.884***	0.146	0.51	0.807	0.892	0.968	1.259
WML Beta	−0.105***	0.21	−0.555	−0.247	−0.11	0.022	0.442
Panel B: Globe 5							
FLOW	−0.704***	5.992	−20.986	−1.669	−0.402	0.498	19.014
CH-4 Alpha	0.412***	0.448	−0.941	0.175	0.43	0.689	1.407
Raw returns	0.435***	6.962	−20.25	−3.01	0.68	4.45	17.48
Volatility	5.927***	2.584	2.457	4.14	5.264	6.975	13.722
Fund Size	3.098***	2.194	−1.433	1.411	3.263	4.886	8.398
Fund Age (Months)	4.952***	0.642	3.434	4.543	5.112	5.425	6.061
Idiosyncratic Volatility	2.881***	1.135	1.179	2.117	2.597	3.289	6.137
Size Beta	0.158***	0.263	−0.638	0.014	0.19	0.32	0.718
MKT Beta	0.911***	0.15	0.561	0.827	0.91	1.006	1.206
WML Beta	−0.104***	0.241	−0.59	−0.267	−0.129	0.044	0.498
Panel C: Globe 1							
FLOW	−0.626***	5.656	−20.986	−1.595	−0.31	0.621	17.422
CH-4 Alpha	0.32***	0.454	−0.599	−0.024	0.298	0.671	1.298
Raw returns	0.619***	7.845	−34.53	−2.95	1.04	4.87	19.78
Volatility	6.391***	3.608	2.219	3.86	5.112	7.597	16.15
Fund Size	3.016***	2.535	−4.491	1.718	3.397	4.738	7.737
Fund Age (Months)	5.069***	0.597	3.497	4.762	5.176	5.533	5.976
Idiosyncratic Volatility	2.898***	1.07	1.262	2.086	2.633	3.451	5.402
Size Beta	−0.152***	0.268	−0.657	−0.351	−0.157	0.019	0.521
MKT Beta	0.799***	0.127	0.522	0.717	0.807	0.877	1.074
WML Beta	−0.064***	0.261	−0.598	−0.257	−0.09	0.101	0.536

Panels A, B and C present the summary statistics of the mutual fund characteristics for the whole sample, low-risk and high-risk funds, respectively. Fund performance is measured by four-factor (CH-4) alphas. Fund flows are based on Franzoni and Schmalz (2017). Fund Size is log(assets). Fund Age is the total number of months in a fund's existence. Idiosyncratic volatility is computed relative to the benchmark Fama and French (2015) 5-factor model via rolling regressions as per Ang et al. (2006). Size, MKT, and WML betas are coefficients obtained through 36-month rolling regressions of the Fama and French (2015) 5-factor model on raw fund returns that capture the fund investment styles tilted towards size, market, and momentum portfolios, respectively. A fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively. Values for raw returns, size, and fund flow are winsorized at 1 % and 99 %.

authorities and other institutions.[7] Specifically, Bua et al. (2024) construct two distinct climate risk vocabularies, with each term associated with a term-frequency inverse-document-frequency score as a measure of term relevance. The physical risk vocabulary encompasses various dimensions of physical risks, including extreme and chronic hazards resulting from climate change. In contrast, the transition risk vocabulary covers different facets of climate risk, such as technological advancements and environmental policies. Terms like 'ecosystems,' 'sea level rise,' and 'precipitation' are indicative of physical risk, whereas terms like 'hydrofluorocarbon', 'bioenergy,' and 'greenhouse gas' are indicative of transition risk.[8] Next, we employ the cosine-similarity approach, employed by Engle, Giglio, Kelly, Lee, and Stroebel (2020) and Bua et al. (2024), to compare the climate risk vocabularies with the corpus of daily news associated with Australasia and generate physical and transition concern series representing the percentage of news coverage dedicated to each type of risk. Finally, we estimate an autoregressive model of order 1 (AR1) and use the residuals from the model to construct the Physical Risk Index (PRI) and the Transition Risk Index (TRI) that represent the two aspects of climate risk. To get the monthly TRI and PRI series, we consider the shocks to the average monthly transition and physical concern time series, respectively.

Figs. 2 and 3 present the time series plots for the climate risk series constructed over the 2018–2022 period. Specifically, the figures show the daily physical and transition media concerns generated by the textual analysis of news articles and a selection of the most relevant PRI and TRI topics (Panel A), the corresponding monthly transition and physical concern time series (Panel B), and the monthly PRI and TRI (Panels C). Table A2 in the Appendix summarises the AR (1) estimates from the monthly concern time series

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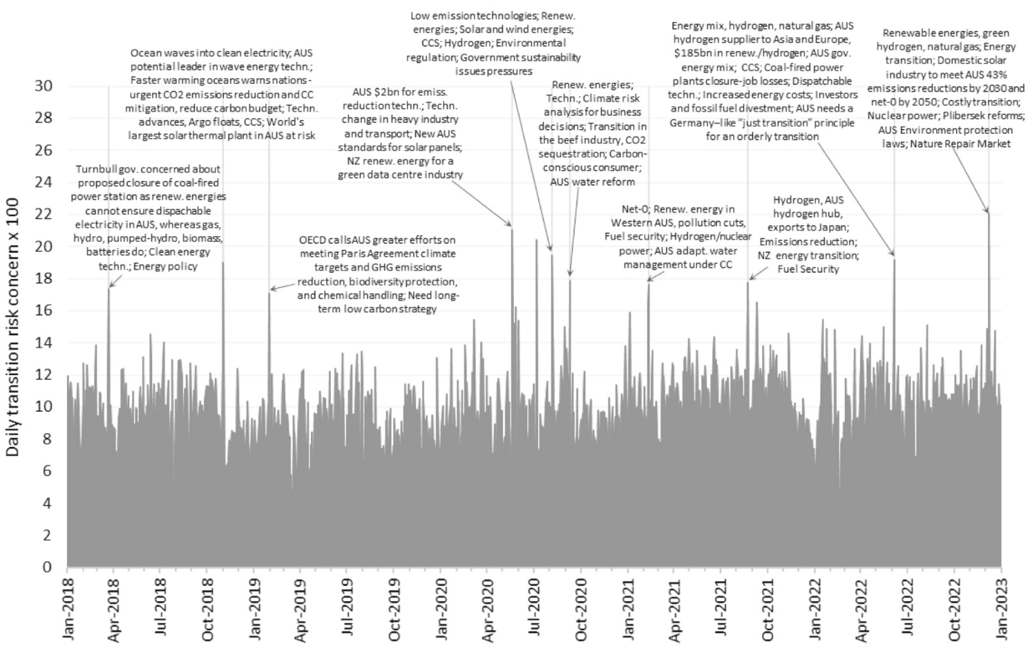
[7] The climate risk-weighted vocabularies of Bua et al. (2024) can be downloaded from the Economic Policy Uncertainty website.

[8] For more details on the vocabulary selection and explanation, please see Bua et al. (2024).

Panel A: Daily transition climate risk



Turnbull gov. concerned about proposed closure of coal-fired power station as renew. energies cannot ensure dispachable electricity in AUS, whereas gas, hydro, pumped-hydro, biomass, batteries do; Clean energy techn.; Energy policy

Ocean waves into clean electricity; AUS potential leader in wave energy techn.; Faster warming oceans warns nations - urgent CO2 emissions reduction and CC mitigation, reduce carbon budget; Techn. advances, Argo floats, CCS; World's largest solar thermal plant in AUS at risk

OECD calls AUS greater efforts on meeting Paris Agreement climate targets and GHG emissions reduction, biodiversity protection, and chemical handling; Need long-term low carbon strategy

AUS $2bn for emiss. reduction techn.; Techn. change in heavy industry and transport; New AUS standards for solar panels; NZ renew. energy for a green data centre industry

Low emission technologies; Renew. energies; Solar and wind energies; CCS; Hydrogen; Environmental regulation; Government sustainabilty issues pressures

Renew. energies; Techn.; Climate risk analysis for business decisions; Transition in the beef industry, CO2 sequestration; Carbon-conscious consumer; AUS water reform

Net-0; Renew. energy in Western AUS, pollution cuts, Fuel security; Hydrogen/nuclear power; AUS adapt. water management under CC

Energy mix, hydrogen, natural gas; AUS hydrogen supplier to Asia and Europe, $185bn in renew./hydrogen; AUS gov. energy mix; CCS; Coal-fired power plants closure-job losses; Dispatchable techn.; Increased energy costs; Investors and fossil fuel divestment; AUS needs a Germany–like “just transition” principle for an orderly transition

Hydrogen, AUS hydrogen hub, exports to Japan; Emissions reduction; NZ energy transition; Fuel Security

Renewable energies, green hydrogen, natural gas; Energy transition; Domestic solar industry to meet AUS 43% emissions reductions by 2030 and net-0 by 2050; Costly transition; Nuclear power; Plibersek reforms; AUS Environment protection laws; Nature Repair Market

Panel B: Monthly transition risk concern

Panel C: Monthly transition risk index (TRI)

