# Are the Hedges of Funds Green?

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**Abstract**

Over the past decade, hedge funds have increasingly embraced green investments. In this study, we develop a return-based method to measure the greenness of hedge funds and find that those with higher green beta not only outperform other funds but also demonstrate lower risk. This superior performance is attributed to fund managers' exceptional skills in selecting green stocks and timing green factors. Additionally, we observe that investors have directed higher inflows to high-performing green funds, particularly after the 2015 Paris Agreement. Lastly, we reveal that political beliefs, climate news sentiment, and participation in the United Nations Principles for Responsible Investment (PRI) significantly influence hedge funds' commitment to environmentally sustainable investing and attract investor fund flows.

Keywords: Climate finance; Carbon risk; Hedge funds; Environmentally sustainable investing; Green picking skill; Green timing skill

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## 1. Introduction

As the global economy transitions to a low-carbon future, financial institutions play an increasingly significant role in combating climate change. Professional asset managers are incorporating sustainability considerations into their investment process.[1] There is a growing literature exploring how firms and financial institutions deal with greenhouse gas emissions (Bolton and Kacperczyk, 2021; In, Park, and Monk, 2019; Berkman, Jona, and Soderstrom, 2019; Karydas and Xepapadeas, 2019; Engle, Giglio, Kelly, Lee, and Stroebel, 2020). Although much has been written about the sustainable investing practice of mutual funds (Ceccarelli et al., 2021, 2022; Choi et al, 2021; Kim and Yoon, 2023), venture capitals (Barber, Morse and Yasuda, 2021) and university endowments (Aragon et al., 2022), the academic literature has devoted surprisingly little attention to how hedge fund managers, arguably the most sophisticated investors, react to climate change and incorporate ESG considerations in their investment process. This is exactly the focus of this paper, and we specifically concentrate on the "E" component of the ESG, i.e., the impact of environmentally sustainable (i.e., green) investing.

Hedge funds have historically been more hesitant in adopting environmentally sustainable investing compared to other institutional investors.[2] The relatively short investment horizon and life span of many hedge funds and laser focus on generating alpha in a very competitive space poses challenges in supporting environmental spending that may yield only long-term benefits. Additionally, hedge fund managers tend to display more skepticism regarding the importance of responsible investment. There is a growing tension between hedge fund investors and fund managers who "want to own ethical companies in a saintly effort to promote good corporate behavior while hoping to do so in a guiltless way that does not sacrifice returns" (Pedersen et al., 2020). To cater to investor preferences, some hedge funds may use responsible investment policies such as window-dressing techniques and engage in the greenwashing practice (Liang, Sun, and Teo, 2022). However, the hedge fund industry is currently undergoing a rapid transformation. Hedge fund managers are recognizing the potential of green investing as an opportunity to generate

[1] A report from the Global Sustainable Investment Alliance showed that sustainable investments total $35.3 trillion in 2021, which is more than a third of all assets in five of the world's biggest markets.

[2] According to 256 investors surveyed as part of bfinance's ESG Asset Owner Survey, only 7% of all investors (and 13% of large investors with more than $25 billion in assets under management) reported that their hedge fund and currently offer "high integration" of ESG principles in their investment processes. See: https://www.bfinance.com/insights/from-laggards-to-leaders-hedge-funds-slowly-embrace-esg/

abnormal returns. Simultaneously, in light of growing client concerns, the lack of consideration for environmental, social, and governance (ESG) factors in investment strategies is increasingly viewed as a risk factor. According to the J.P. Morgan Advisory Group, more than half of hedge fund managers considered ESG to be a source of alpha in December 2020, compared to just 23% in May 2019. This shift implies that fund managers have begun to perceive ESG-related information as a valuable source of investment intelligence.

In this study, we explore environmentally sustainable investing in the hedge fund industry by constructing a sample of 1,963 U.S. equity hedge funds from 2012 to 2021, integrating data from three prominent hedge fund databases (Lipper TASS, Hedge Fund Research, and Morningstar CISDM), and extracting holdings data from 13F filings. We aim to answer the following questions. First, how does a hedge fund's engagement in environmentally sustainable investing impact fund performance and risk, and what underlying mechanisms contribute to these effects? By examining the relationship between green investing and fund performance, we seek to uncover the potential benefits and risks associated with green investment strategies employed by hedge funds. Second, do investors recognize and respond to hedge funds that engage in green investing? We seek to investigate investor perceptions and reactions toward hedge funds that incorporate environmentally sustainable investment practices. Third, which factors contribute to the heterogeneity among hedge funds regarding their willingness to engage in green investing? Factors such as political beliefs, exposure to air pollution, climate news sentiment, and participation in global initiatives like the UN Principles for Responsible Investment (PRI) will be examined to shed light on the drivers that influence investors' behavior and fund managers' varying levels of commitment to environmentally sustainable investing.

We argue that the hedge fund industry provides an important context for studying environmentally sustainable investing due to the following unique factors. To begin with, unlike other responsible institutional investors who may be willing to accept lower expected financial returns in exchange for nonpecuniary benefits from green investing (Gibson et al., 2020; Kim and Yoon, 2023; Barber, Morse, and Yasuda, 2021; Aragon et al., 2022), hedge funds are natural arbitrageurs and prioritize profitability due to private ownership and the incentive fee structure. In the realm of sustainable investing, hedge funds are "ESG-aware" and incorporate ESG information into their risk management and return assessments. This approach allows them to enhance their portfolio's maximum reward-to-risk ratio compared to a ratio based solely on non-ESG

information. In contrast, other institutional investors could be more "ESG-motivated" and prioritize investments in high ESG-rated firms, necessitating a trade-off between ESG considerations and the Sharpe ratio (Pedersen et al., 2021). Consequently, whether hedge funds can achieve green objectives without sacrificing returns remains an intriguing and underexplored question. Next, hedge funds play a significant role in global financial markets and help improve market efficiency by identifying and capitalizing on market anomalies (Cao, Liang, Lo, and Petrasek, 2018). If environmental and climate factors significantly impact company performance but are not fully reflected in market prices (Lindsey, Pruitt, and Schiller, 2022), hedge funds can exploit these mispricing and, in doing so, drive the market toward more accurate pricing of these factors (Cao, Chen, Goetzmann, and Liang, 2018). Lastly, relative to mutual funds, hedge funds employ complex strategies and operate with lower levels of transparency, disclosure, and regulatory oversight. They engage in both long and short positions, often leveraging up the positions. These unique characteristics make hedge funds an important laboratory for studying environmentally sustainable investment practices, as they present distinct challenges and opportunities that differ from those encountered by traditional financial institutions like mutual funds.

We start our analysis by examining hedge funds' aggregate ownership and uncover evidence that hedge funds care about carbon risk and have actively rebalanced their portfolios toward a lower-carbon exposure. Based on carbon risk scores, we sorted industries into green vs. brown, and within each industry we further sorted firms to capture within-industry pollution levels. We find that hedge funds have consistently increased their allocation to green industries, while decreasing their exposure to brown industries. We then examine hedge funds' trading behavior by examining their quarterly transactions. Our findings indicate that hedge funds have adopted a positive screening mechanism, as they actively decarbonize their portfolios by increasing the holdings in green firms, even without completely divesting from brown industries. This finding is also consistent with a recent study by Pástor et al. (2023), which shows that institutions tilt to green stocks but do not eliminate brown stocks in their portfolio. We further uncover asymmetrical trading patterns from hedge funds toward green and brown firms. Specifically, hedge funds exhibit proficiency in identifying and selecting companies within the green industry that have lower levels of pollution. However, when it comes to the brown industry, hedge funds do not differentiate between firms based on carbon risk.

Next, we study the potential impact of hedge funds' greenness on their performance. To facilitate this analysis, we introduce a novel methodology for quantifying hedge funds' engagement in green investing, which we refer to as "green beta". We estimate each hedge fund's green beta by estimating its return exposure to a green factor constructed by Pástor et al. (2022). This return-based measure offers several distinct advantages over the traditional holdings-based measure. It allows researchers to measure hedge fund greenness at the individual fund level instead of the institution level. Additionally, it facilitates the computation of green betas for hedge funds, in the absence of other carbon-related metrics and information on intricate investment strategies that inherently complicate the construction of such measures. Moreover, this method captures both long and short positions, providing a comprehensive assessment of the impact of green investing on hedge fund performance across their entire portfolios.

Utilizing the fund-level green beta, we investigate the empirical relationship between hedge fund green beta and fund performance. Our portfolio sorting and regression findings reveal that green beta positively predicts hedge funds' returns and alpha. The observed outperformance of greener funds underscores the notion that hedge funds can "do well by doing good" (Bénabou and Tirole, 2010). In other words, hedge funds can participate in environmentally sustainable investing without sacrificing performance. Our findings indicate that greener hedge fund managers exhibit ESG awareness and possess expertise needed to extract investment insights from ESG information (Pedersen et al., 2021). We further examine the relation between hedge fund greenness and fund risk. While previous studies have shown that stocks with lower carbon risk also have lower total risk or tail risk (e.g., Bolton and Kacperczyk, 2021a; Engle et al., 2020; Ilhan et al., 2021), the risk properties at the portfolio level remain less clear. Contrary to Ceccarelli et al., (2021), who suggest that green portfolios suffer from less diversification and risk-sharing due to high industry concentration, we document that hedge fund green beta is negatively associated with fund risk, encompassing both total risk and tail risk. These findings suggest that greener hedge funds exhibit superior risk management capabilities through hedging. Greener funds effectively incorporate the low-risk properties observed in green firms to the fund level without compromising the diversification effect.

We then explore whether hedge fund investors recognize and reward hedge funds' sustainable investing practices. To investigate this, we regress fund flows against hedge fund green beta while controlling for factors such as past fund performance and other fund characteristics. We

document that on average hedge funds with higher green beta tend to attract greater investor flows. However, when delving deeper into different time periods, we find that the green flow premium exists only after the 2015 Paris Agreement, and only among funds with high alphas[3]. These findings highlight two interesting aspects. First, it suggests that hedge fund investors have become increasingly climate risk-aware, especially after the Paris Agreement. Their behavior is in line with other researchers' findings that indicate a growing awareness of climate risks and carbon emissions among investors following the Paris Agreement (Choi et al., 2021). Second, our analysis sheds light on the unique attitude of hedge fund investors toward sustainable investing compared to other types of investors. In contrast to some mutual fund investors who may subsidize social and environmental objectives with fund performance (El Ghoul and Karoui, 2017), hedge fund investors are unwilling to compromise performance to support responsible investing. Instead, they reward green funds with higher inflows only when those funds are capable of achieving superior alphas. This underscores hedge funds' emphasis on balancing financial performance with responsible investment practices.

Having documented that green hedge funds outperform other hedge funds in our sample, we further investigate the reasons behind their outperformance.[4] Specifically, we explore whether green hedge fund managers demonstrate superior skills in selecting green stocks, timing the green factor, or both. To assess fund managers' green-picking skills, we first follow Kacperczyk et al. (2014) to evaluate managers' stock-selecting ability in green stocks using 13F holdings data. We find that managers of green funds demonstrate superior picking skills in selecting green stocks. The green stocks selected by these managers outperform other green stocks. We then explore the reasons behind these green stocks' outperformance. Given the market's failure to fully reflect ESG factors in prices (Pedersen et al., 2021) and uncertainty around ESG ratings (Avramov et al., 2021), we hypothesize that green managers favor firms whose sustainability is undervalued. Consistently, we find that green funds tend to favor green firms with high potential for future carbon emission reductions and green patent generation. These are companies whose environmental sustainability

[3] The Paris Agreement, also known as the Paris Climate Accords, is an international treaty adopted in 2015 to address climate change. It focuses on climate change mitigation, adaptation, and financing. The treaty was negotiated by 196 parties during the 2015 United Nations Climate Change Conference held near Paris, France. See https://www.un.org/en/climatechange/paris-agreement.

[4] Throughout this paper, we employ the term "green hedge fund" to refer to hedge funds exhibiting higher green beta. This terminology is used interchangeably with the phrase "hedge funds with higher green beta" in order to denote funds that emphasize green investing practices.

ratings are undervalued or undiscovered, as the market struggles to incorporate information about future green initiatives into prices. The outperformance arises not just from investing in green stocks, but also from identifying and disproportionately favoring companies with an undervalued "greenium." This green premium is attributed to ambiguous sustainable information that complicates accurate valuation by other investors.[5]

To evaluate fund managers' green timing skills, we test two conjectures. First, we examine whether funds with higher green beta are able to increase their green beta exposure in anticipation of a more bullish green factor and outperformance of green assets, a reflection of their ability to time the green factor. We refer to this competency as a fund manager's green timing skill. Second, we test whether such green timing skill contributes to higher fund performance. Our analysis supports both conjectures. We develop a green timing measure building on the classic market timing model by Henriksson and Merton (1981). For each fund, we examine whether it increases (decreases) the loading on the green factor when green sentiment is higher (lower). We document that managers of green hedge funds exhibit better green timing skills. Moreover, the green timing coefficient is positively associated with fund performance after controlling for green beta and other fund characteristics. Green timing skill thus helps explain the outperformance of high green beta funds.