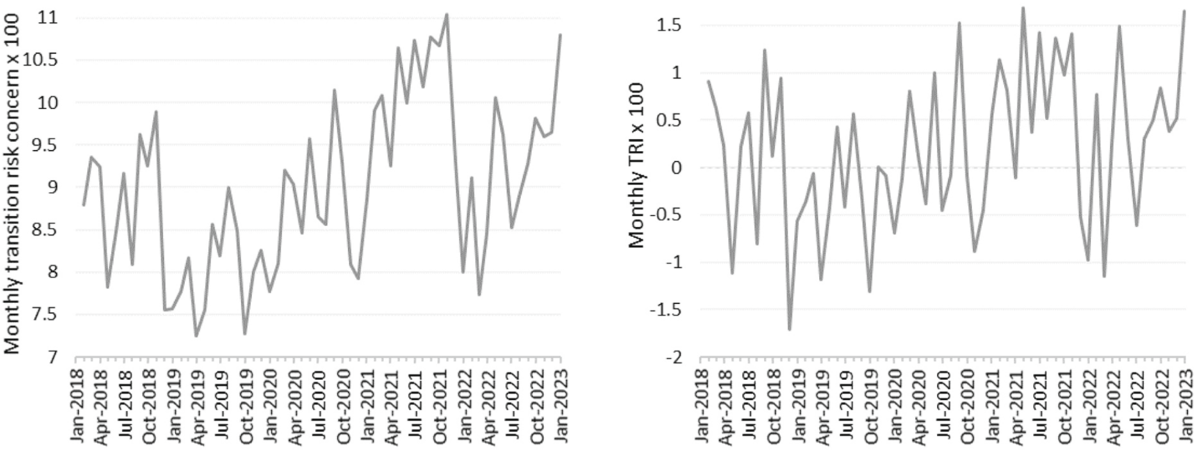


Fig. 2. Transition climate risk 2018–2022.

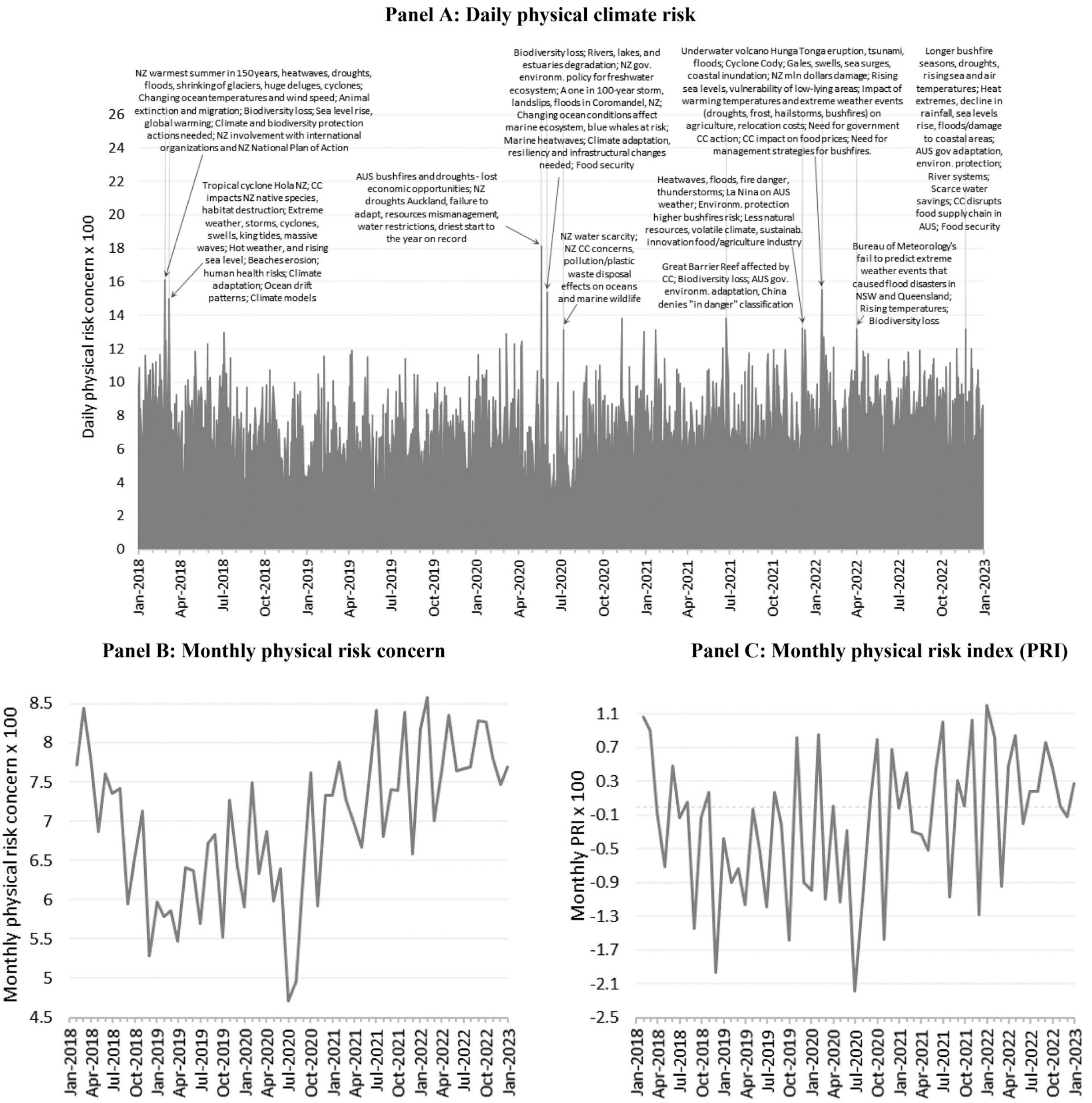
This figure presents daily transition risk concern (Panel A) and major risk shock topics (vertical bars), monthly transition concern (Panel B), and TRI (Panel C) time series from January 2018 to December 2022. *The Australian* and *The New Zealand Herald* news with an Australasia focus. “CC” is an acronym for “climate change”.

models formulated as

$$Concern_{t,PR} = c_{PR} + \phi_{PR} Concern_{t-1,PR} + \varepsilon t, PRI \tag{1a}$$

$$Concern_{t,TR} = c_{TR} + \phi_{TR} Concern_{t-1,TR} + \varepsilon t, TRI \tag{1b}$$

where *Concern* is the daily physical and transition media concerns representing the percentage of news coverage dedicated to each type of risk, c is the drift parameter, ϕ is the autoregressive coefficient, and $\varepsilon t, PRI$ and $\varepsilon t, TRI$ are the residuals. Consistent with Bua et al. (2024), both physical risk and transition risk concerns have a positive drift suggesting a rise in the news coverage of these topics over time, with the transition risk coverage being higher and more persistent than that of physical risk ($c_{TR} > c_{PR}$ and $\phi_{TR} > \phi_{PR}$). Further performing the commonality test of Dang, Moshirian, and Zhang (2015), we find that 80.5 % of the total information embedded in PRI and TRI is accounted for by individual information, implying that our procedure can capture the distinction between physical and


Panel A: Daily physical climate risk

NZ warmest summer in 150years, heatwaves, droughts, floods, shrinking of glaciers, huge deluges, cyclones; Changing ocean temperatures and wind speed; Animal extinction and migration; Biodiversity loss; Sea level rise, global warming; Climate and biodiversity protection actions needed; NZ involvement with international organizations and NZ National Plan of Action

Tropical cyclone Hola NZ; CC impacts NZ native species, habitat destruction; Extreme weather, storms, cyclones, swells, king tides, massive waves; Hot weather, and rising sea level; Beaches erosion; human health risks; Climate adaptation; Ocean drift patterns; Climate models

AUS bushfires and droughts - lost economic opportunities; NZ droughts Auckland, failure to adapt, resources mismanagement, water restrictions, driest start to the year on record

Biodiversity loss; Rivers, lakes, and estuaries degradation; NZ gov. environm. policy for freshwater ecosystem; A one in 100-year storm, landslips, floods in Coromandel, NZ; Changing ocean conditions affect marine ecosystem, blue whales at risk; Marine heatwaves; Climate adaptation, resiliency and infrastructural changes needed; Food security

NZ water scarcity; NZ CC concerns, pollution/plastic waste disposal effects on oceans and marine wildlife

Heatwaves, floods, fire danger, thunderstorms; La Nina on AUS weather; Environm. protection higher bushfires risk; Less natural resources, volatile climate, sustainab. innovation food/agriculture industry

Great Barrier Reef affected by CC; Biodiversity loss; AUS gov. environm. adaptation, China denies "in danger" classification

Underwater volcano Hunga Tonga eruption, tsunami, floods; Cyclone Cody; Gales, swells, sea surges, coastal inundation; NZ mln dollars damage; Rising sea levels, vulnerability of low-lying areas; Impact of warming temperatures and extreme weather events (droughts, frost, hailstorms, bushfires) on agriculture, relocation costs; Need for government CC action; CC impact on food prices; Need for management strategies for bushfires.

Bureau of Meteorology's fail to predict extreme weather events that caused flood disasters in NSW and Queensland; Rising temperatures; Biodiversity loss

Longer bushfire seasons, droughts, rising sea and air temperatures; Heat extremes, decline in rainfall, sea levels rise, floods/damage to coastal areas; AUS gov adaptation, environ. protection; River systems; Scarce water savings; CC disrupts food supply chain in AUS; Food security

Panel B: Monthly physical risk concern

Panel C: Monthly physical risk index (PRI)

Fig. 3. Physical climate risk 2018–2022.

This figure presents daily physical risk concerns (Panel A) and major risk shock topics (vertical bars), monthly physical concerns (Panel B), and PRI (Panel C) time series from January 2018 to December 2022. *The Australian and The New Zealand Herald* news with an Australasia focus. "CC" is an acronym for "climate change".

transition risks associated with climate concerns.

The visual observation of Figs. 2 and 3 provides several clues about some of the notable events that result in spikes in our climate risk index series. For example, examining the transition climate risk series in Fig. 2, we observe the largest shock for TRI is recorded on 08/12/2022, following the release of news concerning the use of renewable energies, like wind and solar, and green hydrogen to support the energy transition, as well as talks about the Australian emissions reduction goals along with the discussion on the application of environmental policies, like the Australian Nature Repair Market Regulation. In contrast, the peak for the physical climate risk index in Fig. 3 is observed on 20/05/2020, primarily as a result of the discussions on an extreme drought hitting Auckland, New Zealand, highlighting the risks of water scarcity. Other PRI peaks relate to the eruption of the underwater Hunga Tonga, cyclone Cody, and other weather events and consequences of physical hazards. These notable spikes are further identified in Tables A3 and A4 in the Appendix, where we provide a summary of the top ten days with the highest physical and transition risk shocks over the period

January 2018 to December 2022.

We observe that high climate shock days encompass a range of physical and transition risk topics. While the PRI series captures various acute physical risks such as floods, tsunamis, cyclones, extreme weather events and chronic risks like rising sea temperatures, droughts, and sea level rise, it is also able to detect news about climate adaptation calls and adverse impacts on ecosystems, such as a loss of biodiversity. It must be noted that this feature of our physical climate risk index distinguishes it from other physical risk databases that primarily associate physical risks with extreme weather events only.[9] In contrast, we see that transition risk spikes with news on regulations and measures to reduce GHG emissions. This includes the development of Australia's effort to meet the climate targets set by the Paris Agreement. Furthermore, news on the costs associated with the transition or advancements in technological innovation and renewable energies to achieve net-zero emissions balance also contributes to high TRI values. Overall, our climate risk series successfully captures various aspects of uncertainty that can be attributed to climate concerns, both from the physical and transitionary or regulatory perspectives.

2.3. Fund flow-performance relationship

To construct the monthly net fund flow series for each fund in the sample, we follow the methodology proposed by Chevalier and Ellison (1997), Sirri and Tufano (1998), Franzoni and Schmalz (2017), among others. Let $TNA_{i,t}$ be the total net assets (in USD) of fund i at the end of month t. Fund flow for fund i in month t is then computed as

$$FLOW_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1}\left(1 + R_{i,t}\right)}{TNA_{i,t-1}} \tag{2}$$

where and $R_{i,t}$ is the return of fund i in month t. Similarly, following the literature, we measure fund performance using the risk-adjusted returns, computed as the Carhart (1997) four-factor alpha, by estimating $R_{i,c,t} - \beta_i^{mkt} MKT_m + \beta_i^{smb} SMB_m + \beta_i^{hml} HML_m + \beta_i^{mom} MOM_m$ where $R_{i,c,t}$ is the fund's raw return.[10] The model is estimated using a 36-month rolling window regression for each fund and if fewer than 36 monthly return observations are available, we use a 24-month window instead. To calculate the alphas, we adopt a region-based approach to risk adjustment similar to Bekaert, Hodrick, and Zhang (2009) and Ferreira, Keswani, Miguel, and Ramos (2012). Additionally, Hollstein (2022) argues that regional factor models capture substantially larger average absolute alphas than local factor models, implying that regional risk factors can appropriately capture the alphas as opposed to country-specific risk factors, we estimate the fund alphas using the risk factors for Australasia, obtained from Kenneth French's data library based on Fama and French (2012).[11]

The benchmark model to test the fund flow-performance relationship is formulated as

$$FLOW_{i,t} = b_1 PERF_{i,t-1} + b_2 PERF\_Squared_{i,t-1} + CONTROLS_{i,t} + u_i + v_t + e_{i,t} \tag{3}$$

where $FLOW_{i,t}$ is the new money growth for fund i in month t and fund performance, $PERF$, is measured by the four-factor (CH-4) alphas as explained earlier. Note that u_i and v_t in the model capture the fund and time fixed effects, respectively, to ensure the results are not driven by fund characteristics or time trends; the standard errors are also double clustered by fund and time. Given that our sample includes mutual funds from Australia and New Zealand, we also include a country dummy in the model to account for country-fixed effects. However, for the simplicity of exposition, we exclude the country subscript in our formulas. This model tests the effect of past performance on subsequent fund flows where a positive and significant b_1 value indicates that investors use past performance as a signal for future performance, thus leading to a positive (negative) effect on subsequent flows as a result of positive (negative) performance. To understand the singular impact of performance on mutual fund flows we estimate a regression of $PERF$ on fund flow in column (1), and in column (2) we add the square of the performance term ($PERF\_Squared_{i,t-1}$) to account for potential non-linearities in the relationship between past performance, and finally, in column (3), we add other control variables for the full sample. Similarly, we estimate $PERF$ by itself in columns (4) and (6) for Globe 5 and Globe 1 funds. Overall, we find that $PERF$ has a positive and statistically significant coefficient in all the regressions, indicating a positive flow-performance relationship as documented by previous studies.

2.4. The effect of climate uncertainty on fund flow performance sensitivity

To test the fund flow-performance relationship in the context of climate risk, we augment the benchmark model in Eq. 3 to account for the effect of climate risk. Specifically, we employ the following regression specification to test our primary hypothesis that climate risk weakens a fund's flow-performance sensitivity and estimate.

$$FLOW_{i,t} = \gamma_1 PERF_{i,t-1} + \gamma_2 (CRI_t) + \gamma_3 PERF_{i,t-1} \text{x } CRI_t + \gamma_4 PERF\_Squared_{i,t-1} + CONTROLS_{i,t} + U_i + \vartheta_t + \varepsilon_{i,t} \tag{4}$$

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[9] Compared to the European PRI developed by Bua et al. (2024), our Asia-Pacific PRI captures additional types of physical hazards that are more typical of Australasia, such as tsunamis and cyclones.

[10] It must be noted that the flow-performance relationship remains consistent when we use market-adjusted fund returns and CAPM-alphas (additional results are available upon request).

[11] Ken French's data library: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html#International. Our inferences and statistical significance remain unchanged when we use local risk factors for Australia and New Zealand.

where $FLOW_{i,t}$ is the new money growth for fund i in month t, $PERF_{i,t-1}$ is the four-factor (CH-4) alpha for the fund and CRI_t is the climate risk index captured either by the Transition Risk Index (TRI) or Physical Risk Index (PRI) described earlier. In this formulation, a significant γ_2 captures the marginal effect of climate risk on fund flows, while γ_3 is used to test whether climate risk has any impact on the predictive power of past performance on subsequent flows. It can be argued that investors facing greater uncertainty regarding the economic implications of climate change on their investments will be more likely to entrust their funds to professional money managers who are deemed to be more informed traders, which in turn would lead to a positive and significant γ_2 estimate in the model. However, one can also argue that the sign of the γ_2 estimate would also depend on the nature of climate risk with respect to the regulatory or actual physical impacts of climate risk, so therefore, one must interpret the results according to the nature of the climate risk in focus.

From the perspective of the interrelationship between climate risk and the predictive power of past returns over subsequent fund flows, a negative and significant estimate for γ_3 would indicate that the funds' flow-performance sensitivities decrease when investors face greater uncertainty regarding climate change. This would then indicate that the higher climate risk described in Section 2.2 hurts the informative role of past performance regarding future fund performance, thus weakening the signals for the predictability of future flows. To further enrich the insights from our analysis and given the recent evidence in Faccini, Matin, and Skiadopoulos (2023) that the political/regulatory implications of climate change are a dominant driver of stock returns compared to physical climate risk, we utilize our physical and transitional climate risk measures in separate models to distinguish between the effect of each type of climate risk on the sensitivity of fund flows to past performance. In that regard, an alternative argument is that greater uncertainty regarding the regulatory implications of climate change, such as changing tax regulations or limits on carbon emissions, will enhance the informational value of past performance as a predictor of subsequent flows to a fund as investors who face greater risk regarding the impact of climate change in their investments will place greater value on the past performance of a fund as an indicator of managerial skill when making investment decisions. Finally, the model includes the fund and time fixed effects captured by u_i and v_t, respectively, to ensure the results are not driven by fund characteristics or time trends; the standard errors are also double clustered by fund and time.

In addition to including the fund, country, and time-fixed effects in all our regressions to account for the unobserved heterogeneity, we also include several control variables that have been shown to explain fund flows and their sensitivity to performance in the literature. Given the evidence that larger funds are expected to attract more flows (e.g., Barber, Odean, & Zheng, 2005; Chevalier & Ellison, 1997; Sirri & Tufano, 1998), we include log [$\text{Assets}_{(t-1)}$] as a fund-level control variable. Likewise, following the argument in the literature that flow sensitivity to performance should be weaker for funds with longer track records, i.e., older funds, we also control for fund age as a determinant of flows by including log (Fund Age) in the model. As mentioned earlier, we also include the squared measure of performance (PERF-Squared) in the model to account for the convex flow-performance relationship as it is found in the literature that flows respond asymmetrically to positive and negative performance. Following the evidence in the literature that returns volatility weakens the flow performance sensitivity (Huang et al., 2022), another control variable included in the model is returns volatility (Volatility), calculated as the time-series standard deviation of the fund's monthly returns over months t-*1* to t-*11*. Finally, following a number of papers including Renneboog et al. (2011), Ferreira et al. (2012), among others, to account for the mutual fund investment style in our tests, we include the Size (Size Beta), Market (MKT Beta) and Momentum (WML Beta) betas obtained by estimating 36- month rolling regressions of the Fama and French (2015) 5-factor model on raw fund returns. Note that the explanatory variables with subscript (*t-1*) are lagged by one month.