Finally, we shift our focus to explore factors influencing hedge funds' engagement in sustainable investing. Specifically, we examine four potential channels: political belief, climate news sentiment, air pollution exposure, and participation in the UN Principles for Responsible Investment (PRI) initiative. The role of political belief has increasingly shaped individuals' attitudes toward climate change risk (Baldauf, Garlappi, and Yannelis, 2020; Hong and Kostovetsky, 2012; Di Giuli and Kostovetsky, 2014). In our analysis, we find that hedge funds located in Republican-leaning states are associated with lower green beta and higher carbon risk. Conversely, funds located in Democrat-leaning states exhibit a greater willingness to adopt greener portfolios with lower carbon risk. Additionally, we observe that investors' reactions to green funds also differ based on the states' attitudes toward climate change. Greener funds attract greater fund flows in Democrat-leaning states, while no such green flow premium is observed in Republican-leaning states. Next, we find that hedge funds actively adjust their portfolio exposure to greener

[5] Previous studies have demonstrated that skilled fund managers tend to favor firms for which they possess superior information (e.g., Cici et al., 2018; Jiang, Verbeek, and Wang, 2014).

assets in response to unexpected climate news shocks. Simultaneously, investor flows toward green hedge funds also increase when there is a surge in social sentiment regarding climate change. These findings support the hypothesis that both hedge fund managers and investors are influenced by increased concerns about climate change. Third, we provide evidence on whether hedge funds changed their investment practice after joining the Principles for Responsible Investment (PRI). Using a difference-in-difference (DID) setting, we find that hedge fund firms increase their exposure to green assets and decrease their holdings of high-carbon-risk stocks after becoming signatories to the PRI. Moreover, investors respond positively to hedge fund firms after they sign the PRI. Our results indicate that hedge fund firms can adopt sustainable investing practices without engaging in greenwashing, extending the study by Liang, Sun, and Teo (2022). Nevertheless, our analysis fails to uncover evidence indicating that local air pollution affects the decision-making of hedge fund managers or investors. [6]

Our paper contributes to several strands of literature. First, this study complements extant research on climate change risk and the investment fund industry. Previous studies have shown that mutual fund managers actively changed their portfolio holdings following increased transparency on climate transition risk (Ceccarelli et al., 2021), especially after natural disasters (Alok, Kumar, and Wermers, 2020) or extreme heat events (Alekseev et al., 2021). Venture capitalists are willing to accept lower financial returns for "impact investments" (Barber, Morse, and Yasuda, 2021). University endowments are also adopting responsible investment policies (Aragon et al., 2022). Our study analyzes sustainable investing practice and their implications within the hedge fund industry. We provide compelling evidence that the hedge fund industry has shifted to a low-carbon direction and become greener over the past decade.[7] Our study also extends the findings from Liang, Sun, and Teo (2022), who argue that hedge funds mainly use participating in the PRI initiative as a way of greenwashing. By utilizing a difference-in-difference model, we provide evidence that hedge funds actively decarbonize their portfolio after joining the PRI.

Second, our paper contributes to the growing body of literature on the costs and benefits of responsible investing. The financial implications of incorporating ESG factors in portfolio

[6] Please see Appendix I for more details.

[7] Another paper that explores responsible investing in hedge funds is Liang, Sun, and Teo (2022), which focuses on investigating hedge fund greenwashing. Our study differs from theirs in several aspects and expands upon their analysis, providing further insights into the environmentally responsible investing practices of hedge funds. We will elaborate on these differences in more detail in the discussion.

strategies have been a subject of debate among researchers. On the one hand, several studies have documented that institutions may sacrifice financial returns in exchange for nonpecuniary benefits derived from responsible investment (Riedl and Smeets, 2017; Kim and Yoon, 2020; Brandon et al., 2021; Liang et al., 2022; Barber et al., 2021). Other studies suggest that responsible investment incurs costs such as reduced diversification effects (Ceccarelli et al., 2021), higher management expenses, and increased portfolio return volatility (Aragon et al., 2022). On the other hand, theoretical models suggest that socially responsible investment could carry no associated costs (Lindsey, Pruitt, and Schiller, 2022) and that the benefits of ESG incorporation can be quantified through the increase in the maximum Sharpe ratio (Pedersen et al., 2021). Our study adds empirical evidence to this theoretical framework by demonstrating that sustainable investing by hedge funds can be advantageous, leading to higher alpha and lower risks. These findings are consistent with Ceccarelli et al. (2022), who find that ESG integration at the institutional level positively impacts financial performance.

Third, our study contributes to the literature by uncovering a new source of hedge fund performance and hedge fund managers' skills. While previous research has extensively examined hedge fund managers' skills in areas such as volatility, liquidity, macroeconomic uncertainty, sentiment trading, and political sensitivity (Chen and Liang, 2007; Cao et al., 2013; Bali, Brown, and Caglayan, 2014; Chen, Han, and Pan, 2021; Chen et al., 2022), we provide compelling evidence of the positive impact of green investing on hedge fund performance. We decompose the green investing skill into two aspects: green stock picking and green factor timing. Our findings reveal that green hedge funds exhibit better green picking skills and green timing skills and both skills contribute to successful performance. Our study underscores the significance of green investing as a distinct and valuable driver to generate hedge fund alpha.

Finally, our study also contributes to the behavioral finance literature by providing additional evidence on how heterogeneity in political beliefs, social sentiment, and news shock can influence investors' beliefs and behaviors. Our findings indicate that hedge fund managers and investors do not have a uniform utility function; rather, their reactions to responsible investing are influenced by their political beliefs and current news. Our study builds upon and expands previous research in this area. Hong and Kostovetsky (2012) have documented significant differences in the holdings of socially responsible companies by mutual funds run by Democratic-leaning and Republican-leaning fund managers. Bonaparte, Kumar, and Page (2017) reveal that fund managers

tend to become more optimistic about the economy and increase risky asset allocations when their preferred party is in power.[8] Prior literature also established a connection between investor sentiment and stock pricing (e.g., Baker and Wurgler 2006; Tetlock 2007; Stambaugh et al., 2012). In more recent studies, researchers link public sentiment to responsible investing. Serafeim (2020) demonstrates that the valuation premium for high ESG rating firms increases with positive momentum in public sentiment. Pástor et al. (2022) show that the green stock outperformance is mainly attributed to climate-related news shocks. Huynh and Xia (2021) highlight the pricing of climate change news sentiment in corporate bonds. By focusing on the hedge fund industry, our study complements the previous studies by providing additional evidence and insights into the role of political beliefs, social sentiment, and news shocks in shaping sustainable investing behavior.

Our paper is closely related to a contemporaneous paper (Aragon et al., 2023) that substantiates our core finding that greener hedge funds outperform their counterparts and attract higher fund flows. Distinct from Aragon et al. (2023), who consider the general skills of the entire hedge funds sector and attribute this outperformance to the aggregate portfolio of green stocks held by all hedge funds surpassing the market portfolio of green stocks, our research pinpoints the unique green investing skill within green hedge funds and establishes a direct correlation between fund green beta and its performance. We demonstrate that the outperformance of green hedge funds is driven by their distinct green stock picking and green factor timing skills—capabilities not uniformly distributed across the hedge fund universe but rather specific to green hedge funds. Furthermore, we complement the findings of Aragon et al. (2023) by documenting a previously unexplored aspect of green hedge funds: risk management. Our analysis shows that green hedge funds not only generate higher returns but also manage risk more effectively, providing a dual advantage to investors.

The paper proceeds as follows. Section 2 discusses the data and introduces the measurement of hedge fund greenness. Section 3 presents the empirical results. Section 4 presents the robustness analysis. Section 5 concludes.

[8] Studies in political science and public surveys have consistently shown that people's perceptions of the economy are heavily influenced by partisan politics (e.g., Gerber and Huber, 2010; Lewis-Beck, Martini, and Kiewiet, 2013; Prior, Sood, and Khanna, 2015).

## 2. Data and methodology

In this section, we summarize various datasets used in our empirical analysis. Moreover, we introduce a novel method for measuring a hedge fund's greenness, which enables us to assess the hedge fund's exposure to green stocks at the individual fund level.

### 2.1 Hegde fund data

We construct a comprehensive hedge fund sample consisting of both live and defunct hedge funds from TASS, HFR, and Morningstar CISDM. We restrict our sample to U.S. equity hedge funds with 13F holdings data. These screens yield a final sample of 11,512 fund-year observations from January 2012 to December 2021. Our fund universe has a total of 1,963 hedge funds, of which 890 are live funds and 1,073 are dead (defunct) funds. We aggregate 1,177 distinctive funds from HFR, 645 funds from TASS, and 141 funds from Morningstar CISDM, highlighting the benefits of utilizing multiple sources of data. In addition to net-of-fee returns and assets under management (AUM), we obtain a broad range of fund characteristics, including management fee, incentive fee, lock-up period, leverage, high water mark, investment style, inception date, fund location, and fund manager information. We categorize funds into twelve distinct investment styles following Liang et al. (2022).

To examine whether hedge funds become greener after joining the United Nations PRI (Principles for Responsible Investment), we also get access to a complete list of signatories from the PRI website and manually match the PRI signatories to hedge fund management firms by name and headquarters location. The PRI website provides various details regarding signatories, such as the name of the signatory, category of the organization (investment manager, asset owner, or service provider), location of the headquarters, date of signature, organizational overview, governance structure, investment strategy, and reporting practices. As of December 2021, there are 312 hedge funds joined the PRI in our final sample and 51% of the funds joined the PRI after 2019.[9]

[9] As of 2023, the PRI has 5,319 signatories all over the world, representing US$121trn of AUM. Please see https://www.unpri.org/signatories/signatory-resources/quarterly-signatoryupdate#:~:text=We%20added%20140%20global%20organisations,US%24121trn%20of%20AUM.

Commercial hedge fund databases suffer from two potential biases: backfilling bias and incubation bias. Backfilling bias stems from the inclusion of returns before fund listing dates into the databases. This practice is driven by the tendency of funds with robust track records to list on databases to attract investment capital. As such, the backfilled returns tend to be higher than the actual returns realized post-listing, which may lead to an overestimation of the fund's performance (Liang, 2000; Fung and Hsieh, 2009; Bhardwaj, Gorton, and Rouwenhorst, 2014). To mitigate the potential impact of backfilling bias on our analysis, we only include hedge fund returns reported post-fund database listing date. In cases where databases do not provide information on listing dates, we employ the Jorion and Schwarz (2019) algorithm to infer the listing dates. Incubation bias is a phenomenon that can lead to inflated returns during the early stages of a hedge fund's operation. This bias arises from the tendency of hedge fund managers to leverage their prior successful investment strategies during the incubation period. To eliminate the incubation bias, we delete the first 24 months of return data and remove hedge funds with less than 24 months of returns.

Panel A in Table I presents the summary statistics. For all hedge funds in our sample, the average monthly return is 0.55%, while the monthly seven-factor alpha is 0.12%. In terms of risk, the total risk average is 2.77%, whereas the tail risk averages 5.33% per month. The average monthly fund flow is 0.55%, but the variation among funds is substantial. The average fund age is 8.8 years, and the mean of assets under management (AUM) is $346.6 million. The average characteristics of funds within our sample period are largely consistent with those in the previous literature.

[insert Table I about here]

**2.2 Carbon risk data**

To construct a sample of hedge fund carbon risk scores, we use the firm-level carbon risk scores from Sustainalytics. Sustainalytics is a leading provider of ESG and corporate governance research, ratings, and analysis. It provides Carbon Risk Ratings to evaluate the extent to which public and private firms are capable of managing transition risk. The ratings are determined by evaluating a company’s material exposure to and management of carbon issues. The database covers over 4,000 publicly traded firms across 147 subindustries on a global scale, incorporating a range of carbon signals into a singular quantitative evaluation. The carbon risk score varies

between 0 and 100, where lower scores indicate firms with lower carbon risk (green firms), while higher scores indicate firms with higher carbon risk (brown firms). Unlike carbon emission data, which represents a static measurement of a firm's current carbon intensity, this approach takes a forward-looking stance and gauges the firm's potential to transition toward a low-carbon economy dynamically. Moreover, this measure has garnered significant adoption among industry practitioners for assessing carbon risk exposure. Morningstar utilizes the Carbon Risk Ratings to develop the Morningstar Portfolio Carbon Risk Score, a metric that enables investors to assess a portfolio's carbon risk exposure. Table A1 in Appendix II shows firms' average carbon risk scores by industry. It reveals that the average carbon risk score across all firms is 12.2. Furthermore, the oil and gas industry exhibits the highest carbon risk score (46.5), whereas the healthcare industry displays the lowest score (3.1).

To measure hedge fund firm-level carbon risk scores, we first collect hedge fund holdings data following the method of Brunnermeier and Nagel (2004) and Griffin and Xu (2009) from the Thomson Reuters CDA/Spectrum Institutional (13F) Holdings Database. The 13F dataset discloses quarterly stock holdings of all institutions with more than $100 million under management and stocks long positions greater than 10,000 shares or $200,000. We then link hedge fund firm holding data with individual stock's carbon risk score. Hedge fund performance and other characteristics are manually matched with 13F holdings data by hedge fund firm names. We calculate both annual and quarterly hedge fund firm carbon risk scores. Quarterly carbon risk scores represent the value-weighted average of the carbon risk scores of the hedge fund firms' stock holdings over the corresponding quarter. The annual carbon risk scores are obtained by averaging the quarterly carbon risk scores over the year. We are able to match a reasonably large number of stocks in the 13F holdings with the carbon risk scores. Specifically, for any given quarter, carbon risk scores are available for 57.1% of hedge fund 13F holdings. As shown in Table I, the average hedge fund firm's carbon risk score is 11.54 that is slightly lower than the average carbon risk score of all firms (12.16). This shows that hedge funds tend to hold greener assets than the market. Time series analysis also reveals that the average hedge fund carbon risk score decreased from 14 in 2012 to 8 in 2021, which again indicates hedge funds have become greener, on average, over the past years.

### 2.3 Hedge fund green beta

We construct a novel method to capture a hedge fund's exposure to green assets at the individual fund level and define it as green beta. Specifically, we estimate fund green beta using the following regression:

$$r_{i,t} = \alpha_i + \beta_g f_{green,t} + \sum_{j=1}^{J} \beta_j f_{j,t} + \varepsilon_{i,t} \quad (1)$$

where $r_{i,t}$ is the excess return of fund *i* in month *t* over the risk-free rate. $f_{green,t}$ is the green factor proposed in Pástor et al. (2022) in which the authors define the green factor as the market-hedged excess return obtained from a portfolio comprising long positions in green stocks and short positions in brown stocks. The green factor is referred to as the return on a "zero-cost" long-short factor. Theoretically, it is calculated by assigning each stock a weight based on its degree of greenness, with green stocks receiving positive weights and brown stocks receiving negative weights. $\beta_g$ is the green beta that measures fund *i*'s exposure to green assets. A higher (lower) green beta indicates that the fund is greener (browner) due to its exposure to a greater (smaller) number of green stocks. $f_{j,t}$ denotes the seven factors from Fung and Hsieh (2004) seven-factor model. The seven factors, comprising both linear and option-like factors, have demonstrated a significant ability to account for the variations in hedge fund returns. Specifically, the seven factors include a market factor of excess return on the Standard and Poor's (S&P) 500 index; a size factor constructed as the difference between the Russell 2000 and S&P 500 stock indexes; a credit factor created by the change in the credit spread of Moody's BAA bond over the ten-year Treasury bond; the monthly change in the yield of the ten-year Treasury; and three trend-following factors for bonds, currencies, and commodities. In the main regression analysis, we use 24-month rolling windows to estimate the coefficients. But the results are consistent if we change the rolling window to 12 months or 18 months.