3. Empirical results

3.1. Fund flow-performance relationship

Table 3 presents the results for the benchmark model in Eq. 3 to test the effect of fund performance (in addition to several fund-level controls) on monthly fund flows. In line with the literature, fund performance is measured by four-factor (CH-4) alphas, and fund flows are based on Franzoni and Schmalz (2017). We report the findings for all funds in the sample and for Morningstar's Globe 1 and Globe 5 funds. As noted earlier, a fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe.

The results for all funds in the sample confirm the positive relationship between fund flows and past performance, indicating that fund flows respond positively to past performance, thus leading to money inflows to the funds. We find that every 1 % increase in the past performance of a fund predicts a 0.659 % inflow. This suggests that investors use past performance of a fund as a signal for managerial skills, which in turn, leads to a positive predictive relationship with subsequent fund flows. Interestingly, however, when we examine the results for funds with high (Globe 5) and low (Globe 1) ESG ratings, we find that the response of fund flows to past performance is stronger for Globe 5 (i.e., low ESG risk), with every 1 % increase in past performance predicting a 1.175 % rise in money inflows into the funds. In contrast, we observe relatively weaker flow-performance sensitivity in the case of Globe 1 (i.e., high ESG risk) with a b_1 estimate of 0.750, suggesting that investors' learning regarding the managerial ability to deliver in the future is relatively stronger for funds that have relatively stronger sustainability ratings. This finding is indeed in line with the multi-objective utility function proposed by Pedersen et al. (2021) that ESG scores play a dual role as they not only provide valuable information regarding firm fundamentals but also affect investors' preferences, consistent with the models of Berk and Green (2004) and Huang et al. (2022) where rational investors use past returns as a signal to form their posterior expectations about the ability of a fund manager.

Examining the fund-level control variables used in the model, while fund size is negatively related to flows across all ESG rating categories, implying that larger funds tend to experience relatively lower money flows, we find that fund age is positively related to

Table 3
Mutual fund flows and performance.

Dependent variable		Fund Flow$_{(t)}$					
Perf:		CH4- Alpha					
		All Funds		Globe 5		Globe 1	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PERF $_{(t-1)}$	0.756***	0.774***	0.659***	1.811***	1.175***	1.541***	0.750*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.094)
		0.138***	0.129***		0.052		−0.095
PERF-Squared $_{(t-1)}$		(0.000)	(0.000)		(0.872)		(0.808)
			−0.007		−0.015		−0.174***
Volatility $_{(t-1)}$			(0.714)		(0.851)		(0.001)
			−0.759***		−1.052***		−1.477***
log (Assets) $_{(t-1)}$			(0.000)		(0.000)		(0.000)
			0.547*		8.660***		2.951**
log (Fund Age) $_{(t-1)}$			(0.094)		(0.000)		(0.015)
			2.084***		3.431***		3.752***
Size Beta $_{(t-1)}$			(0.000)		(0.000)		(0.000)
			−1.506***		−4.183***		0.315
MKT Beta $_{(t-1)}$			(0.000)		(0.002)		(0.820)
			1.767***		2.292***		2.956***
WML Beta $_{(t-1)}$			(0.000)		(0.002)		(0.000)
	0.391**	0.345**	1.683	0.714	−33.669***	0.379	−8.022
Intercept	(0.299)	(0.078)	(0.292)	(0.81)	(0.000)	(0.998)	(0.182)
N	59,770			4921		7071	
Adj. R-Squared	0.17	0.18	0.183	0.200	0.214	0.19	0.21
Country Fund and Time FE	Yes						

The table presents the results for Eq. 3, which tests the effect of fund performance (in addition to several fund-level controls) on monthly fund flows. Fund performance is measured by four-factor (CH-4) alphas. Fund flows are based on Franzoni and Schmalz (2017). The explanatory variables with subscript (t-1) are lagged by one month. Low, Medium, and High-risk funds are based on the sustainability ratings published by the Morningstar database. A fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe. All models include country, fund, and time fixed effects. The robust p-values are reported in parentheses. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively. Values for raw returns and fund flow are winsorized at 1 % and 99 %.

flows, suggesting that funds with longer histories tend to enjoy greater money flows as the older the fund, the more investors know about the manager's track record, thus providing valuable information for investors in their decision making to allocate their capital to these funds. At the same time, return volatility seems to be insignificant for subsequent flow dynamics, although we observe a negative and significant volatility effect on flows for Globe 1 funds, possibly as investors view higher ESG risk coupled with greater volatility in their past performance as a negative indicator of future performance, which in turn, negatively affects flows into these funds. Finally, further examining the coefficient of performance squared, we find a positive and statistically significant value for all funds (0.129), implying the presence of an asymmetric response of fund flows to past performance such that flows respond asymmetrically to good and poor past performance i.e., there is more inflow of money than outflow of money to the funds. This is consistent with the previous literature (see e.g., Busse, 2001; Chevalier & Ellison, 1997; Del Guercio & Tkac, 2002; Sirri & Tufano, 1998). Overall, the benchmark model on the fund flow-performance relationship confirms the positive association between flows and performance, while we observe some heterogeneity in the sensitivity of funds based on their ESG ratings.

3.2. The effect of climate risk on the fund flow-performance sensitivity

As explained earlier, one of the contributions of our analysis is that we examine the interrelations between climate risk, ESG ratings, and the predictive power of past fund performance on flows to mutual funds. To that end, motivated by the evidence in the climate finance literature (e.g. Bua et al., 2024; Cepni, Demirer, Pham, & Rognone, 2023; Faccini et al., 2023), we consider two types of climate risk captured by the transitional risk index (TRI) and physical risk index (PRI) described in Section 2.2. The effect of climate risk on the fund flow performance sensitivity is then examined via Eq. 4. Panels A and B in Table 4 present the results for transition and physical climate risks, respectively. Once again, we perform separate analyses for all funds in the sample as well as funds in Globe 5 and Globe 1.

Here, too, we fund the positive flow-performance relationship consistently in each panel in Table 4, suggesting that flows respond positively to past performance, indicated by the positive coefficient for *PERF*. Interestingly, however, we also observe that fund flows respond asymmetrically to climate risk depending on the nature of the risk. For example, the coefficients for *Climate Risk* (CRI) are positive (negative) for transition (physical) climate risk on fund flows in Panels A and B, respectively. Considering that transition climate risk captures the uncertainty faced by corporations, institutions, or sectors associated with the operational or regulatory changes driven by climate change (Cepni et al., 2023), the finding that flows respond positively to higher transition uncertainty could be explained by the fact that news related to climate transition could be considered good news for long-term sustainability. Therefore, fund investors react positively to such climate regulatory-related news.

In contrast, physical climate risks materialize in a physical form wherein either extreme weather events or climate chronic hazards

Table 4

Climate risks and fund-flow-performance relationship.

	Panel A: Transitional climate risk index (**TRI**)			**Panel B:** Physical climate risk index (**PRI**)		
	All Funds	Globe 5	Globe 1	All Funds	Globe 5	Globe 1
PERF $_{(t-1)}$	0.628***	0.937**	0.802*	0.706***	1.277***	0.815*
	(0.000)	(0.027)	(0.074)	(0.000)	(0.002)	(0.070)
Climate Risk (CRI)	2.116***	4.152***	2.278***	−3.185***	−6.514***	−3.640***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
PERF $_{(t-1)}$ x Climate Risk	0.19**	0.74***	−0.47*	0.257***	0.674***	0.382
	(0.013)	(0.004)	(0.096)	(0.000)	(0.007)	(0.118)
PERF-Squared $_{(t-1)}$	0.117***	0.111	−0.057	0.122***	0.040	−0.134
	(0.000)	(0.733)	(0.885)	(0.000)	(0.903)	(0.732)
Volatility $_{(t-1)}$	−0.007	−0.015	−0.177***	−0.008	−0.010	−0.176***
	(0.734)	(0.848)	(0.001)	(0.694)	(0.899)	(0.001)
log (Assets) $_{(t-1)}$	−0.761***	−1.103***	−1.469***	−0.766***	−1.113***	−1.488***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log (Fund Age) $_{(t-1)}$	0.544*	8.883***	2.975**	0.551*	8.836***	2.982**
	(0.096)	(0.000)	(0.015)	(0.092)	(0.000)	(0.014)
Size Beta $_{(t-1)}$	2.085***	3.402***	3.751***	2.093***	3.508***	3.800***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
MKT Beta $_{(t-1)}$	−1.505***	−4.114***	0.356	−1.536***	−4.409***	0.217
	(0.000)	(0.003)	(0.797)	(0.000)	(0.001)	(0.876)
WML Beta $_{(t-1)}$	1.741***	2.247***	3.037***	1.709***	2.278***	2.800***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.002)	(0.000)
Intercept	−17.98***	−73.43***	−29.21***	−2.159	−41.854***	−12.475*
	(0.000)	(0.000)	(0.002)	(0.208)	(0.000)	(0.055)
N	59,770	4921	7071	59,770	4921	7071
R-Squared	0.183	0.215	0.209	0.183	0.215	0.209
Country, Fund and Time FE	Yes					

Panels A (B) present the results for Eq. 4, which tests the effect of transition (physical) climate risks and fund performance (in addition to several fund-level controls) on monthly fund flows. Climate risks (CRI) are captured by the transitional risk index (TRI) and physical risk index (PRI) described in Section 2.2 and reported in Panels A and B, respectively. Fund performance is measured by four-factor (CH-4) alphas. Fund flows are based on Franzoni and Schmalz (2017). The explanatory variables with subscript (t-1) are lagged by one month. A fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe. All models include country and time-fixed effects. The robust *p*-values are reported in parentheses. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively. Values for raw returns and fund flow are winsorized at 1 % and 99 %.

incur financial losses for the economy and society (Bua et al., 2024; Cepni, Demirer, & Rognone, 2022). So, the negative effect of physical climate risk on fund flows could be explained as such news is considered bad news, prompting investors to react negatively and move their money to safe-haven assets such as gold during periods of high physical climate uncertainties as investors move their investments out of risky equities during such periods of observable, physical stress conditions. Interestingly, however, comparing the results for funds with high and low sustainability ratings, we find that Globe 5 funds have the greatest sensitivity in their flows to climate risks. This suggests that the sustainability rating of a fund is a significant determinant of the sensitivity of fund flows to climate risks, which reflects the informational value of sustainability ratings from the perspective of investors.

In Table 4, we further augment the flow-performance relationship through the interaction between a fund's past performance and climate risk, $PERF_{(t-1)}$x CRI. We find that the interaction term is positive and significant for the entire sample of funds, consistently for both the transition and physical climate risk proxies. This suggests that higher climate uncertainty, irrespective of its nature, makes fund flows more sensitive to past performance. In other words, one can argue that the informational value of past performance over managerial skills becomes more important when investors face greater uncertainty regarding the implications of climate change on the economy. However, we see that the positive effect of the interaction between climate uncertainty and past performance on flows is primarily driven by Globe 5 funds. This suggests that the sustainability rating of a fund complements the performance signal more widely when investors face greater climate uncertainty such that high climate uncertainty drives the greater allocation of capital to more sustainable funds because of favorable past performance. This finding adds an interesting insight to the multi-objective utility function proposed by Pedersen et al. (2021), highlighting the informational value of sustainability ratings in that it implies that investors attribute greater importance to past performance for ESG fund managers during periods of high climate uncertainty. Overall, the results in Table 4 show that the ESG rating of a fund complements the informational value of past performance on fund flows, more so during periods when investors face greater climate risks.

Tables 5a and 5b present the results for Eq. 4 for funds with a domestic and international focus, respectively, in Panels A and B. Table 5a reports the results for transition risk, while Table 5b reports for physical risk. As noted earlier, to classify the funds into international and domestic, we use the fund investment category from Morningstar. The results in Table 5 appear to be consistent with those reported in Table 4; we find that flows respond positively (negatively) to higher transition (physical) climate uncertainty consistently across both the international and domestic-focused funds. Interestingly, we observe that past performance is less of a concern for international-focused funds, implied by the insignificant coefficients for *PERF* in Panel B in both tables. In the case of domestic funds, however, we find that past performance is a strong predictor of flows only for Globe 1 funds. This means that when

Table 5a

Investment focus, climate risk (Transitional) and fund-flow-performance relationship.

	Panel A: Domestic funds			**Panel B:** International funds		
	All Funds	Globe 5	Globe 1	All Funds	Globe 5	Globe 1
PERF $_{(t-1)}$	0.529***	0.715	1.296**	0.010	0.184	1.512
	(0.000)	(0.305)	(0.013)	(0.967)	(0.765)	(0.387)
	2.046***	4.018***	1.402*	2.353***	5.155***	2.327*
Transition Risk (TRI)	(0.000)	(0.000)	(0.054)	(0.000)	(0.000)	(0.065)
	0.026***	0.082**	−0.116***	0.035**	0.069	0.071
PERF $_{(t-1)}$ x TRI	(0.005)	(0.012)	(0.002)	(0.038)	(0.114)	(0.337)
	0.092***	0.720	0.016	0.690***	−0.437	−0.227
PERF-Squared $_{(t-1)}$	(0.001)	(0.142)	(0.971)	(0.000)	(0.377)	(0.873)
	−0.054*	−0.222*	−0.168**	−0.019	0.343*	−1.214***
Volatility $_{(t-1)}$	(0.052)	(0.067)	(0.017)	(0.750)	(0.055)	(0.000)
	−1.047***	−0.831**	−1.118***	−0.479***	−1.297***	−2.128***
log (Assets) $_{(t-1)}$	(0.000)	(0.040)	(0.000)	(0.000)	(0.005)	(0.000)
	1.782***	7.907***	0.866	−1.116**	9.904***	6.544**
log (Fund Age) $_{(t-1)}$	(0.000)	(0.000)	(0.554)	(0.043)	(0.000)	(0.025)
	1.904***	2.229**	2.658***	3.747***	7.229***	6.705***
Size Beta $_{(t-1)}$	(0.000)	(0.012)	(0.001)	(0.000)	(0.000)	(0.000)
	−1.004**	−3.164	−1.409	−4.722***	−9.970***	7.496*
MKT Beta $_{(t-1)}$	(0.034)	(0.130)	(0.449)	(0.000)	(0.000)	(0.067)
	1.858***	1.863*	2.878***	1.123***	0.945	−0.149
WML Beta $_{(t-1)}$	(0.000)	(0.062)	(0.000)	(0.004)	(0.486)	(0.949)
	−23.11***	−69.72***	−11.61	−10.28**	−81.77***	−42.80**
Intercept	(0.000)	(0.000)	(0.327)	(0.017)	(0.000)	(0.037)
N	38,693	2401	5630	21,077	2520	1441
R-Squared	0.181	0.231	0.172	0.189	0.210	0.272
Country, Fund and Time FE	Yes					

This table presents the results for Eq. 4, which tests the effect of climate risks and fund performance (in addition to several fund-level controls) on monthly fund flows across the international and domestic funds. Panels A and B present the results of domestic and international-focused funds, respectively. To classify the funds into international and domestic, we use the fund investment category from Morningstar. Climate risks are by the transition (TRI) and physical (PRI) risk indexes described in Section 2.2. Tables 5a and 5b present the results based on transition and physical climate risk, respectively. Fund performance is measured by four-factor (CH-4) alphas. Fund flows are based on Franzoni and Schmalz (2017). A fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe. The explanatory variables with subscript (t-1) are lagged by one month. All models include country, fund, and time fixed effects. The robust p-values are reported in parentheses. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively. Values for raw returns and fund flow are winsorized at 1 % and 99 %.

Table 5b

Investment focus, climate risk (Physical) and fund-flow-performance relationship.

	Panel A: Domestic funds			**Panel B:** International funds		
	All Funds	Globe 5	Globe 1	All Funds	Globe 5	Globe 1
PERF $_{(t-1)}$	0.625***	1.054	1.225**	0.150	0.517	1.765
	(0.000)	(0.130)	(0.019)	(0.529)	(0.383)	(0.312)
	−3.089***	−6.526***	−2.532**	−3.569***	−7.859***	−3.447*
Physical Risk (PRI)	(0.000)	(0.000)	(0.017)	(0.000)	(0.000)	(0.063)
	0.274***	0.771**	0.531	0.409**	0.638	0.249
PERF $_{(t-1)}$ x PRI	(0.000)	(0.012)	(0.107)	(0.010)	(0.139)	(0.724)
	0.101***	0.655	−0.267	0.665***	−0.482	−0.345
PERF-Squared $_{(t-1)}$	(0.000)	(0.181)	(0.549)	(0.000)	(0.329)	(0.807)
	−0.053*	−0.214*	−0.169**	−0.020	0.340*	−1.208***
Volatility $_{(t-1)}$	(0.056)	(0.077)	(0.016)	(0.730)	(0.057)	(0.000)
	−1.052***	−0.846**	−1.146***	−0.484***	−1.320***	−2.134***
log (Assets) $_{(t-1)}$	(0.000)	(0.037)	(0.000)	(0.000)	(0.004)	(0.000)
	1.803***	7.912***	0.793	−1.118**	9.778***	6.694**
log (Fund Age) $_{(t-1)}$	(0.000)	(0.000)	(0.589)	(0.043)	(0.000)	(0.022)
	1.898***	2.301***	2.822***	3.794***	7.395***	6.822***
Size Beta $_{(t-1)}$	(0.000)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)
	−1.036**	−3.388	−1.611	−4.831***	−10.383***	7.374*
MKT Beta $_{(t-1)}$	(0.029)	(0.105)	(0.388)	(0.000)	(0.000)	(0.072)
	1.840***	1.857*	2.568***	1.123***	0.961	−0.166
WML Beta $_{(t-1)}$	(0.000)	(0.062)	(0.001)	(0.004)	(0.478)	(0.943)
	−7.866***	−39.378***	−1.133	7.464***	−42.250***	−25.795*
Intercept	(0.000)	(0.000)	(0.890)	(0.008)	(0.000)	(0.057)
N	38,693	2401	5630	21,077	2520	1441
R-Squared	0.181	0.231	0.171	0.189	0.210	0.272
Country, Fund and Time FE	Yes					

investors evaluate funds with poor ESG performance, they place more emphasis on the past performance of these funds as an indicator of managerial skills while past performance becomes less of a concern regarding managerial skills when it comes to funds with superior ESG performance. This finding is indeed consistent with Pedersen et al. (2021), where the authors argue that 'ESG aware' investors assets' ESG ratings to update their views on risk and expected return. It is also consistent with the evidence that environmental and social investments have been quite resilient during the COVID-19 crisis (Albuquerque et al., 2020) and investors remained focused on sustainability even during periods of high uncertainty (Pastor & Vorsatz, 2020; Yousaf et al., 2022).