The average hedge fund green beta in our sample is 0.01 while the median value stands at 0.03. These findings suggest that, on average, hedge funds exhibit relatively low exposure to environmentally friendly stocks. However, the green beta measure has a standard deviation of 0.99, indicating a considerable variation in the degree of exposure to green assets across different funds. The degree of ESG adoption across hedge fund managers varies and is mainly driven by the nature

of the strategies themselves. Panel A of Table II reports the distribution of green beta among diverse hedge fund investment strategies. As one would expect, long-only hedge funds demonstrate the most pronounced green beta, with a value of 0.49, followed by multi-strategy and long-short strategy.[10] Those strategies are more fundamentally oriented and thus are highly adaptable to ESG screening. Contrarily, hedge fund strategies such as short bias, emerging market, and sector-focused funds have the lowest green beta. This is attributable to the diminished focus these funds assign to green assets in their investment decision-making process as they face more challenges when incorporating ESG into their investment strategies.[11]

Panel B of Table II reports the differences in fund characteristics between greener hedge funds and browner hedge funds. We sort funds by their green betas each month into five quintiles and then compare the average fund characteristics between the first quintile (the group with the lowest green beta) and the fifth quintile (the group with the highest green beta). We find that greener hedge funds charge higher fees, earn higher returns and alphas, exhibit less risks, impose longer lock-up periods, are more mature, have more live funds, and manage more capital than browner hedge funds. In alignment with Stein (2005), the extended lock-up period in greener hedge funds is attributable to their engagement in strategies targeting long-term investment opportunities. This is ascribed to their ability to attract environmentally conscious capital, which tends to be more patient in nature. We will show in Section 3.4 that the larger AUM of greener hedge funds can be traced to their enhanced capacity to attract greater investor flows. We also find that a hedge fund's green beta displays a fair amount of persistence in the short run. As observed in Table A3, about 84% (39%) of the hedge funds placed in the top green beta quintile in a given month will continue to be in the top decile one month (one year) later.

[insert Table II about here]

One concern is that a hedge fund's exposure to the green factor may inherently entail exposure to the market factor, implying that the green beta could partially reflect the hedge fund's exposure to market beta. To address this issue, we investigate the correlation between the green

[10] This is in line with the results of a survey by Barclays Strategic Consulting Analysis. Investors believe that ESG is most applicable within equity long-short (94%) and least applicable within merger arbitrage and discretionary macro strategies. Please see https://www.cib.barclays/our-insights/3-point-perspective/esg-gains-traction-among-hedge-fund-investors.html.

[11] An increasing number of hedge funds such as AQR and Man Group are incorporating short selling as part of an ESG-focused investment strategy. Please see https://www.aqr.com/Insights/Perspectives/Shorting-Counts and https://www.man.com/maninstitute/big-green-short.

beta and each of the betas in the seven-factor model. As demonstrated in Table A2 in Appendix II, the correlation between green beta and market beta is positive, yet the magnitude remains relatively small at 0.16. This indicates that, although some overlap exists between the information contained in the green factor and market factor, the extent to which green beta and market beta pick up similar information remains minimal. Furthermore, the low correlations between green beta and all other betas provide no evidence that the green beta captures exposure to other risk factors.

An alternative approach to assessing a hedge fund's exposure to the green factor is to calculate the value-weighted average carbon risk score using the stock holding data of hedge fund firms (Liang et al., 2022). In this method, higher carbon risk scores signify browner firms, whereas lower scores indicate greener firms, which is opposite to the measure of green beta. We argue that our green beta methodology offers several advantages over this alternative measure. Firstly, the cross-sectional coverage of our measure surpasses that of the hedge fund firm-level carbon risk measure. Our method enables the estimation of sensitivities toward a green factor for any hedge fund with observable returns. Consequently, our approach permits the calculation of green betas for hedge funds that lack other carbon-related measures, for which the strategy is inherently challenging to construct such metrics (e.g., commodity trading advisors (CTA)). The estimation process is transparent and uniform across all hedge funds, which does not rely on the voluntary disclosure of carbon-related information. Secondly, the green beta is computed at the individual fund level, whereas the carbon risk measure is determined at the hedge fund management firm level, which is prone to higher noise as one firm may comprise multiple funds with varying strategies. Our green beta measure can be directly employed to analyze the relationship between hedge fund green exposure and its performance, risk, and flows. Third, hedge funds may pursue decarbonization strategies by short-selling brown stocks, which is not reflected in the holding-based measures. Our return-based approach overcomes this issue by accounting for both long and short positions, capturing a more comprehensive representation of the hedge fund's efforts toward decarbonization. Nonetheless, as a robustness test, we examine the hedge fund holding-based carbon risk measure in Section 4, and the results are found to be consistent.

## 3. Empirical Results

### 3.1 Do hedge funds care about carbon risk?

We begin our analysis by examining whether hedge funds care about carbon risk and incorporate sustainable investing into their investment strategies. We first analyze hedge funds' ownership based on their 13F fillings. Figure 1 illustrates the distribution of hedge fund holdings across various industries. It shows that hedge funds tend to allocate a larger proportion of their investments toward companies within green industries, with an average of 35% of their capital invested in firms belonging to the lowest carbon risk quartile, as opposed to the 15% allocated to firms in the highest carbon risk quartile. Examining the time series trend, we observe a consistent increase in hedge funds' weights in green industries over the past decade, with a notable acceleration after 2015 when the Paris Agreement was adopted. During our sample period, the allocation to green industries has risen from 33% to 42%. In contrast, the weight of brown industries has steadily declined throughout our sample period, decreasing from 20% to 14%. Overall, these findings give us the first evidence that hedge funds do care about carbon risk and fund managers have actively rebalanced their portfolios toward a lower-carbon direction.

[insert Figure 1 about here]

Next, we examine hedge funds' trading behavior in greater detail. The observed increase in ownership of green firms and the decrease in ownership of brown firms could be driven by either positive screening (loading up on low-carbon risk companies) or negative screening (excluding high-carbon risk companies). To distinguish between these two mechanisms, we analyze hedge funds' quarterly trading patterns. In Figure 2, we plot the average weight of hedge fund quarterly net purchases, where the weight is defined as the net purchase value of firms divided by the total holding value of hedge funds in each quarter. It shows that over the past ten years, hedge funds have overall allocated their investment in the green industry, with their net purchases peaking in 2015 and again in 2020 due to COVID-19. Previous researchers have found that institutional shareholders have started to move away from high-carbon risk firms since the Paris Agreement (Choi et al., 2020). However, we observe that hedge funds do not completely exit the brown industry; they maintain a net purchase of approximately 10% of high-carbon firms each quarter. This is consistent with Pástor et al. (2023) that most of this divestment in brown firms involves reducing positions rather than eliminating them. Our findings lend greater support to the

positive screening mechanism, as hedge funds decarbonize their portfolios by increasing their holdings of green stocks while maintaining a presence in brown industry.

[insert Figure 2 about here]

Having established that hedge funds actively pivot their investments to the green industry, we further investigate hedge funds' trading behavior on the stock level. To achieve this, we employ a double-sorting methodology. Each year, we begin by categorizing firms into three ranks based on the industry's average carbon risk score. Firms with the lowest industry average carbon risk scores are classified as in the green industry, while those with the highest industry average carbon risk scores are classified as in the brown industry. Next, within each industry, we further categorize firms into three groups based on their carbon risk scores. This double sorting results in two ranks for each firm: one indicating their industry classification as green or brown, and the other reflecting their relative greenness within the industry.

We then examine hedge funds' trading behavior at the stock level, focusing separately on the green and brown industries. Figure 3 plots hedge funds' net quarterly trading for each category of stocks as a percentage of their previous quarterly holdings. It reveals several interesting findings. First, in line with the observations from Figures 1 and 2, hedge funds shift their investment to green assets (the net trading percentage for green assets is consistently higher than for brown assets, suggesting that hedge funds favor green stocks), while maintaining their position in brown assets (the net trading percentage for brown assets is positive). More importantly, we observe an asymmetrical trading pattern exhibited by hedge funds concerning the green and brown industries. When selecting stocks from the green industry, hedge funds demonstrate the ability to identify and select the firms with even higher relative green ranking within such an industry. However, when picking stocks from the brown industry, hedge funds do not appear to differentiate among firms within the industry. This asymmetry can be attributed to hedge funds' financial motivations. Research shows that green assets have outperformed in recent years due to growing climate concerns (Pástor et al., 2022). Companies leading the green industry are often at the forefront of innovation and have the most potential for significant growth as the world transitions to a low-carbon economy. Hedge funds, leveraging their resources and expertise, can identify these companies as attractive investment opportunities and subsequently profit from selecting the greenest firms within the green industry.

[insert Figure 3 about here]

Overall, these results regarding hedge funds' holding and trading behaviors carry a substantial implication: hedge funds demonstrate a genuine concern for carbon risk. They actively increase their ownership in green assets and adjust their allocation to prioritize the cleanest stocks within the green industry, while not completely divesting from the brown industry. This behavior underscores their recognition of the importance of addressing environmental factors and suggests a proactive approach toward integrating sustainability considerations into their investment strategies.

### 3.2 Hedge funds greenness and performance

As the hedge fund industry moves toward a more sustainable direction, there is significant diversity in the level of "greenness" (exposure to green assets) among different hedge funds. In this section, we explore the potential influence of hedge funds' greenness, as measured by the green beta introduced in Section 2.3, on their performance.

We start with the univariate analysis. Each month, funds are sorted into quintiles based on their green beta. We then evaluate the portfolio performance over the next month for funds in each quintile. We measure fund performance in two ways: fund excess return and the out-of-sample seven-factor alphas (Fung and Hsieh, 2004) using a rolling 24-month window. Panel A of Table III reports the results. We observe a monotonic increase in hedge fund performance as the fund's green beta increases. The time series average of equal-weighted alpha is 21 basis points per month for the funds in the highest quintile of green beta, which is 19 basis points higher than that for the funds in the lowest quintile. The spread widens to an economically significant 40 basis points when we consider fund excess return. This initial evidence suggests that high green beta funds outperform their low green beta counterparts.

The sorting results may be driven by other known factors that explain hedge fund returns. To alleviate this concern, we estimate the following multivariate regression:

$$Fund\ performance_{i,t+1} = \beta_0 + \beta_1 * Green\ beta_{i,t} + \beta_2 * Log(size)_{i,t} + \beta_3 * Age_{i,t} + \beta_4 * Lockup_{i,t} + \beta_5 * Management\ fee_{i,t} + \beta_6 * Incentive\ fee_{i,t} + \beta_7 * High\ water\ mark_{i,t} + \beta_8 * Leveraged_{i,t} + \varepsilon_{i,t} \quad (2)$$

where fund performance represents hedge fund excess return or the seven-factor alpha in the next month. Fund green beta is measured as the coefficient of the green factor (Pástor et al., 2022) when

regressing fund monthly return on the green factor and the seven-factor. Size is a fund's assets under management (AUM) in USD millions. Fund age measures years since the fund's inception date. The lock-up period is measured in months. Both management and incentive fees are reported in percentage. High-water mark is a dummy variable that takes the value of one if the hedge fund uses a high-water mark and zero otherwise. Leveraged is a dummy variable that equals one if the hedge fund uses leverage, and zero otherwise. We include year-month fixed effect and fund investment style fixed effect and cluster the standard errors by fund and month.

Panel B of Table III reports the regression results. The results show that fund future performance increases as fund green beta increases adjusting for various fund characteristics that could explain fund performance. The effects are both statistically and economically significant. Specifically, a one-unit increase in fund green beta will result in a 0.84% per annum (=0.07%x12) increase in fund alpha and a 1.75% (=0.146%x12) increase per annum in the excess return. Both coefficient estimates are significant at the 1% level. The signs of the coefficients on fund control variables broadly agree with the extant literature. Fund age is negatively associated with performance (Aggarwal and Jorion, 2010), and fund size positively relates to performance (Chen et al., 2022).

To summarize, this section provides empirical evidence that a hedge fund's green beta positively predicts the fund's performance, which is not driven by other fund characteristics. We will discuss the mechanism behind this finding in more detail in Section 3.5.

[insert Table III about here]

### 3.3 Hedge funds greenness and risk

Previous studies have established that stocks with lower carbon risk also have lower total risk (e.g., Bolton and Kacperczyk, 2021a; Engle et al., 2020) and tail risk (Ilhan et al., 2021). However, no consensus has been reached on how the risk properties behave at the portfolio level. One argument is that green portfolios have a high degree of industry concentration and thus will result in a high degree of return covariance. This heightened return covariance may curtail the diversification effect and reduce the risk-sharing effect at the portfolio or fund-holding level (Ceccarelli et al., 2021). Other researchers argue that low-carbon funds possess risk properties similar to their low-carbon holdings because the risk characteristics of brown securities cannot be diversified away from traditional portfolio strategies and are transferred to funds through their

holdings (Huan and Liang, 2021). Given their sophisticated nature as investors, the hedge fund industry provides an intriguing laboratory to explore this matter further.

To test whether the risk properties at the fund level exhibit differently from the individual stock level, we examine the relation between hedge fund green beta and fund risk, including both total risk and tail risk. Specifically, we run the following regression model:

$$Fund\ risk_{i,t+1} = \beta_0 + \beta_1 * Green\ beta_{i,t} + \beta_2 * Log(size)_{i,t} + \beta_3 * Age_{i,t} + \beta_4 * Lockup_{i,t} + \beta_5 * Management\ fee_{i,t} + \beta_6 * Incentive\ fee_{i,t} + \beta_7 * High\ water\ mark_{i,t} + \beta_8 * Leveraged_{i,t} + \varepsilon_{i,t} \quad (3)$$

Table IV reports the regression results. The dependent variables in Models (1) and (2) are fund total risk, which is the standard deviation of the monthly rate of returns. The dependent variables in Models (3) and (4) are fund tail risk, which is measured as a hedge fund two-year 95% value-at-risk (VaR). The results show that hedge funds with higher green beta exhibit both lower total risk and tail risks. Specifically, a one-unit increase in fund green beta is associated with a 0.073% decrease in fund total risk and a 0.12% decrease in tail risk. Although the economic impact may not be substantial in comparison to the average total risk of 2.77% and tail risk of 5.33% in Table I, both coefficients are statistically significant at the 5% level. Regarding the other control variables, fund size is negatively correlated with the total risk and tail risk, while the lock-up period is positively related to both risk measures. Overall, our analyses show that hedge funds benefit from better risk diversification effects when incorporating green factors in their investment strategies. Fund green beta negatively predicts fund risk. This finding carries a significant implication for investing and portfolio management. It underscores sustainable investing as a crucial strategy for investors to mitigate a novel source of risk that the traditional portfolio approaches may not address. Embracing green investment opportunities enables investors to enhance diversification outcomes.