From Table 5, we also find that the effect of climate uncertainty on the flow-performance relationship is largely restricted to domestic funds rather than their international-focused counterparts. We argue that the enhanced diversification offered by internationally focused funds alleviates the climate-related concerns of investors in their asset allocation strategies. One can also argue that funds with greater international holdings are less sensitive to local climate risks, which in turn, makes climate risk less of a factor when it comes to assessing managerial skills in the context of past performance for these funds. However, for domestic funds (Panel A of Table 5a), we find that the interaction term is positive and significant for Globe 5 funds while the opposite holds for Globe 1 funds. This implies that high climate risk dampens the informational value of past performance, particularly when it comes to funds with poor ESG performances. In contrast, the opposite pattern is observed for Globe 5 funds with a positive interaction term, suggesting that past performance becomes more of an indicator of managerial skills for these funds when faced with high climate uncertainty.

3.3. Robustness checks

To ensure that our results and inferences of the effect of climate risk on the fund flow-performance relationship are robust, we conduct two additional tests. First, we re-estimate our alphas using country-level risk factors rather than regional risk factors obtained from the data library of Jensen, Kelly, and Pedersen (2023).[12] Next, we re-estimated all the regression specifications. We find that using local risk factors does not change the significance and inferences of our main results.

As a second robustness check, we re-estimate our models by replacing the climate risk index used in our tests with an alternative climate risk index (CRI_NW) that is constructed similarly to the original indexes via textual analysis but excludes the news articles published on the weekends. The rationale behind this alternative measure is that excluding the news articles published over the weekend allows us to mitigate possible stale information effects on market prices since timelier public information results in a closer alignment of information sets of traders (Gropp & Kadareja, 2012). Although we do not report these additional tests for brevity, we find that our results have similar signs and significance as our main tests and yield similar inferences.[13]

In our final robustness check, we ensure that our results are not driven by winsorized values since we winsorize the fund returns and fund flows for our main analyses. Although, this approach is standard in the literature (Ferreira, Keswani, Miguel, & Ramos, 2013; Hoepner et al., 2024). However, other previous studies have winsorized the fund flow only rather than other fund-level variables (see, for example, Pastor & Vorsatz, 2020; Ben-Rephael et al., 2012, among others). Therefore, to ensure that our results are not an artifact of winsorization, we re-estimate Tables 3 & 4 with un-winsorized returns but with winsorized fund flow only. Tables A5 and A6 under the appendix report the additional regression results. We find that the signs and significance are similar to those in our main results. Specifically, in Table A5, we find that *PERF* is positive and statistically significant for all the models, suggesting a positive flow-performance relationship. Although the coefficient estimates are slightly smaller in magnitude the inference remains unchanged. In Table A6 too, we find consistent results in Table 4. For example, the interaction term ($PERF_{(t-1)}$ x *CRI*) is positive and significant for the full sample, for both the transition and physical climate risk proxies, with Globe 5 funds having a stronger effect. These additional results suggest that our results are robust and are not affected by winsorization.[14]

3.4. Policy/economic implications

Our results confirm the dual role of sustainability ratings not only as an indicator of the investment principles adopted by the fund manager but also the informational value of past performance as an indicator of managerial skills. In line with the argument by Pedersen et al. (2021), this suggests that ESG-aware investors place significant value on the sustainability rating of a fund not only from a portfolio optimization perspective but also as a performance signal complement.

Furthermore, we show that the nature of climate uncertainty, in terms of transition or physical risk, plays a significant role on the sensitivity of fund flows to past performance such that the response of fund flows to past performance is particularly stronger for sustainable funds. This finding further highlights the informational value of sustainability ratings for a fund, more so during market states when investors are more concerned about climate risk both from physical and regulatory perspectives. Considering that high ESG ratings for a fund indicate greater transparency and information available for investors regarding fund holdings and characteristics, thus alleviating information asymmetries between the investors and fund managers, one can argue that investors feel more confident in using past performance as an indicator of managerial skills for highly rated funds during periods of high climate uncertainty. In contrast, for funds with poor ESG ratings, past performance carries lower value for future performance when investors face greater risks regarding the economic implications of climate change.

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[12] The data for country specific risk factors can be found at https://jkpfactors.com/.

[13] The results for these supplementary tests are available upon request from the authors.

[14] We also observe that the the mean and median fund alphas (winsorized alpha: Mean = 0.34, Median = 0.33 vs non-winsorized alpha: Mean = 0.34, Median = 0.36) are comparable, suggesting that we do not have outliers in our sample.

Overall, we show that climate uncertainty indeed has a significant impact on the informational role of past performance over managerial skills depending on the ESG rating of such funds and the nature of climate risk. Additionally, transition climate risk captures the uncertainty faced by investors regarding the operational and/or regulatory implications of climate change on firms and sectors of the economy, is found to be a more dominant determinant of the fund flow-performance sensitivity of mutual funds, consistent with the evidence in Faccini et al. (2023), who argue that transition climate risk is a dominant driver of stock returns compared to physical climate risk. From a practical perspective, our findings highlight the importance of developing and actively monitoring various aspects of climate risks that affect decision-making by investors. Professional money managers should not only monitor such climate risks to develop market timing strategies in their investments but also strive to alleviate any informational asymmetries that may arise between them and their investors, particularly under high climate stress conditions.

4. Conclusion

Growing concerns about the economic and social implications of climate change have led to a flurry of investments in mutual funds that have adopted responsible investment principles over the past decade. Although the literature has largely focused on the pricing implications of climate risk in financial markets, the role of climate concerns as a determinant of decision-making in the mutual funds industry is relatively understudied. Against this backdrop, we provide two major contributions to the literature by (i) extending the burgeoning literature on climate finance by examining the informational role of mutual fund sustainability ratings on the asset allocation decisions by investors when faced with greater climate uncertainty; and (ii) developing two indexes of physical and transition climate risk for Australasia via textual analysis of an extensive list of news articles using the physical and transition climate risk weighted vocabularies of Bua et al. (2024) and the cosine-similarity approach of Engle et al. (2020).

While our findings confirm the established evidence that fund flows respond positively to past performance, we find that the nature of climate uncertainty (i.e., transition or physical risk), along with the sustainability rating of the fund, play a significant role on the sensitivity of fund flows to past performance. Specifically, we find that the response of fund flows to past performance is particularly stronger for funds that enjoy high sustainability ratings, i.e. Globe 5 funds, suggesting that rational investors use past returns as a signal to form their subsequent expectations about the ability of a fund manager. This supports the argument by Pedersen et al. (2021) that ESG scores play a dual role as they not only provide valuable information regarding firm fundamentals but also affect investors' preferences.

We also show that higher climate risk makes fund flows more sensitive to past performance. In other words, the informational value of past performance over managerial skills becomes more important when investors face greater uncertainty regarding the implications of climate change on the economy. We show that transition risk dampens the flow-performance relationship, particularly in the case of funds with poor sustainability ratings. This implies that high ESG risk coupled with uncertainty associated with the operational or regulatory changes faced by certain institutions or sectors of the economy presents a double challenge for investors regarding their assessment of managerial skills via the past performance of a fund. This finding also suggests that a favorable ESG rating of a fund helps to mitigate information asymmetries between investors and fund managers. Finally, we find that the effect of climate uncertainty on the flow-performance relationship is largely restricted to domestic funds rather than their internationally focused counterparts. We argue that the enhanced diversification offered by internationally focused funds alleviates the regional climate concerns of investors, which makes climate uncertainty less of a factor when it comes to assessing managerial skills in the context of past performance for these funds.

In essence, our findings suggest that the sustainability rating of a fund complements the performance signal more prevalently when investors face greater climate uncertainty such that high climate uncertainty drives the greater allocation of capital to more sustainable funds as a result of favorable past performance. In that regard, our findings add an interesting insight to the multi-objective utility function proposed by Pedersen et al. (2021), highlighting the informational value of sustainability ratings in that investors attribute greater weight to favorable past performance when they make capital allocation decisions to funds that enjoy high sustainability scores, particularly when they face high transition climate uncertainty, highlighting the role of favorable past performance for these funds regarding managerial skills. Overall, our findings provide insights into the emerging literature on the effect of climate risk in financial markets by establishing evidence that climate uncertainty plays a significant role on the informational value of past fund performance as an indicator of managerial skills, more so for funds that enjoy favorable sustainability ratings. Future research could explore the relationship between fund characteristics and fund flows because such funds that are truly sustainable could be more sensitive to climate risk, this could help broaden our understanding of the effect of climate uncertainty on capital allocation decisions towards the mutual funds industry.

Author statement

We confirm that the research idea, plan, data collection, empirical analyses, and writing of the current and previously submitted drafts of this paper were solely conducted by the authors. All authors contributed equally. The paper has not been submitted or published anywhere else.