[insert Table IV about here]

### 3.4 Do investors recognize green funds?

So far, we have provided evidence that greener hedge funds tend to achieve superior performance and exhibit lower risk profiles. In this section, we aim to examine whether hedge fund investors recognize green funds and reward them with larger capital inflows. To estimate

fund flows, we follow prior research (e.g., Sirri and Tufano,1998) and measure fund flows as follows:

$$Fund\ flows_{i,t} = \frac{[TNA_{i,t} - TNA_{i,t-1}(1+R_{i,t})]}{TNA_{i,t-1}} \quad (4)$$

where $TNA_{i,t}$ and $TNA_{i,t-1}$are the total net assets of hedge fund *i* at times *t* and *t*–1 respectively, and $R_{i,t}$ is the raw return from time *t*–1 to *t*. We then run regression analysis of fund flows on hedge fund green beta based on the following specifications:

$$\begin{aligned} Fund\ flow_{i,t+1} = {} & \beta_0 + \beta_1 * Green\ beta_{i,t} + \beta_2 * Log(size)_{i,t} + \beta_3 * Age_{i,t} + \beta_4 * Lockup_{i,t} \\ & + \beta_5 * Management\ fee_{i,t} + \beta_6 * Incentive\ fee_{i,t} + \beta_7 * \\ & High\ water\ mark_{i,t} + \beta_8 * Leveraged_{i,t} + \beta_9 * \\ & Past\ performance\ rank_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (5)$$

where the dependent variable $Fund\ flow_{i,t+1}$ is defined in equation (4). $Past\ performance\ rank_{i,t}$ is calculated as either past 12-month fund return rank (past return rank) or alpha rank (past alpha rank). All the other control variables are the same as in previous regressions.

Panel A of Table V reports the regression results. It shows that hedge funds with higher green beta attract greater investor flows after controlling for past fund performance and a variety of fund characteristics. Specifically, one unit increase of green beta will result in a 0.3% increase in next quarter's fund flows. This effect is economically significant, equivalent to an inflow of $1.03 million per quarter. We can also see that investors are chasing well-performed hedge funds as the coefficients for both past return rank and past alpha rank are positively significant at the 1% level. In contrast, fund size and age are negatively correlated with future fund flows.

The flow premium associated with greener funds could also be affected by the evolving awareness of hedge fund investors regarding carbon risk. In recent years, hedge fund investors such as pension funds and endowments, are increasingly requiring their investments to align with their sustainability objectives and push hedge funds to adopt greener strategies. To capture the shift in sentiment toward carbon risk, we follow previous literature and use the 2015 Paris Agreement as a cutoff point. The Paris Agreement raised societal awareness of the risks tied to carbon emissions and the prospect of regulatory interventions (Bolton and Kacperczyk, 2021). Consequently, we anticipate an increase in the flow premium for green funds following the agreement. To test this hypothesis, we estimate the regression model in equation (5) separately for

two sub-periods: 2012-2014 (pre-Paris Agreement) and 2015-2021 (post-Paris Agreement). Furthermore, investors' attitudes toward green funds may differ depending on fund performance. To account for this aspect, we further divide our sample into two groups-high alpha funds and low alpha funds, within each sub-period.

We report the results in Panel B of Table V. We find that flow premium is only significant for funds with high alpha within the subsample period after the 2015 Paris Agreement. Specifically, one unit increase of green beta will result in a 0.8% increase in next quarter's fund flows. However, this relationship does not exist in the pre-Paris Agreement period or for low alpha funds in the post-Paris Agreement period. These findings reveal several interesting aspects. First, it confirms that hedge fund investors' awareness of climate risks is constantly evolving, and consistent with other studies, the 2015 Paris Agreement played a pivotal role. Moreover, these investors are not willing to sacrifice returns for green funds. They reward green funds with higher inflows only when these funds can generate high alphas. In other words, investors primarily chase performance and then seek green characteristics when the funds meet their return expectations.

[insert Table V about here]

### 3.5 What explains the green beta-fund performance relation?

We continue to investigate what drives green hedge funds' outperformance. Given the existence of "green premium" as documented by other researchers, one might question whether this outperformance stems merely from green funds' increased exposure to green assets with higher returns, or whether it reflects the superior green investing skills of the green fund managers. We are interested in whether hedge fund managers exhibit superior green investing skills. Specifically, in this section, we delve into the mechanism behind green funds' outperformance by investigating two potential explanations: green picking skill and green timing skill. It is important to emphasize that the two explanations are not mutually exclusive.

#### 3.5.1 Green picking skill

One potential explanation for the outperformance is that hedge fund managers with high green betas are better at picking under-valued green stocks. To test this conjecture, we follow Kacperczyk et al (2014) and measure hedge fund manager's green stock picking skills as follows:

$$Green\ picking\ skill_{i,t} = \sum_{j=1}^{N^i} \left(w_{j,t}^{i} - w_{j,t}^{m}\right)\left(R_{t+1}^{j} - \beta_{j,t}R_{t+1}^{m}\right) \quad (6)$$

where $w_{j,t}^{i}$ is hedge fund firm *i*'s portfolio weight in stock *j* at the start of quarter *t* and $w_{j,t}^{m}$ is the market weight in stock *j*. The covariance of stock *j*'s return, $R^{j}$, with the market return, $R^{m}$, divided by the variance of the market return is $\beta_{j}$. *N* is the number of green firms. A fund with a high green-picking ability holds a larger fraction of a green firm in periods when that firm's realized stock return is high.

Since the green stock picking skill is calculated using 13F holdings data and is captured at the hedge fund firm level, we aggregate individual fund level green betas and other control variables to the hedge fund firm level using both equal-weighted and value-weighted methods. We then regress hedge fund firm green-picking skills on the aggregated green beta and other characteristics in the following regression:

$$\begin{aligned} Green\ picking\ skill_{i,t+1} = {} & \beta_0 + \beta_1 * Green\ beta_{i,t} + \beta_2 * Log(size)_{i,t} + \beta_3 * Age_{i,t} \\ & + \beta_4 * Lockup_{i,t} + \beta_5 * Management\ fee_{i,t} + \beta_6 * Incentive\ fee_{i,t} \\ & + \beta_7 * High\ water\ mark_{i,t} + \beta_8 * Leveraged_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (7)$$

Table VI reports the regression results. The coefficient of the variable of interest is positive and significant across all models in both equal-weighted and value-weighted settings. It shows that hedge funds' green beta is linked to green-picking skills, indicating that managers of green hedge funds exhibit exceptional green stock selection abilities. This finding expands Aragon et al. (2023), which shows that green stocks selected by all hedge funds outperform certain green benchmark indexes. Our analysis suggests that such outperformance can mainly be attributed to green hedge funds. Overall, we document that green hedge fund managers engage in more than just allocating assets to green firms. They also possess the skill to identify and invest in the better-performing companies within the green industry. This conclusion resonates with the research of Ceccarelli et al. (2022), which emphasizes that ESG-aware mutual funds are characterized by their specific investment skills in ESG, further affirming the existence of specialized investment acumen in the realm of green and ESG-focused investing.

[insert Table VI about here]

Having demonstrated that green fund managers are adept at selecting better-performing green stocks, we broaden our investigation to examine the characteristics of green firms that

capture the interest of these funds. Our focus centers on whether these firms possess sustainability-related information not yet reflected in market prices. We analyze this information across two dimensions: carbon reduction and green innovation. Specifically, we estimate the following linear regression model:

$$\Delta Firm\ Characteristics_{j,n} = \beta_0 + \beta_1 * Overweight_{j,t} + \beta_2 * BMratio_{j,t} + \beta_3 * Return_{j,t} + \beta_4 * Log(size)_{j,t} + \beta_5 * ROA_{j,t} + \varepsilon_{j,t} \quad (8)$$

where $\Delta Firm\ Characteristics_{j,n}$ represents the change in firm *j*'s carbon risk score or change in the number of green patents firm issues *n* years from year *t*. We let *n* take the values of respectively 1, 2, and 3 years. $Overweight_{j,t}$ is defined as the difference between stock *j*'s portfolio weight in the green hedge fund and the market portfolio where the green hedge funds are defined as the funds in the top quintile of green beta. We control the firm book to market ratio, return, log of size, and return-to-asset ratio. We also control for year and industry fixed effect and cluster standard errors at the firm level.

Table VII presents the regression results. We observe that green hedge funds are inclined to favor firms poised for future carbon emission reduction or an increase in green innovation. Specifically, a 10% overweight by green hedge funds is associated with a reduction in carbon emissions by 48.85% in the short term (three years) and 63.73% in the longer term (five years). Additionally, these firms generate on average 8.16 (three consecutive years) to 7.46 (five years) more green patents. These findings imply that the firms selected by green hedge funds hold sustainability information that is yet to be discovered by the market, making it challenging for other investors to precisely evaluate their future potential in carbon reduction or green innovation. However, green hedge fund managers are able to identify these firms whose green attributes are under-valued by the market. As a result, when the market eventually adjusts to fully account for this information, green hedge funds stand to gain substantial returns. Our analysis highlights that the outperformance of green hedge funds is not solely due to their exposure to green stocks. Instead, it also stems from their ability to identify firms whose green value is underestimated. This edge is derived from managers' deep understanding and exploitation of uncertain sustainability information, demonstrating the sophisticated investment skills of hedge fund managers.

[insert Table VII about here]

### 3.5.2 Green timing skill

Another explanation attributes the outperformance of green hedge funds to their green timing skills. In general, timing ability refers to the ability of fund managers to adjust factor exposures at opportune times as market conditions change. Prior hedge fund studies find evidence of timing skills concerning market returns, volatility, liquidity, and macro uncertainty (e.g., Chen (2007), Chen and Liang (2007), Cao et al. (2013), Bali, Brown, and Caglayan (2014). In our analysis, we focus on funds' green timing skills and examine whether hedge funds are capable of anticipating shifts in the green factor and adjusting their asset allocation accordingly. Specifically, we test two conjectures. First, we investigate if green fund managers can time their exposures to the green factor, increasing green beta when there is a favorable shift in the green factor and subsequent superior performance of green assets. Our second conjecture is that green timing skills contribute to performance. We expect hedge funds with positive green timing skills to produce higher alpha.

We begin by measuring green timing skill at the individual fund level. We propose a green timing model based on the classic market timing model of Henriksson and Merton (1981) in which fund managers have higher (lower) exposure to the stock market when market returns are expected to be higher (lower). We examine the dynamics of hedge fund exposure to the green factor. Specifically, for each hedge fund with at least 24 monthly return observations, we perform the green timing regression:

$$r_{i,t} = \alpha + \beta_g f_{green,t} + \gamma f_{green,t} \times \boldsymbol{I}(g\_sentiment_t - \overline{g\_sentiment_t}) + \sum_{j=1}^{J} \beta_j f_{j,t} + \varepsilon_{i,t} \quad (9)$$

where $r_{i,t}$ is the excess return on fund $i$ in month $t$, $\beta_g$ is the hedge fund green beta, $f_{j,t}$ is the green factor, and $\boldsymbol{I}$(.) is a dummy variable equal to 1 when the market overall green sentiment is greater than its time series mean, and 0 otherwise. Green sentiment is proxied by the climate news sentiment index from *The Wall Street Journal.* The coefficient $\gamma$ picks up the fund manager's green timing skill. A fund manager with the ability to time the green factor would dynamically adjust their exposure to the green factor and increase the fund's exposure to the green factor when the market's overall green sentiment is high, leading to a positive γ in regression (9). We therefore refer to $\gamma$ as the measure of the green timing coefficient.

Next, we are interested in whether heterogeneity in hedge fund green timing skill is related to the cross-sectional dispersion in hedge fund green beta. We regress hedge fund green timing skills on fund green beta and control for other characteristics in the following regression:

$$Green\ timing\ skill_{i,t+1} = \beta_0 + \beta_1 * Green\ beta_{i,t} + \beta_2 * Log(size)_{i,t} + \beta_3 * Age_{i,t} + \beta_4 * Lockup_{i,t} + \beta_5 * Management\ fee_{i,t} + \beta_6 * Incentive\ fee_{i,t} + \beta_7 * High\ water\ mark_{i,t} + \beta_8 * Leveraged_{i,t} + \varepsilon_{i,t} \quad (10)$$

We find that the hedge fund green timing skill and green beta are significantly positively correlated, as shown in Table VIII. This result supports our first conjecture, which holds that green hedge funds tend to have better green timing skills. Our findings reveal that although green hedge funds have higher green beta and larger allocation to green stocks, their exposure to green factors is not constantly high at all time periods. Instead, they strategically change their exposure to the green factor, increasing the fund's green beta when the market's overall green sentiment is high and decreasing the fund's green beta when the market's overall green sentiment is low[12].

[insert Table VIII about here]

Finally, to investigate whether green timing skill contributes to fund performance, we regress one-month-ahead fund performance (excess return or alpha) on the green timing coefficient. The green timing coefficient is estimated from running regression (9) using data from a 24-month backward-looking rolling window. As in Table IX, regardless of whether we use the excess return or alpha as the dependent variable, the coefficient of the green timing skill is positive and statistically significant. Meanwhile, green beta continues to exhibit a strong relation with hedge fund performance. Consistent with our second conjecture, we find that the green timing coefficient does indeed contribute to hedge fund performance. In line with the bubble-riding behavior documented in Brunnermeier and Nagel (2004) and Chen et al. (2021), our evidence shows that green hedge funds are skilled at timing investor green sentiment and realize higher returns.[13]

[12] On average, green factor is positive in our sample period from 2012 to 2021. However, there exists a large time series variation in green factor and 36% of the time the green factor is negative in our sample.

[13] In an untabulated table, we looked into the market timing skill of hedge funds and found no evidence that greener hedge funds possess better market timing abilities compared to other hedge funds. This does not imply that greener funds are unable to time the market; rather, it suggests that they may possess strong market-timing skills but do not significantly differentiate themselves from other hedge funds. The insignificant coefficient associated with market timing skills further supports the notion that the outperformance of greener hedge funds stems from their superior green picking and green timing skills.

[insert Table IX about here]

In conclusion, our findings suggest that the outperformance of green hedge funds is not merely a result of luck, but rather a reflection of their distinct expertise in green investing. We investigate their green investing skill in two aspects: green picking skills and green timing skills. In addition to their exceptional abilities to identify and prioritize green firms whose green value is not fully recognized by the market, green hedge fund managers also can time green factor and adjust their positions accordingly. Both the green picking skill and green timing skill contribute to superior fund performance.

### 3.6 What affects hedge fund greenness?

Having demonstrated that there exists a large variation in hedge fund greenness among different funds, we now turn to investigate what factors influence the hedge fund's exposure to green assets. In this section, we test four potential channels: political belief, climate news sentiment, joining the UN PRI initiative, and exposure to air pollution.

#### 3.6.1 Political belief

The role of political belief has increasingly become a salient factor in shaping individuals' attitudes toward climate change. Studies have shown that Republican-leaning votes are more likely to exhibit resistance towards climate issues (Hong and Kostovetsky, 2012; Di, Giuli, and Kostovetsky, 2014). Additionally, the surrounding community's attitude also plays an important role. Researchers have documented that regions with a higher Republican presence tend to be less inclined to believe in the occurrence of climate change (Baldauf, Garlappi, and Yannelis 2020). Furthermore, studies show mutual fund families located in pro-environmental states demonstrate a significantly greater reduction in emissions after signing the PRI compared to fund families in states with less environmental concern (Humphrey and Li, 2021). Building upon this body of literature, we thus conjecture that hedge funds located in Republican-leaning states are less likely to be concerned about carbon risk than those located in Democrat-leaning states.

To test whether hedge funds share their local public views about carbon risk, we regress each hedge fund's greenness on a dummy variable that equals to one if the hedge is in a Republican state, and zero otherwise. Following prior research (Bae et al., 2021; Bhandari and Golden, 2021; Dunbar et al., 2020; Hutton et al., 2014), we identify a state as Republican-leaning if a Republican

presidential candidate won the most votes in that state during the most recent Presidential election and vice versa. We also include the control variables that are the same as those in equation (2). Panel A of Table X reports the regression results. In columns (1) and (2), the dependent variables are the hedge fund's green beta. In columns (3) and (4), the dependent variables are the carbon risk score at the fund level, which is calculated as the value-weighted average carbon risk score of the hedge fund's total stock holdings. Both the green beta and the carbon risk score measure a fund's greenness, where a higher green beta is associated with a lower carbon risk score. The coefficients in columns (1) and (2) are significantly negative, while those in columns (3) and (4) are significantly positive. These results indicate that funds located in Republican-leaning states have lower exposure to green assets and exhibit higher carbon risk at the fund level. These findings align with the notion that hedge funds located in pro-environmental states are more inclined to incorporate environmentally friendly investments and transition towards a low-carbon economy.

Our second conjecture is to examine whether hedge fund investors' reaction to green funds also correlates with their political leanings. We run the same regression as in equation (5) in two subsamples: funds in Republican-leaning states and funds in Democrat-leaning states and focus only on post Paris Agreement period from 2015 to 2021. Panel B of Table X reports the regression results. We observe that the coefficient for green beta is positively significant in column (4), where hedge funds are in Democrat-leaning states and achieve high alphas. In all the other columns, the coefficient is not significant. This result suggests that greener funds attract greater fund flows in Democratic state conditioning on the fund generating high alpha, while there is no such green flow premium for funds located in Republican states even for outperforming funds.

Collectively, our findings underscore the influential role of local community political belief in driving peoples' attitudes and actions toward climate change. Both hedge funds and hedge fund investors are notably influenced by the prevailing attitudes within their respective geographic locations toward climate-related concerns. Hedge funds situated in Democratic states possess a dual characteristic: they not only showcase a stronger dedication to sustainable practices but also attract a substantial influx of investor capital due to their commitment to sustainable investing.

[insert Table X about here]

### 3.6.2 Climate news sentiment

Over the past decade, we have witnessed a significant surge in climate concerns, which has inevitably had an impact on various stakeholders within the financial industry, including both hedge fund managers and investors.[14] On the one hand, this heightened awareness of climate-related risks can alert fund managers to the severity and urgency of climate change risk and thus change their investment behavior. Meanwhile, the increased climate concerns will also influence investor behaviors as they seek to allocate capital to funds that align with their sustainability objectives. On the other hand, hedge funds and investors may also need to adjust their holdings so that they can hedge against climate news, particularly during periods of pronounced negative climate news sentiment. Such hedging portfolios can be constructed without changing their exposures to the other risk factors in their portfolios (Engle et al., 2020). In this section, we examine how climate news sentiment influences the behavior of hedge fund managers and investors.

We follow Engle et al. (2020) to construct an index to measure climate news sentiment from major U.S. newspapers. The index is calculated as the correlation between the text content of *The Wall Street Journal* (WSJ) each month and a fixed climate change vocabulary. We measure shocks to climate news sentiment as prediction errors from AR (1) models applied to the underlying WSJ climate change news index.[15] In each month, we regress the hedge fund greenness-fund level green beta or portfolio carbon risk score on the WSJ climate news shock in the previous month[16] and include other control variables. Panel A of Table XI shows the regression results. As expected, the coefficients are significantly positive in columns (1) and (2), where the variable of interest is the hedge fund green beta. The coefficients are significantly negative in columns (3) and (4), where the variable of interest is portfolio carbon risk. Overall, the results suggest that hedge funds adjust their portfolio exposure to greener assets and exhibit lower carbon risk after unexpected climate news shocks.

[14] Sautner et al. (2021) offer corroborating evidence indicating an intensification of climate concerns subsequent to 2012. The authors assess firms' exposure to climate change by quantifying the degree to which climate change-related topics are addressed during earnings calls. Their analysis reveals a marked escalation in climate change exposure during the period spanning from 2013 to 2018.

[15] Please refer to Engle et al. (2020) for how to construct the index.

[16] Pástor et al. (2022) show evidence of delayed stock price reactions to climate news.

We next examine whether increased climate news concerns have an impact on investors' behavior. Specifically, we augment our regression analysis in equation (5) by incorporating the WSJ climate news shock variable, as well as the interaction term between the WSJ climate news shock variable and fund green beta. As shown in Panel B of Table XI, the coefficient of the interaction term is positive and significant when the climate news sentiment is most pronounced. This finding indicates that investors actively allocate more capital toward greener funds when the social sentiment on climate change is extremely high. The positive effect of green beta on hedge fund flows will be intensified when the news coverage on climate change is strong.

In sum, our findings reveal that both hedge fund managers and investors are influenced by climate change sentiment. Following a shock in climate news, fund managers load more on greener stocks, and investors channel capital into more environmentally oriented funds.

[insert Table XI about here]

### 3.6.3 Effect of joining the UN PRI

In recent years, there has been a notable increase in the number of hedge funds becoming signatories to the UN Principles for Responsible Investment (PRI). Upon becoming signatories, hedge funds are obligated to exhibit a dedication to responsible investment practices. To facilitate the adoption and implementation of such practices, the PRI has developed various resources including a due diligence questionnaire, a technical guide on the integration of ESG factors in hedge fund strategies, and resources that address short selling and responsible investment considerations.[17] Humphrey and Li (2021) discovered that mutual fund families that become signatories to the PRI exhibit significantly reduced portfolio emissions following their commitment to the initiative compared to non-signatory counterparts. On the other hand, Liang, Sun, and Teo (2022) argue that hedge funds mainly use the PRI as a window-dressing narrative and their cross-sectional analysis shows that hedge funds that are the PRI signatories exhibit higher ESG risk compared to non-PRI signatories.

We use a difference-in-difference (DID) setting to further explore whether joining the PRI initiative causes hedge funds to change their sustainable investing practice and increase their exposure to green assets. Since the signatories are assigned at the hedge fund management firm

[17] See https://www.unpri.org/investor-tools/hedge-funds.

level, we aggregate fund green beta, carbon risk score, and other control variables at the firm level and use the following specifications:

$$Greenness_{j,t} = \beta_0 + \beta_1 * UNPRI * Post + \beta_2 * Log(size)_{j,t} + \beta_3 * Age_{j,t} + \beta_4 * Lockup_{j,t} + \beta_5 * Management\ fee_{j,t} + \beta_6 * Incentive\ fee_{j,t} + \beta_7 * High\ water\ mark_{j,t} + \beta_8 * Leveraged_{j,t} + \beta_9 * Past\ return_{j,t} + \varepsilon_{j,t} \quad (11)$$

where the dependent variable $Greenness$ is either hedge fund green beta or firm-level carbon risk score. $UNPRI$ takes a value of 1 if a hedge fund firm is a PRI signatory and 0 otherwise. $Post$ takes a value of 1 after the hedge fund firm signs the PRI and 0 before. The main variable of interest is the interaction term of $UNPRI$ and $Post$. We control for fund firm fixed effect and time fixed effect which absorb the two dummy variables of $UNPRI$ and $Post$. All other control variables are defined the same as previous equations.

Penal A of Table XII reports the regression results. The coefficient of the interaction term is positive in columns (1) and (3) where the variable of interest is the fund green beta, and negative in columns (2) and (4) where the variable of interest is portfolio carbon risk. The coefficients are statistically significant across all models. This indicates that after signing the PRI initiative, hedge fund firms actively increase their exposure to green assets (higher green beta) and decrease the holdings of high carbon risk stocks (lower portfolio carbon risk score). Our results extend the findings of Liang, Sun, and Teo (2022). Our analysis focuses on the time-series differences in hedge fund firms' behavior and examines the effects of joining the PRI within a difference-in-differences (DID) framework. Our findings establish the causal effects of joining the PRI on increasing hedge funds' sustainable investing practices.

We further investigate whether investors respond to hedge funds joining the PRI. Prior literature has demonstrated a flow premium to signatory mutual funds compared to non-signatory funds (Humphrey and Li, 2021; Kim and Yoon, 2023). We aim to test whether there exists a similar pattern in hedge funds. We augment our regression analysis in equation (9) and replace the dependent variable with annual fund flows aggregated at the firm level. As shown in Panel B of Table XII, investors respond positively to hedge fund firms after they sign the PRI as the coefficient for the interaction term is all positively significant. This result is in line with Liang et al. (2022) but we do not observe hedge fund greenwashing.

To conclude, our findings build upon and extend previous studies. We observe that hedge funds, upon joining the PRI initiative, exhibit a notable increase in their allocation to green assets, while concurrently reducing their exposure to carbon-intensive firms. This finding underscores the effectiveness of the PRI in promoting responsible investment behavior within the hedge fund industry. Furthermore, our analysis reveals that investors respond positively to the pro-environmental signal conveyed by hedge funds when they become signatories to the PRI. This indicates that hedge fund investors recognize and appreciate the commitment of hedge funds to incorporating sustainable and responsible investment practices.

[insert Table XII about here]

We also examine whether a hedge fund's exposure to local air pollution affects a fund's sustainable investing practice, utilizing the Air Quality Index (AQI) data[18] to measure air pollution. We find no evidence that air pollution alters the attitude of hedge fund managers or investors toward sustainable investing. The regression analysis and results are discussed in Table A4 of Appendix II.

**4. Robustness**

An alternative method for evaluating a hedge fund's exposure to the green factor involves calculating the value-weighted average carbon risk score using stock holding information from hedge fund firms (Liang et al., 2022). With this approach, higher carbon risk scores represent browner firms, while lower scores signify greener firms. Because the carbon risk score can only be calculated at the hedge fund firm level, we assign each fund within the same firm with the same carbon risk score. To investigate whether the results are sensitive to our measurement of green beta, we reproduced the baseline results using a holdings-based carbon risk score.

We report the estimates of these regressions in Table A5 in Appendix II and show that our results remain strongly significant in these specifications. Specifically, we observe negative coefficients in columns (1) and (2), suggesting that hedge funds with higher carbon risk exposure are associated with lower raw returns and risk-adjusted returns. As for the risk, higher carbon risk hedge funds tend to have both higher total risk and tail risk as shown in columns (3) and (4). The coefficients are all significant at least at the 10% level though this carbon risk measure is noisier

[18] The Air Quality Index (AQI) data are from the Environmental Protection Agency's (EPA) Air Quality System (AQS) database.

because the carbon risk score is not measured at the individual fund level. We cannot directly compare the magnitude of the coefficients for the carbon risk score with the one for green beta in the baseline test because of different scales. Our findings indicate that our overarching conclusion remains robust regardless of the specific measure of hedge fund environmental sustainability selected for analysis.

## 5. Conclusion

This study delves into various crucial aspects of sustainable investing practices within the hedge fund industry. Through the development of a unique metric (termed green beta) to assess the extent to which fund returns align with green factor returns, we can assess the level of hedge fund involvement in green investments at the individual fund level. In summary, we offer the initial empirical evidence regarding hedge funds' approach to managing climate change risk and demonstrate their active transition towards a low-carbon investment profile in our sample. We present compelling evidence demonstrating that hedge funds with greater exposure to green assets not only significantly outperform their counterparts but also exhibit reduced risk levels. This result is at odds with the conventional view that environmentally sustainable investing is costly as asset managers have to sacrifice returns for nonpecuniary benefit. Our result does lend support, however, to the view that skilled managers can improve fund performance via "doing well by doing good" and limit the risk while keeping investing green.

We show that green hedge funds' outperformance stems from fund managers' superior green investing skills. Specifically, we investigate two distinct but not mutually exclusive skills. The first explanation, green stock picking skill, holds that the outperformance of high green beta hedge funds comes from the fund manager's ability to analyze highly uncertain environmentally sustainable information and identify undervalued green stocks. This specific ability helps funds to identify and favor green firms whose greenium (i.e., green stock premium) is undiscovered and undervalued by other market participants. The green firms favored by green hedge funds reduce their carbon emission and produce more green innovations in the future. The second explanation attributes green funds' performance to fund managers' green factor timing skill. Green timers exhibit both high green betas and large alphas and returns. Skilled green fund managers are able to profit from fluctuations of green factors by predicting changes in the return of green stocks.

Both green picking skills and green timing skills enhance fund performance and empower hedge funds to optimize their portfolios towards a more sustainable trajectory.

We then analyze investor reactions to green hedge funds and document that hedge funds with larger green beta attract greater investor fund flows, particularly following the implementation of the 2015 Paris Agreement. However, investors only reward green funds with higher fund inflows when these funds can generate significant alphas. These findings shed light on the multifaceted nature of hedge fund investors' utility function. In addition to social preferences and signaling, financial motives also factor into their decision-making process when it comes to sustainable investment choices. This nuanced perspective underscores the importance of considering both social and financial aspects in understanding the behavior of hedge fund investors within the context of sustainable investing.

Finally, our study unveils the impact of political belief, climate news sentiment, and participation in the UN Principles for Responsible Investment (PRI) on hedge funds' engagement in sustainable investing and investor flows. Specifically, we find that hedge funds located in Republican-leaning states exhibit lower green beta and higher carbon risk compared to those in Democrat-leaning states. Furthermore, greener funds attract greater investor flows in Democrat-leaning states, while no such green flow premium is observed in Republican-leaning states. Moreover, we document that both hedge fund managers and investors are influenced by the prevailing news sentiment surrounding climate change. Climate news sentiment shock leads to more asset allocation toward green stocks by fund managers and increase in fund flows to greener funds from investors. Lastly, we provide evidence that hedge funds, upon signing the PRI initiative, actively increase their exposure to green assets while reducing their holdings of high-carbon-risk stocks. Hedge fund investors demonstrate positive response to these hedge fund firms by increasing fund flows.