CRediT authorship contribution statement

Sara Ali: Writing – review & editing, Software, Resources, Data curation. **Ihsan Badshah:** Writing – review & editing, Validation, Project administration, Methodology, Investigation, Conceptualization. **Riza Demirer:** Writing – original draft, Methodology,

Investigation, Conceptualization. **Prasad Hegde:** Writing – review & editing, Validation, Methodology, Investigation, Formal analysis, Data curation. **Lavinia Rognone:** Validation, Software, Methodology, Data curation.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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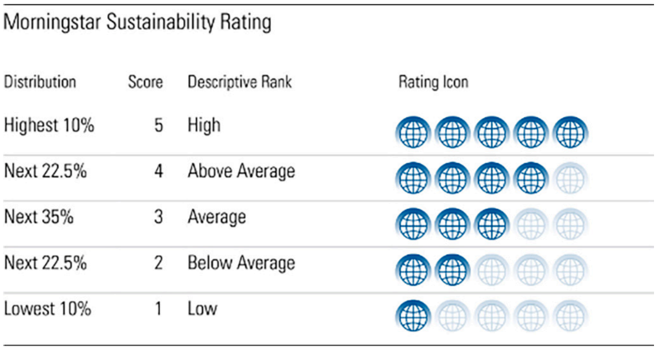
Appendix A. Appendix



Morningstar Sustainability Rating

Distribution	Score	Descriptive Rank	Rating Icon
Highest 10%	5	High	●●●●●
Next 22.5%	4	Above Average	●●●●○
Next 35%	3	Average	●●●○○
Next 22.5%	2	Below Average	●●○○○
Lowest 10%	1	Low	●○○○○

Fig. A1. Morningstar Globe rating.

This figure provides the mapping of the sustainability (ESG) ratings with the rating description and rating icon (Globe) as published on Morningstar's website.[15]

Table A1
Descriptive statistics of mutual funds

	Mean	Std. Dev.	Min.	p25	Median	p75	Max.
Panel D: Domestic funds							
FLOW	−0.894***	5.589	−20.986	−1.702	−0.455	0.355	16.1
CH-4 Alpha	0.265***	0.469	−0.652	0.004	0.252	0.534	1.276
Raw returns	0.56***	7.494	−24.71	−2.69	1.06	4.93	18.64
Volatility	6.302***	3.053	2.416	4.062	5.38	7.885	15.466
Fund Size	2.957***	2.38	−2.848	1.316	3.067	4.73	7.488
Fund Age (Months)	5.087***	0.573	3.497	4.82	5.182	5.472	6.057
Idiosyncratic Volatility	2.668***	1.081	1.136	1.889	2.395	3.143	5.431
Size Beta	−0.045***	0.265	−0.697	−0.201	−0.054	0.11	0.628
MKT Beta	0.9***	0.129	0.537	0.839	0.91	0.974	1.207
WML Beta	−0.049***	0.203	−0.467	−0.189	−0.057	0.076	0.473
Panel E: International funds							

(*continued on next page*)

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[15] A fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe. The details of the ratings can be found here: https://www.morningstar.com/articles/957266/the-morningstar-sustainability-rating-explained

Table A1 (*continued*)

	Mean	Std. Dev.	Min.	p25	Median	p75	Max.
FLOW	−0.617***	6.36	−20.986	−1.667	−0.194	0.794	20.174
CH-4 Alpha	0.475***	0.365	−0.58	0.278	0.498	0.705	1.209
Raw returns	0.495***	6.126	−14.93	−3.31	1.2	4.345	15.33
Volatility	5.261***	1.856	2.346	3.932	4.884	6.339	10.937
Fund Size	3.173***	2.471	−2.636	1.355	3.434	5.076	8.374
Fund Age (Months)	4.88***	0.631	3.434	4.431	5.011	5.375	5.984
Idiosyncratic Volatility	2.727***	1.076	1.248	1.955	2.446	3.187	5.647
Size Beta	0.032***	0.216	−0.569	−0.086	0.034	0.158	0.51
MKT Beta	0.853***	0.169	0.494	0.757	0.831	0.938	1.293
WML Beta	−0.207***	0.184	−0.602	−0.336	−0.199	−0.093	0.258

Panel F: Pair-wise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) *FLOW*	1.000									
(2) CH-4 Alpha	0.069***	1.000								
(3) Raw returns	0.000	−0.057***	1.000							
(4) Volatility	−0.071***	−0.102***	0.300***	1.000						
(5) Fund Size	0.048***	0.215***	−0.015***	−0.049***	1.000					
(6) Fund Age	−0.128***	−0.053***	0.008*	0.068***	0.071***	1.000				
(7) Idiosyncratic Volatility	−0.094***	−0.157***	0.055***	0.220***	−0.024***	−0.012***	1.000			
(8) Size Beta	0.035***	0.206***	0.002	−0.057***	0.010**	−0.070***	−0.151***	1.000		
(9) MKT Beta	−0.017***	0.116***	0.002	0.249***	−0.019***	0.112***	0.000	0.205***	1.000	
(10) WML Beta	0.054***	−0.254***	−0.008**	−0.008*	−0.038***	0.000	−0.354***	−0.111***	−0.084***	1.000

Panels D and E present the summary statistics of the mutual fund characteristics for domestic and international funds, respectively. Panel F presents the pair-wise correlations among the variables used in Panel A. We classify the funds into international and domestic based on the fund investment category from Morningstar. Fund performance is measured by four-factor (CH-4) alphas. Fund flows are based on Franzoni and Schmalz (2017). Fund Size is log(assets). Fund Age is the total number of months in fund's existence. Idiosyncratic volatility is computed relative to the benchmark Fama and French (2015) 5-factor model via rolling regressions as per Ang, Hodrick, Xing, and Zhang (2006). Size, MKT and WML betas are coefficients obtained through 36- month rolling regressions of Fama and French (2015) 5-factor model on raw fund returns that capture the fund investment styles tilted towards size, market and momentum portfolios respectively. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively. All the values are winsorized at 1 % and 99 %.

Table A2

AR (1) estimates of physical and transition climate risk concerns

	$Concern_{t,PR}x100$	$Concern_{t,TR}x100$
Drift *c*	7.01	9.02
	(0.21)	(0.24)
ϕ	0.51	0.58
	(0.11)	(0.11)

This table presents the estimates of the monthly autoregressive process of order 1 concern time series on physical risk (Eq. 1a) and transition risk (Eq. 1b) for the period January 2018 to December 2022. Standard errors are shown in parentheses.

Table A3

Transition climate risk top news articles

Date	TRI %	Transition risk news topics	Transition risk relevant news titles/[extracts]
08/12/2022	13.19	Renewable energies, wind, solar, green hydrogen, natural gas; Energy transition; Domestic solar manufacturing industry to meet AUS 43 % emissions reductions by 2030 and net-0 by 2050; Costly transition; Nuclear power; AUS National environment protection agency; Plibersek reforms; Environment laws; Nature Repair Market Regulation	Forrest the biggest green player after $4bn-plus CWP buy; Solar manufacturing industry essential, says CSIRO; Highbury helps Forrest land $4bn CWP deal; Nuclear should remain a key option in energy debate; Finally, laws with teeth to reverse the decline of nature
20/05/2020	12.34	Mitigation actions - AUS $2bn for emission reduction technologies; Techn. change in heavy industry and transport; New AUS standards for solar panels; NZ renew. Energy for a green data center industry	Climate still a battleground as ALP goes on the attack; [NZ's high renewable energy base can rocket us to the forefront as world shifts to greener, more tech-based ways of working in the 21st century]; Power must 'switch on' energy reform; Solar panel shake-up to offer clarity on supply
06/08/2020	11.01	Low emission technologies; Renewable energies; Solar and wind energies; CCS; Hydrogen; Environmental regulation; Government sustainability issues pressures	Slump smudges clean energy fund; [Environmental regulations]

(*continued on next page*)

Table A3 (*continued*)

Date	TRI %	Transition risk news topics	Transition risk relevant news titles/[extracts]
06/06/2022	10.54	Energy mix, hydrogen, natural gas; AUS potential key hydrogen supplier to Asia and Europe, $185bn in renew. /hydrogen projects; AUS gov. energy mix challenges; CCS; Coal-fired power plants closure - job losses; Dispatchable techn.; CC increases energy costs; Investors and fossil fuel divestment; AUS needs a Germany–like “just transition” principle to ensure an orderly transition	Energy users pre-empting policy on hydrogen: GE; Eastern {Australian} states have gas they just need the will to extract it; The rise of woke capitalism harms national interest; Why natural gas is critical for energy security; Labor’s race for answers as energy crisis bites; Power workers didn’t need a tech guru to show it’s crunch time
02/11/2018	10.07	Ocean waves into clean electricity; AUS potential leader in wave energy technology; Faster warming oceans warns nations - urgent CO2 emissions reduction and CC mitigation, reduce carbon budget; Techn. advances, Argo floats, CCS; World’s largest solar thermal plant in AUS at risk	Momentum swells for wave energy; Ocean study’s climate change warning; BHP won’t stop mining coal; Row taints review of solar plant
10/09/2020	9.36	Renew. energies; Techn. for decarbonisation; Climate risk analysis for business decisions; CC and transition in the beef industry, CO2 sequestration and offset; Carbon-conscious consumer; AUS water reform	BHP executives face carbon test; Study to beef up carbon-neutral credentials; Water reforms a win for farmers and improved use
31/01/2019	8.74	OECD calls AUS greater efforts on meeting Paris Agreement climate targets and GHG emissions reduction, biodiversity protection, and chemical handling; Need long-term low carbon strategy	Mixed review from OECD as our biodiversity worsens
24/08/2021	8.60	Hydrogen energy, AUS hydrogen hub development, potential exports to Japan; Carbon emissions reduction; NZ gov. concerned on energy transition; Fuel Security	Rio in deal with Sumitomo for Qld hydrogen hub; Strategic logic fuels the race for scale in Z Energy takeover
23/03/2018	8.56	Turnbull gov. is concerned about the proposed closure of coal-fired power stations as renew. Energies cannot ensure dispatchable electricity in AUS, whereas gas, hydro, pumped-hydro, biomass and batteries do; Clean energy technology; Energy policy	Liddell is a loss, but an energy guarantee would light the way forward
11/02/2021	8.55	Net-0 targets; Renew. energy projects Western AUS, pollution cuts, Fuel security fears; Hydrogen/nuclear power; AUS adaptation water management in a changing climate	Thinking about our planet in the wake of the pandemic; State Libs to close coal-fired plants; Fuel security fears as Altona closes; Emergency water plan on table

This table reports the dates, the Transition Risk Index in percentage (TRI %), the main news topics, and lists of relevant article titles/extracts for the ten days with the highest transition risk over the period January 2018 to December 2022. News sourced from The Australian and The New Zealand Herald *Reuters News* with an Australasia focus. “CC” is an acronym for “climate change”.

Table A4
Physical climate risk top news articles

Date	PRI %	Physical risk news topics	Physical risk relevant news titles/[extracts]
20/05/2020	10.91	AUS Bushfires and Droughts - lost economic opportunities; NZ Droughts Auckland, failure to adapt, resources mismanagement, water restrictions, driest start to the year on record	[Drought-stricken Auckland]; Water storage falls, outlook bleak; [Recent bushfires and droughts loss of economic opportunities]
27/02/2018	8.68	NZ’s warmest summer in 150 years, heatwaves, droughts, floods, shrinking of glaciers, huge deluges, cyclones; Changing ocean temperatures and wind speed; Animal extinction and migration; Biodiversity loss; sea level rise, global warming; Climate and biodiversity protection actions needed; NZ involvement with international organizations and NZ National Plan of Action	[… warmest summer in 150 years. It has been quite remarkable, really, being 2C above average with heatwaves, droughts, and floods. Our glaciers shrank yet again with the heat.]; Rare albatross in rapid decline
02/06/2020	8.16	Biodiversity loss; Rivers, lakes, and estuaries degradation; NZ gov. environm. policy for freshwater ecosystem; A one in 100-year storm, landslips, floods in Coromandel, NZ; Changing Ocean conditions affect marine ecosystem, blue whales at risk; Marine heatwaves; Climate adaptation, resiliency and infrastructural changes needed; Food security	Clean river promises have been swept away; Coromandel farmers to wake to slips; How NZ’s blue whales stay cool and get their krill
17/01/2022	8.01	Underwater volcano Hunga Tonga eruption, tsunami, floods; Cyclone Cody; Gales, swells, sea surges, coastal inundation; NZ mln dollars damage; Rising sea levels, vulnerability of low-lying areas; Impact of warming temperatures and extreme weather events (droughts, frost, hailstorms, bushfires) on agriculture, relocation costs; Need for government CC action; CC impact on food prices; Need for management strategies for bushfires	Cool change a hot topic for wineries; Family fears for island home from Tonga swell; Brutal surges sink 12 boats, smash marina; {Cyclone} Cody skirts New Zealand
08/03/2018	7.27	Tropical cyclone Hola NZ; CC impacts NZ native species, habitat destruction; Extreme weather, storms, cyclones, swells, king tides, massive waves; Hot weather, and rising sea level;	Cyclone looms Tropical Cyclone Hola is lying in wait just to the east of Vanuatu; Summer storms sweep away a generation of little blue penguins; Chilling fact is most

(*continued on next page*)

Table A4 (*continued*)

Date	PRI %	Physical risk news topics	Physical risk relevant news titles/[extracts]
		Beaches erosion; Human health risks; Climate adaptation; Ocean drift patterns; Climate models	climate change theories are wrong; 'World's oldest message in a bottle' surfaces after 132 years
24/06/2021	6.44	Great Barrier Reef affected by CC; Biodiversity loss; AUS gov. environm. Adaptation, China denies "in danger" classification	China hits back over {Great Barrier} reef 'smear'
07/07/2020	6.02	NZ water scarcity; NZ CC concerns and pollution/plastic waste disposal effects on oceans and marine wildlife	Park irrigation 'beyond stupid'; 5 ugly facts With Plastic Free July underway, Herald science reporter Jamie Morton looks at five figures that reveal the alarming enormity of NZ's plastic problem — and five things we can do about it [growing concerns about plastic pollution and climate change]
23/11/2022	5.94	Longer bushfire seasons, droughts, rising sea and air temperatures; Heat extremes, the decline in rainfall, sea levels rise, floods/damage to coastal areas; AUS gov adaptation, environ. Protection; River systems; Scarce water savings in the Murray Darling Basin; CC disrupts food supply chain in AUS; Food security	Future shock: more heat, more bushfires, more droughts; Why we will oppose reforms to the RMA; Up the creek on Murray-Darling water targets; Plan needed to keep shelves full
06/12/2021	5.90	Heatwaves, floods, fire danger, thunderstorms; Impact of La Nina on AUS weather patterns, rivers flood risk; Environment protection from increased bushfires risk; Declining natural resources, volatile climate, sustainable innovation in the food/agriculture industry	Heatwaves hit west as floods swamp east; Plant-based meat can feed and protect the planet
01/04/2022	5.79	Bureau of Meteorology's failure to predict extreme weather events that caused flood disasters in NSW and Queensland; Rising temperatures; AUS avoided deforestation; Savannah burning; Biodiversity loss	Under-fire weather bureau 'has been failed on funding'; Big project developers back carbon market review

This table reports the dates, the Physical Risk Index in percentage (PRI %), the main news topics, and lists of relevant article titles/extracts for the ten days with the highest physical risk over the period January 2018 to December 2022. News sourced from *Reuters News* with an Australasia focus. "CC" is an acronym for "climate change".

Table A5

Re-estimating Table 3 using non-winsorized returns.

Dependent variable	Fund Flow$_{(t)}$					
Perf:	CH4- Alpha					
	All Funds		Globe 5		Globe 1	
PERF $_{(t\text{-}1)}$	0.190***	0.228***	0.695**	0.644***	0.408**	0.38**
	(0.000)	(0.000)	(0.01)	(0.012)	(0.01)	(0.04)
Controls $_{(t\text{-}1)}$	No	Yes	No	Yes	No	Yes
Intercept	-0.87***	-1.40***	-1.016***	5.592***	-0.79***	-10.90*
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.06)
N	59,770		4920		7071	
Adj. R-Squared	0.17	0.20	0.08	0.08	0.19	0.20
Country Fund and Time FE	Yes					

This table estimates the regressions in Table 3 using non-winsorized returns on monthly fund flows. Fund performance is measured by four-factor (CH-4) alphas. Fund flows are based on Franzoni and Schmalz (2017). The explanatory variables with subscript (t-1) are lagged by one month. Low, Medium and High-risk funds are based on the sustainability ratings published by the Morningstar database. A fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe. All models include country, fund, and time fixed effects. The robust *p*-values are reported in parentheses. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively. Fund flow is winsorized at 1 % and 99 %.

Table A6

Re-estimating Table 4 using non-winsorized returns.

	Panel A: Transitional climate risk index (**TRI**)			**Panel B:** Physical climate risk index (**PRI**)		
	All Funds	Globe 5	Globe 1	All Funds	Globe 5	Globe 1
PERF $_{(t\text{-}1)}$	0.214***	0.026	0.366*	0.297***	0.219	0.425**
	(0.000)	(0.92)	(0.07)	(0.000)	(0.87)	(0.03)
	−0.026***	−0.047***	−0.025**	−0.304***	−0.479***	−0.307***
Climate Risk (CRI)	(0.000)	(0.000)	(0.026)	(0.000)	(0.000)	(0.003)
	0.034***	0.059***	0.01	0.280***	0.456**	0.244
PERF $_{(t\text{-}1)}$ x Climate Risk	(0.000)	(0.000)	(0.73)	(0.000)	(0.03)	(0.16)
Controls $_{(t\text{-}1)}$	Yes	Yes	Yes	Yes	Yes	Yes
	13.355***	−15.30**	8.84**	12.247***	−16.94***	7.917
Intercept	(0.000)	(0.01)	(0.01)	(0.000)	(0.000)	(0.030)
N	59,770	4921	7071	59,770	4921	7071
Adj. R-Squared	0.12	0.15	0.14	0.12	0.15	0.14
Country, Fund and Time FE	Yes					

This table estimates the regressions in Table 4 using non-winsorized returns on monthly fund flows. Panels A & B present the results for Eq. 4, which tests the effect of transition (physical) climate risks and fund performance (in addition to several fund-level controls) on monthly fund flows. Climate risks (CRI) are captured by the transitional risk index (TRI) and physical risk index (PRI) described in Section 2.2 and reported in Panels A and B, respectively. Fund performance is measured by four-factor (CH-4) alphas. Fund flows are based on Franzoni and Schmalz (2017). The explanatory variables with subscript (t-1) are lagged by one month. A fund with high (low) ESG risk relative to its Morningstar Global Category would receive 1 (5) globe. All models include country and time-fixed effects. The robust p-values are reported in parentheses. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively. Fund flow is winsorized at 1 % and 99 %.

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