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**Figure 1. Hedge Fund Holdings by Firm Industry**

This figure plots the weight of hedge fund 13F holdings sorted by firms' industry. Each quarter firms are sorted into quartiles based on their industry average carbon risk scores. Green industry firms include firms whose industry is in the lowest carbon risk quartile. Brown industry firms include firms whose industry is in the highest carbon risk quartile. Weight is defined as the holding value of firms in each quartile divided by the total holding value of hedge funds. The sample includes all the 13F stocks held by hedge funds from TASS, HFR, and Morningstar CISDM databases. The sample period is 2012 to 2021.

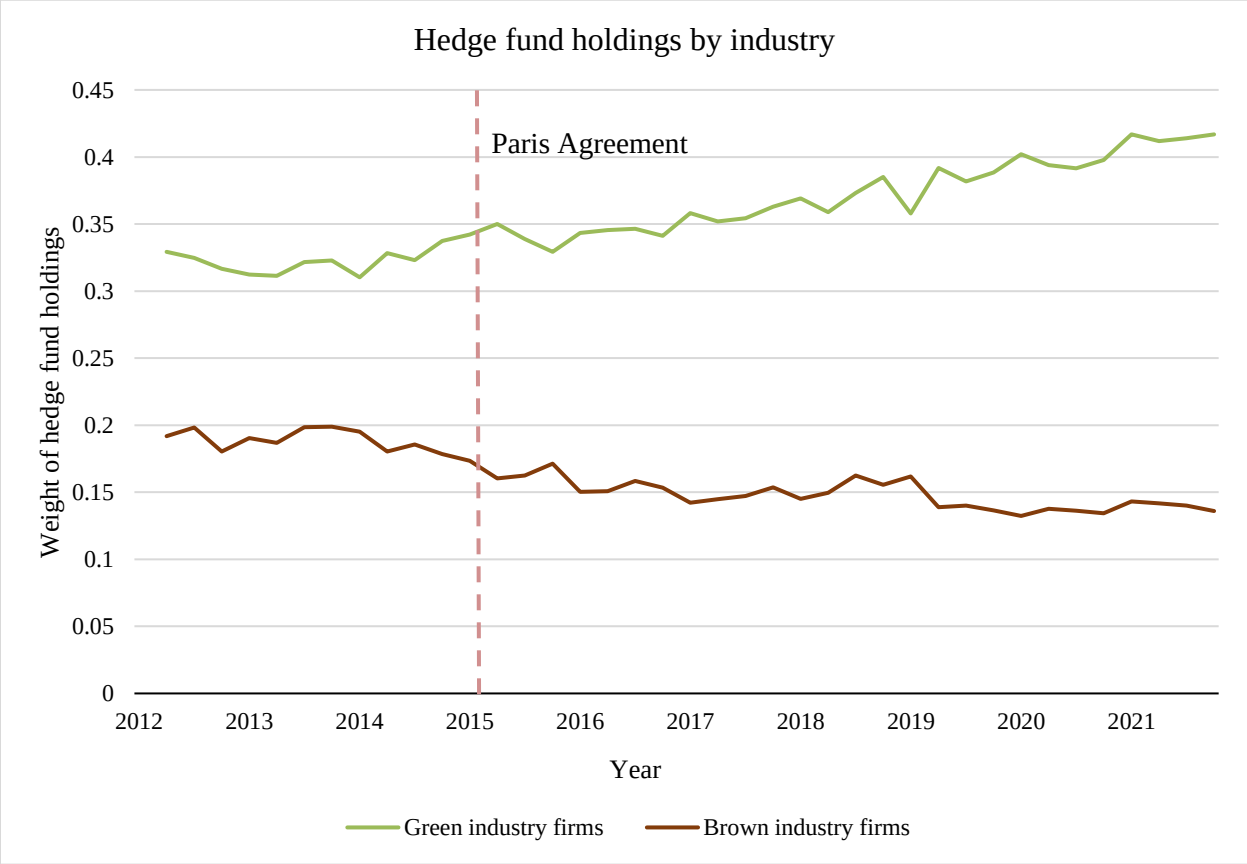

**Figure 2. Hedge Fund Net Purchase by Firm Industry**

This figure plots the average weight of hedge fund quarterly net purchases sorted by firms' industry. Each year firms are sorted into 3 ranks based on their industry average carbon risk scores. Green industry includes firms whose industry is in the lowest carbon risk rank. Brown industry includes firms whose industry is in the highest carbon risk rank. Weight is defined as the net purchase value of firms in each rank divided by the total holding value of hedge funds in each quarter. The sample includes all the 13F stocks held by hedge funds from TASS, HFR, and Morningstar CISDM databases. The sample period is 2012 to 2021.

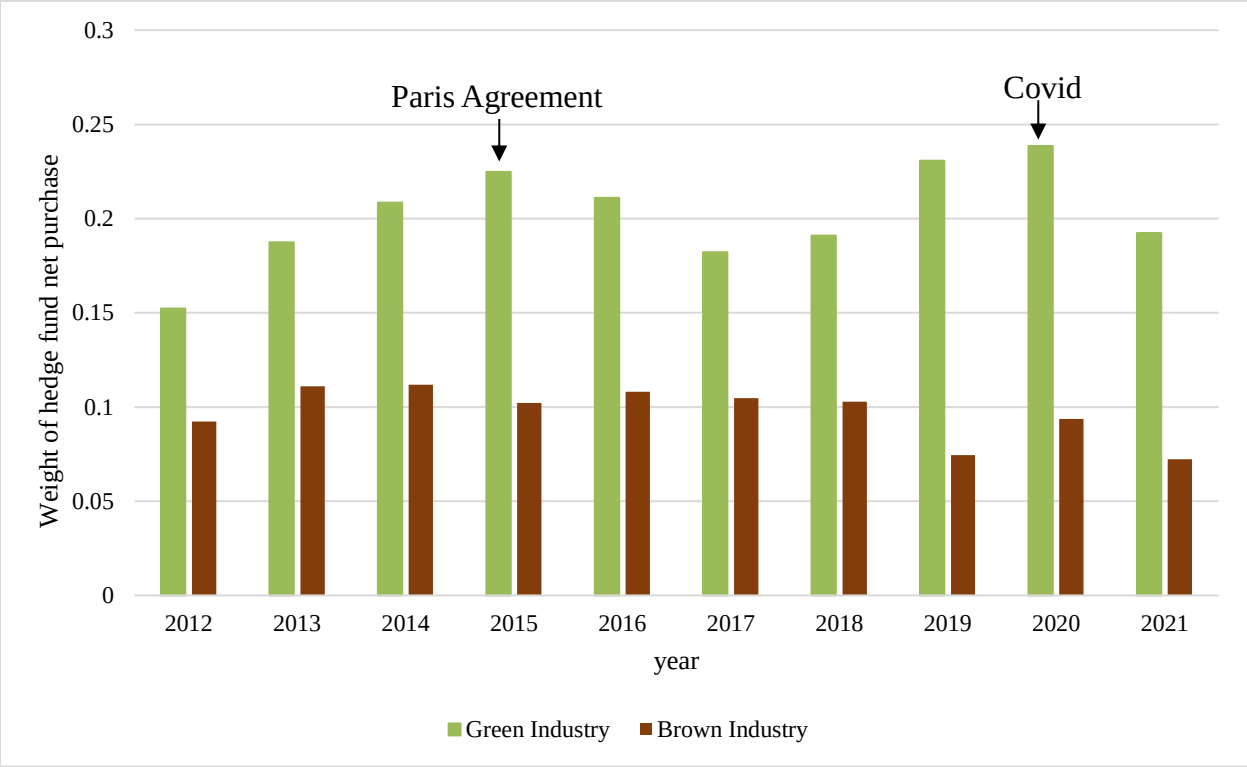

**Figure 3. Hedge Fund Net Purchase by Firm Industry**

This figure plots the weight of hedge fund quarterly net purchase (total purchase minus total sell) sorted by firms' industry. Each year firms are first sorted into 3 ranks based on their industry average carbon risk scores. Green industry firms include firms whose industry is in the lowest carbon risk rank. Brown industry firms include firms whose industry is in the highest carbon risk rank. Within each industry, firms are further sorted into another 3 ranks based on their carbon risk scores. Panel A reports the hedge fund net purchase in the green industry. Panel B reports the hedge fund net purchases in the brown industry. Weight is defined as the net purchase value of firms in each category divided by the total holding value of hedge funds in each quarter. The sample includes all the 13F stocks held by hedge funds from TASS, HFR, and Morningstar CISDM databases. The sample period is 2012 to 2021.

Figure A: Hedge fund net purchase in the green industry

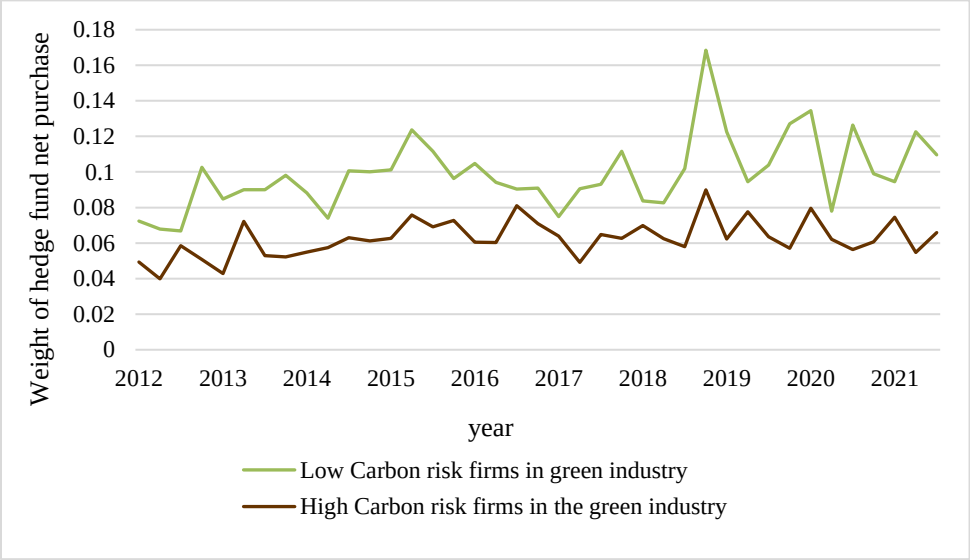


Figure B: Hedge fund net purchase in the brown industry

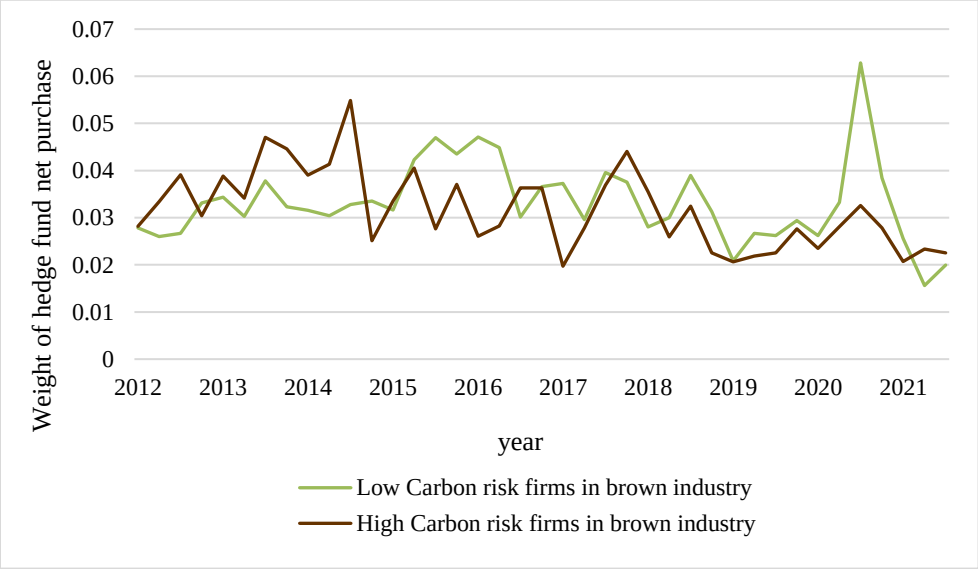

**Table I. Summary Statistics**

Panel A: Descriptive Statistics of Fund Characteristics

| | Mean | Median | S.D. | Min | Max |
|---|---|---|---|---|---|
| AUM (US $m) | 346.63 | 85.31 | 775.52 | 0.51 | 5,004.00 |
| Management fee (%) | 1.36 | 1.50 | 0.45 | 0.25 | 2.00 |
| Incentive fee (%) | 15.15 | 20.00 | 8.02 | 0.00 | 25.00 |
| High water mark (dummy) | 0.72 | 1.00 | 0.45 | 0.00 | 1.00 |
| Leveraged (dummy) | 0.59 | 1.00 | 0.49 | 0.00 | 1.00 |
| Redemption period (days) | 85.25 | 90.00 | 88.98 | 0.00 | 365.00 |
| Lock-up period (months) | 4.55 | 0.00 | 7.17 | 0.00 | 36.00 |
| Rate of return (%) | 0.55 | 0.54 | 3.20 | -10.33 | 10.79 |
| Alpha (%) | 0.12 | 0.10 | 0.69 | -1.81 | 2.23 |
| Fund age | 8.82 | 7.00 | 6.60 | 0.00 | 28.00 |
| Flow (%) | 0.55 | 0.03 | 0.75 | -25.23 | 42.36 |
| Total risk (%) | 2.77 | 2.51 | 1.49 | 0.45 | 7.05 |
| Tail risk (%) | 5.33 | 4.74 | 3.07 | 0.38 | 10.39 |
| Fund green beta | 0.01 | 0.03 | 0.99 | -3.33 | 2.87 |
| Fund carbon risk score | 11.54 | 11.07 | 6.23 | 0.00 | 36.01 |

Panel B: Correlation Matrix

| | AUM | Manage-ment fee | Incen-tive fee | High water-mark | Leve-raged | Redemp-tion period | Lock up period | Rate of return | Alpha | Fund age | Flow | Total risk | Tail risk | Green beta |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AUM | 1 | | | | | | | | | | | | | |
| Management fee | 0.03 | 1 | | | | | | | | | | | | |
| Incentive fee | -0.04 | 0.32 | 1 | | | | | | | | | | | |
| High water mark | -0.06 | 0.25 | 0.83 | 1 | | | | | | | | | | |
| Leveraged | 0.08 | 0.00 | 0.23 | 0.28 | 1 | | | | | | | | | |
| Redemption period | 0.01 | 0.07 | 0.40 | 0.36 | 0.00 | 1 | | | | | | | | |
| Lock up period | -0.02 | 0.22 | 0.31 | 0.30 | -0.02 | 0.23 | 1 | | | | | | | |
| Rate of return | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 | 0 | 1 | | | | | | |
| Alpha | 0.08 | 0.21 | 0.13 | 0.12 | 0.02 | 0.08 | 0.07 | 0.11 | 1 | | | | | |
| Fund age | 0.09 | -0.15 | 0.2 | 0.17 | 0.01 | 0.27 | 0.03 | 0.01 | -0.11 | 1 | | | | |
| Flow | 0.03 | -0.01 | -0.01 | -0.01 | 0.00 | 0.00 | 0.01 | 0.04 | 0.1 | -0.06 | 1 | | | |
| Total risk | -0.18 | -0.13 | -0.05 | -0.05 | -0.03 | -0.02 | 0.02 | 0.09 | -0.21 | 0.07 | -0.02 | 1 | | |
| Tail risk | -0.16 | -0.11 | -0.06 | -0.05 | -0.03 | -0.04 | -0.01 | 0.03 | -0.33 | 0.07 | -0.05 | 0.88 | 1 | |
| Green beta | 0.03 | 0.09 | 0.07 | 0.03 | 0.06 | 0.02 | 0.01 | 0.06 | 0.12 | 0.02 | 0.01 | -0.02 | -0.01 | 1 |

This table presents descriptive statistics for a sample of equity-oriented hedge funds over the period 2012–2021 in the U.S. Panel A reports the descriptive statistics of fund characteristics. Panel B presents the correlation coefficients between the main variables. AUM is the fund's reported assets under management at the end of each month ($ millions). Both management and incentive fees are reported in percentage. High-water mark is a dummy variable that takes the value of one if the hedge fund uses a high-water mark and zero otherwise. Leveraged is a dummy variable that equals one if the hedge fund uses leverage, and zero otherwise. Redemption period is the number of days of advance notice an investor must provide the fund to withdraw capital. The lock-up period is measured in months. Rate of return is the monthly fund return net of fees (%). Alpha is calculated using the Fung and Hsieh (2004) seven-factor model. Fund age measures years since the fund's inception date. Flow is the monthly net inflows of

funds. Total risk is the standard deviation of the monthly rate of returns. Tail risk is measured as hedge funds' two-year 95% value-at-risk. Fund green beta is defined as the coefficient of the green factor (Pástor et al., 2022) when regressing fund monthly return on the green factor and Fung and Hsieh (2004) seven-factor. Fund carbon risk score is the value-weighted average carbon risk score of hedge fund total stock holdings. The summary statistics are based on fund-month observations. All variables are winsorized at the 1% and 99% levels.

**Table II. Hedge Fund Green Beta**

Panel A: Green Beta and Hedge Fund Strategy

| Fund Strategy | Green beta (mean) | Std. dev. | Observations |
|---|---|---|---|
| Long only | 0.493 | 0.740 | 343 |
| Multi-strategy | 0.132 | 0.754 | 5,675 |
| Long short | 0.097 | 1.199 | 58,838 |
| Global macro | 0.034 | 1.083 | 11,057 |
| Market neutral | -0.077 | 0.625 | 4,420 |
| Event-driven | -0.134 | 0.891 | 14,536 |
| CTA | -0.191 | 0.695 | 1,710 |
| Relative value | -0.223 | 0.807 | 9,902 |
| Other | -0.426 | 0.513 | 489 |
| Emerging market | -0.611 | 1.664 | 1,050 |
| Sector | -0.635 | 0.672 | 41 |
| Short bias | -0.730 | 0.784 | 89 |

Panel B: Univariate Analysis

| | High green beta funds (Top quintile) | Low green beta funds (Bottom quintile) | High-Low |
|---|---|---|---|
| AUM (US $m) | 325.74 | 305.62 | 20.12*** |
| Management fee (%) | 1.45 | 1.35 | 0.10*** |
| Incentive fee (%) | 17.18 | 15.44 | 1.75*** |
| High water mark (dummy) | 0.83 | 0.75 | 0.08*** |
| Leveraged (dummy) | 0.64 | 0.59 | 0.06*** |
| Lock-up period (months) | 5.05 | 4.78 | 0.27*** |
| Rate of return (%) | 0.79 | 0.39 | 0.40*** |
| Alpha (%) | 0.21 | 0.02 | 0.20*** |
| Fund age | 9.96 | 9.81 | 0.15** |
| Flow (%) | 0.20 | -0.30 | 0.50*** |
| Total risk (%) | 3.44 | 3.51 | -0.07*** |
| Tail risk (%) | 6.52 | 6.59 | -0.07*** |
| Fund carbon risk score | 10.08 | 13.89 | -3.81*** |
| Fund green beta | 1.36 | -1.38 | 2.74*** |

Panel A presents the statistics of fund green beta by fund investment strategy. Long-only funds take only long positions in stocks. Multi-strategy funds combine different single hedge fund strategies. Long/short

funds take both long and short positions. Global Macro funds trade on a broad range of strategies that attempt to profit from broad market swings caused by political or economic events. Market-neutral funds maintain a net zero exposure to the equity market by offsetting long and short positions. Event-driven funds take advantage of temporary stock mispricing that happens around corporate events. CTA funds aim to profit from technical or fundamental-based strategies in commodity markets. Relative value funds take positions on spread relations between prices of financial assets and aim to minimize market exposure. Emerging Markets funds typically invest in Emerging Market equities. Sector funds focus on specific sectors or industries. Short bias funds take a net short position in equity markets. Others include Funds that do not fit into the previous eleven investment styles. The summary statistics are based on fund-month observations. Panel B reports the univariate analysis of fund characteristics and fund green beta. Each month, green betas are sorted into five quintiles. High green beta funds include funds with the highest green beta (fifth quintile) and low green beta funds include funds with the lowest green beta (first quintile).

**Table III. Hedge Fund Green Beta and Fund Performance**

Panel A: Hedge Fund Performance Sorted by Fund Green Beta

| Green beta | Return | Alpha |
|---|---|---|
| Rank 5 (highest) | 0.788 | 0.214 |
| Rank 4 | 0.536 | 0.134 |
| Rank 3 | 0.526 | 0.148 |
| Rank 2 | 0.497 | 0.099 |
| Rank 1 (lowest) | 0.391 | 0.019 |
| Highest-Lowest | 0.397*** | 0.195*** |

Panel B: Hedge Fund Green Beta and Fund Performance

| | Alpha | | Excess return | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Green beta | 0.078*** | 0.070*** | 0.133*** | 0.146*** |
| | (6.46) | (4.87) | (10.57) | (9.82) |
| Log (size) | | 0.043*** | | 0.024*** |
| | | (6.16) | | (3.04) |
| Fund age | | -0.018*** | | -0.004* |
| | | (-8.90) | | (-1.78) |
| Lock up period | | -0.000 | | 0.002 |
| | | (-0.25) | | (1.00) |
| Management fee | | 0.197*** | | 0.019 |
| | | (6.12) | | (0.52) |
| Incentive fee | | 0.006** | | -0.005 |
| | | (1.97) | | (-1.30) |
| High water mark | | 0.121** | | 0.070 |
| | | (2.16) | | (1.14) |
| Leveraged | | -0.002 | | -0.033 |
| | | (-0.08) | | (-1.03) |
| Year-month FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |
| Observations | 108,150 | 68,396 | 108,150 | 68,396 |
| *R*-squared | 0.0597 | 0.1091 | 0.2598 | 0.2514 |

Panel A reports the univariate analysis of fund performance and fund green beta. Each month, funds are sorted into five ranks based on their green beta. Green beta increases monotonically from Rank 1 to Rank 5. Panel B reports the regression results of equation (2), the fund performance on fund green beta, and other characteristics. The dependent variables in Models (1) and (2) are Fung and Hsieh (2004) seven-factor alpha (%). The dependent variables in Models (3) and (4) are fund monthly excess return (%). The regression includes the following control variables: the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for a fund with a high water mark

and a dummy variable for a fund with leverage. The dependent variable is in month $t + 1$ and all the independent variables are in month $t$. The *t*-statistics are in parentheses. Standard errors are clustered by fund and month. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table IV. Hedge Fund Green Beta and Fund Risk**

| | Total risk | Total risk | Tail risk | Tail risk |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Green beta | -0.099*** | -0.073** | -0.166*** | -0.119** |
| | (-3.69) | (-2.21) | (-3.73) | (-2.13) |
| Log (size) | | -0.085*** | | -0.134*** |
| | | (-3.75) | | (-3.30) |
| Fund age | | 0.007 | | 0.023** |
| | | (1.16) | | (2.04) |
| Lock up period | | 0.015** | | 0.018* |
| | | (2.27) | | (1.75) |
| Management fee | | 0.020 | | -0.027 |
| | | (0.22) | | (-0.17) |
| Incentive fee | | -0.011 | | -0.021 |
| | | (-1.33) | | (-1.44) |
| High water mark | | 0.129 | | 0.224 |
| | | (0.87) | | (0.87) |
| Leveraged | | -0.079 | | -0.216 |
| | | (-0.85) | | (-1.33) |
| Year-month FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |
| Observations | 108,150 | 68,396 | 108,150 | 68,396 |
| *R*-squared | 0.2456 | 0.2487 | 0.2497 | 0.2453 |

This table reports the regression results of fund risk on fund green beta and other characteristics as in equation (3). The dependent variables in Models (1) and (2) are fund total risk, which is the standard deviation of the monthly rate of returns. The dependent variables in Models (3) and (4) are fund tail risk, which is measured as a hedge fund two-year 95% value-at-risk (VaR). The regression includes the following control variables: the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for funds with high watermark, and a dummy variable for a fund with leverage. The dependent variable is in month $t+1$ and all the independent variables are in month $t$. The *t*-statistics are in parentheses. Standard errors are clustered by fund and month. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table V. Hedge Fund Green Beta and Fund Flows**

Panel A: Full Sample Analysis

| | Flow | Flow | Flow |
|---|---|---|---|
| | (1) | (2) | (3) |
| Green beta | 0.388*** | 0.303** | 0.330*** |
| | (3.13) | (2.53) | (2.82) |
| Past return rank | | 0.999*** | |
| | | (14.56) | |
| Past alpha rank | | | 1.601*** |
| | | | (18.09) |
| log (size) | | -0.302*** | -0.446*** |
| | | (-4.42) | (-6.34) |
| Fund age | | -0.230*** | -0.167*** |
| | | (-12.09) | (-8.98) |
| Lock up period | | 0.020 | 0.022 |
| | | (1.20) | (1.29) |
| Management fee | | 0.022 | -0.484* |
| | | (0.08) | (-1.67) |
| Incentive fee | | -0.018 | -0.049* |
| | | (-0.62) | (-1.69) |
| High water mark | | 0.227 | 0.041 |
| | | (0.47) | (0.09) |
| Leveraged | | -0.044 | -0.083 |
| | | (-0.16) | (-0.31) |
| Year-quarter FE | YES | YES | YES |
| Investment style FE | YES | YES | YES |
| Observations | 26,764 | 22,845 | 22,845 |
| *R*-squared | 0.0129 | 0.0447 | 0.0630 |

Panel B: Before and after the 2015 Paris Agreement

| | Year<2015 | | Year>=2015 | |
|---|---|---|---|---|
| | Flow (Low alpha funds) | Flow (High alpha funds) | Flow (Low alpha funds) | Flow (High alpha funds) |
| | (1) | (2) | (3) | (4) |
| High green beta | 0.308 | 0.633 | 0.342 | 0.831** |
| | (0.73) | (1.23) | (1.01) | (2.46) |
| log (size) | -0.299** | -0.525*** | -0.472*** | -0.322** |
| | (-2.25) | (-2.62) | (-4.48) | (-2.55) |
| Fund age | -0.129*** | -0.388*** | -0.072** | -0.275*** |
| | (-3.12) | (-7.05) | (-2.52) | (-8.79) |
| Lock up period | 0.060 | -0.053 | 0.070*** | 0.011 |
| | (1.64) | (-1.35) | (3.00) | (0.41) |
| Management fee | -0.798 | -0.641 | -1.253*** | 0.936* |
| | (-1.25) | (-0.96) | (-2.96) | (1.79) |
| Incentive fee | -0.215*** | -0.043 | -0.006 | -0.053 |
| | (-3.99) | (-0.58) | (-0.13) | (-0.98) |
| High water mark | 1.707** | -0.509 | -0.294 | -0.637 |
| | (2.06) | (-0.40) | (-0.35) | (-0.68) |
| Leveraged | 0.118 | -0.178 | -0.200 | -0.016 |
| | (0.24) | (-0.25) | (-0.50) | (-0.04) |
| Year-quarter FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |
| Observations | 4,032 | 4,267 | 6,877 | 7,669 |
| *R*-squared | 0.0370 | 0.0540 | 0.0353 | 0.0427 |

Panel A reports the full sample analysis from 2012 to 2021 of equation (5), fund flows on the lagged fund green beta, and other characteristics. The dependent variable is fund quarter flow, which equals the percentage change in TNA after adjusting for the fund's total return, as in equation (5). The dependent variable is in quarter $t+1$ and all the independent variables are in quarter $t$. The regression includes the following control variables: hedge fund past 12-month Fung and Hsieh (2004) alpha rank (past alpha rank), hedge fund past 12-month return rank (past return rank), the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for the fund with high water mark and a dummy variable for a fund with leverage. Panel B reports the sub-sample test results. Low alpha funds are defined as the funds whose alpha in the previous quarter is below the median. High alpha funds are defined as the funds whose alpha in the previous quarter is above the median. High green beta is a dummy variable that equals 1 if the green beta is in the top tercile in the previous quarter and 0 otherwise. The *t*-statistics are in parentheses. Standard errors are clustered by the fund and quarter. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table VI. Green Picking Skill and Fund Green Beta**

| | Green picking skill (Equal weighted) | | Green picking skill (Value weighted) | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Green beta | 0.041*** | 0.037** | 0.033** | 0.034** |
| | (2.63) | (2.14) | (2.04) | (1.98) |
| Log (size) | | -0.025** | | -0.024** |
| | | (-1.98) | | (-2.04) |
| Fund age | | -0.001 | | -0.001 |
| | | (-0.27) | | (-0.24) |
| Lock up period | | -0.003 | | -0.003 |
| | | (-0.95) | | (-1.01) |
| Management fee | | 0.063 | | 0.061 |
| | | (1.16) | | (1.17) |
| Incentive fee | | -0.004 | | -0.003 |
| | | (-0.92) | | (-0.82) |
| High water mark | | 0.053 | | 0.035 |
| | | (0.75) | | (0.50) |
| Leveraged | | -0.011 | | -0.008 |
| | | (-0.21) | | (-0.17) |
| Time FE | YES | YES | YES | YES |
| Observations | 9,259 | 7,009 | 8,286 | 7,007 |
| *R*-squared | 0.0464 | 0.0466 | 0.0454 | 0.0465 |

This table reports the regression results from regressions of hedge fund green picking skills on fund green beta as in equation (7). Hedge fund green-picking skill is defined in equation (6) based on the fund's 13F holding. The green-picking skills in models (1) and (3) are calculated using the equal-weighted method. The green-picking skills in models (2) and (4) are calculated using value-weighted method. Fund green beta is measured as the coefficient of the green factor (Pástor et al., 2022) when regressing fund monthly return on the green factor and Fung and Hsieh (2004) seven-factor. The regression includes the following control variables: the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), dummy variable for a fund with high water mark and a dummy variable for the fund with leverage. All the variables in models (1) and (2) are equal weighted aggregate at the hedge fund firm level. All the variables in models (3) and (4) are value-weighted aggregate at the hedge fund firm level. The *t*-statistics are in parentheses. Standard errors are clustered at the hedge fund firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table VII. Green Hedge Fund Overweight and Firm Characteristics**

| | Δ Carbon risk | | | Δ Green patent | | |
|---|---|---|---|---|---|---|
| | Δ Carbon risk t1-t0 | Δ Carbon risk t3-t0 | Δ Carbon risk t5-t0 | Δ Green patent t1-t0 | Δ Green patent t3-t0 | Δ Green patent t5-t0 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Overweight | -1.193 | -4.885*** | -6.373*** | 15.774 | 81.574* | 74.641* |
| | (-1.21) | (-3.60) | (-2.72) | (1.47) | (1.69) | (1.87) |
| BM Ratio | 0.093 | 0.005 | -0.372 | -2.032** | -7.118*** | -12.108** |
| | (0.88) | (0.02) | (-0.91) | (-2.29) | (-2.75) | (-2.46) |
| Return | 0.199 | -0.072 | -0.330** | -0.678 | -1.341 | 0.209 |
| | (1.41) | (-0.93) | (-2.08) | (-0.98) | (-1.19) | (0.24) |
| Log(size) | -0.025 | -0.096** | -0.141** | 0.640*** | 1.825*** | 3.441*** |
| | (-1.24) | (-2.33) | (-2.11) | (3.40) | (3.52) | (3.20) |
| ROA | -0.334* | 0.034 | 0.522 | 1.867 | 9.124 | 11.192 |
| | (-1.75) | (0.06) | (0.56) | (0.96) | (1.58) | (1.13) |
| Year FE | YES | YES | YES | YES | YES | YES |
| Industry FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES |
| Observations | 2,127 | 1,566 | 1,076 | 1,852 | 1,335 | 843 |
| *R*-squared | 0.048 | 0.079 | 0.115 | 0.055 | 0.103 | 0.190 |

This table reports the regression results examining the relationship between the change in green firm's environmental policy and the extent to which a firm is favored by green hedge funds. Green firms are defined as firms ranked in the lowest tertile of carbon risk. The dependent variables in models (1) to (3) are changes in the level of carbon risk of green firms in one, three, and five years respectively. The dependent variables in models (4) to (6) are changes in the number of green patents the green firms file in one, three, and five years respectively. Overweight measures the difference between the average stock's weight in green hedge funds and the average stock's weight in all hedge funds (green hedge fund is defined as funds ranked in the highest quintile based on green beta). All columns control the firm's book-to-market ratio (BM Ratio), annual return, natural logarithm of firm size (Log(size)) and return on asset (ROA). Standard errors are clustered by firm. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table VIII. Green Timing Skill and Fund Green Beta**

| | Green timing skill | Green timing skill | Green timing skill |
|---|---|---|---|
| | (1) | (2) | (3) |
| Green beta | 0.095** | 0.100*** | 0.067* |
| | (2.43) | (2.71) | (1.85) |
| Log (size) | -0.035** | -0.052*** | -0.047*** |
| | (-2.18) | (-3.30) | (-2.97) |
| Fund age | -0.007 | -0.008 | -0.005 |
| | (-1.53) | (-1.63) | (-0.59) |
| Lock up period | -0.007 | -0.002 | -0.002 |
| | (-1.51) | (-0.46) | (-0.45) |
| Management fee | 0.027 | -0.016 | 0.013 |
| | (0.36) | (-0.22) | (0.18) |
| Incentive fee | 0.008 | 0.011 | 0.001 |
| | (1.05) | (1.40) | (0.13) |
| High water mark | -0.221* | -0.198* | -0.123 |
| | (-1.78) | (-1.69) | (-1.06) |
| Leveraged | -0.073 | -0.080 | -0.073 |
| | (-1.09) | (-1.23) | (-1.14) |
| Time FE | NO | NO | YES |
| Investment style FE | NO | YES | YES |
| Observations | 68,396 | 68,396 | 68,396 |
| *R*-squared | 0.0058 | 0.0164 | 0.0725 |

This table reports the regression results from regressions of hedge fund green timing skills on fund green beta as in equation (10). The dependent variable is the hedge fund's green timing skill, which is defined as the green coefficient (γ) in equation (9). Fund green beta is measured as the coefficient of the green factor (Pástor et al., 2022) when regressing fund monthly return on the green factor and Fung and Hsieh (2004) seven-factor. The regression includes the following control variables: the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for funds with high water mark and a dummy variable for the fund with leverage. All the variables in models (1) and (2) are equal-weighted aggregate at the hedge fund firm level. All the variables in models (3) and (4) are value-weighted aggregate at the hedge fund firm level. The *t*-statistics are in parentheses. Standard errors are clustered at the hedge fund firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table IX. Green Timing Skill and Fund Performance**

| | Excess return | | Alpha | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Green timing skill | 0.055*** | 0.043*** | 0.012** | 0.012** |
| | (6.30) | (5.23) | (2.21) | (2.22) |
| Green beta | 0.158*** | 0.143*** | 0.056*** | 0.069*** |
| | (9.96) | (9.59) | (4.04) | (4.81) |
| Log (size) | 0.014 | 0.026*** | 0.048*** | 0.043*** |
| | (1.63) | (3.26) | (7.05) | (6.24) |
| Fund age | -0.004 | -0.004* | -0.018*** | -0.017*** |
| | (-1.49) | (-1.74) | (-9.53) | (-8.92) |
| Lock up period | 0.004** | 0.002 | 0.000 | -0.000 |
| | (2.00) | (1.05) | (0.20) | (-0.23) |
| Management fee | -0.026 | 0.019 | 0.194*** | 0.193*** |
| | (-0.72) | (0.51) | (6.41) | (6.14) |
| Incentive fee | 0.004 | -0.005 | 0.007** | 0.006** |
| | (1.26) | (-1.34) | (2.18) | (1.99) |
| High water mark | 0.025 | 0.075 | 0.106* | 0.123** |
| | (0.42) | (1.24) | (1.90) | (2.18) |
| Leveraged | -0.058* | -0.030 | -0.007 | -0.001 |
| | (-1.75) | (-0.93) | (-0.25) | (-0.05) |
| Time FE | NO | YES | NO | YES |
| Investment style FE | NO | YES | NO | YES |
| Observations | 68,396 | 68,396 | 68,396 | 68,396 |
| *R*-squared | 0.0046 | 0.2521 | 0.0798 | 0.1101 |

This table reports the regression results of fund performance on fund green timing skills and other characteristics. The dependent variables in Models (1) and (2) are fund monthly excess return (%). The dependent variables in Models (3) and (4) are Fung and Hsieh (2004) seven-factor alpha (%). Green timing skill is defined as the green coefficient (γ) in equation (9). Fund green beta is measured as the coefficient of the green factor (Pástor et al., 2022) when regressing fund monthly return on the green factor and Fung and Hsieh (2004) seven-factor. The regression includes the following control variables: the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for a fund with a high water mark and a dummy variable for the fund with leverage. The *t*-statistics are in parentheses. Standard errors are clustered by fund and month. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table X. Hedge Fund Political Beliefs**

Panel A: Hedge Fund Political Belief and Carbon Risk Exposure

| | Green beta | Green beta | Carbon risk | Carbon risk |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Republican state | -0.137* | -0.253** | 3.337*** | 5.130*** |
| | (-1.66) | (-2.20) | (3.41) | (3.44) |
| Control variables | NO | YES | NO | YES |
| Year-month FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |
| Observations | 48,875 | 35,204 | 41,548 | 28,781 |
| *R*-squared | 0.0363 | 0.0639 | 0.1088 | 0.1438 |

Panel B: Hedge Fund Green Beta, Fund Flows, and Political Beliefs

| | Republican state | | Democratic state | |
|---|---|---|---|---|
| | Flow (Low alpha funds) | Flow (High alpha funds) | Flow (Low alpha funds) | Flow (High alpha funds) |
| | (1) | (2) | (3) | (4) |
| High green beta | 0.217 | 0.472 | 0.391 | 0.783** |
| | (0.88) | (0.38) | (1.05) | (2.03) |
| log (size) | -0.475 | -0.599 | -0.402*** | -0.317** |
| | (-0.84) | (-0.98) | (-3.11) | (-2.07) |
| Fund age | -0.259* | -0.422*** | -0.089*** | -0.237*** |
| | (-1.94) | (-3.38) | (-2.84) | (-6.83) |
| Lock up period | 0.138 | 0.157* | 0.068** | 0.014 |
| | (0.49) | (1.92) | (2.53) | (0.46) |
| Management fee | -0.876 | 1.142 | -1.823*** | 0.750 |
| | (-0.56) | (0.64) | (-3.64) | (1.20) |
| Incentive fee | 0.201 | 0.382 | 0.034 | -0.045 |
| | (0.90) | (1.45) | (0.70) | (-0.71) |
| High water mark | -4.986 | -9.543* | -0.256 | -0.905 |
| | (-0.97) | (-1.75) | (-0.30) | (-0.88) |
| Leveraged | 0.532 | 0.953 | 0.074 | 0.642 |
| | (0.32) | (0.70) | (0.16) | (1.41) |
| Year-quarter FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |
| Observations | 548 | 543 | 5,099 | 5,582 |
| *R*-squared | 0.0582 | 0.1193 | 0.0390 | 0.0415 |

Panel A reports the regression results of fund carbon risk exposure on hedge fund political belief and other characteristics. The dependent variable in models (1) and (2) is the fund green beta, which is measured as the coefficient of green factor (Pástor et al., 2022) when regressing the fund monthly return on the green factor and Fung and Hsieh (2004) seven-factor. The dependent variable in models (3) and (4) is the fund carbon risk score, which is measured as the value-weighted average carbon risk score of hedge fund total stock holdings. The variable of interest is a dummy variable that equals one if the hedge fund is located in

a republican state, and zero otherwise. The control variables include the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for funds with high water mark, and a dummy variable for the fund with leverage. Standard errors are clustered by fund and month. Panel B reports the regression of fund flows on the lagged fund green beta and other fund characteristics. Models (1) and (2) include funds that are located in Republican states and models (3) and (4) include funds that are located in Democratic states. The dependent variable is in quarter $t + 1$ and all the independent variables are in quarter $t$. The sample period is from 2015 to 2021. The *t*-statistics are in parentheses. Standard errors are clustered by the fund and quarter. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table XI. Hedge Fund Carbon Risk Exposure, Fund Flows, and Climate News Shock**

Panel A: Hedge Fund Carbon Risk Exposure and Climate News Shock

| | Green beta | Green beta | Carbon risk | Carbon risk |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| WSJ climate news shock | 0.080*** | 0.080*** | -1.303*** | -1.458*** |
| | (3.92) | (2.67) | (-10.17) | (-7.45) |
| Control variables | NO | YES | NO | YES |
| Year-month FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |
| Observations | 67,896 | 42,744 | 54,626 | 33,816 |
| *R*-squared | 0.0299 | 0.0488 | 0.0756 | 0.1061 |

Panel B: Hedge Fund Green Beta, Fund Flows, and Climate News Shock

| | Flow | Flow |
|---|---|---|
| | (1) | (2) |
| Green beta | 0.125 | 0.336 |
| | (0.68) | (1.60) |
| WSJ climate news shock | -0.320** | -0.403** |
| | (-2.34) | (-2.53) |
| Green beta * WSJ climate news shock | 0.541*** | 0.476*** |
| | (3.86) | (3.55) |
| Past return rank | 0.910*** | |
| | (8.29) | |
| Past alpha rank | | 0.817*** |
| | | (11.41) |
| log (size) | -0.448*** | -0.526*** |
| | (-2.95) | (-4.07) |
| Fund age | -0.301*** | -0.224*** |
| | (-7.04) | (-5.29) |
| Lock up period | -0.011 | 0.004 |
| | (-0.26) | (0.11) |
| Management fee | 0.202 | -0.186 |
| | (0.43) | (-0.16) |
| Incentive fee | 0.146 | 0.102 |
| | (0.75) | (0.14) |
| High water mark | 0.207 | -0.273 |
| | (0.15) | (-0.21) |
| Leveraged | 0.375 | 0.203 |
| | (0.53) | (0.30) |
| Year-quarter FE | YES | YES |
| Investment style FE | YES | YES |
| Observations | 6,354 | 6,354 |
| *R*-squared | 0.0707 | 0.0477 |

Panel A reports the regression results of fund carbon risk exposure on news sentiment measured by the WSJ index and other characteristics. The dependent variable in models (1) and (2) is the fund's green beta, which is measured as the coefficient of the green factor (Pástor et al., 2022) when regressing the fund's monthly return on the green factor and Fung and Hsieh (2004) seven-factor. The dependent variable in models (3) and (4) is the fund carbon risk score, which is measured as the value-weighted average carbon risk score of hedge fund total stock holdings. The variable of interest is WSJ climate news shock, which is calculated as the monthly sentiment score of the newspaper coverage of climate change-related news. The control variables include the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for a fund with high water mark, and a dummy variable for the fund with leverage. Standard errors are clustered by fund and month. Panel B reports the regression of fund flows on the lagged fund green beta and other fund characteristics. The dependent variable is in quarter $t + 1$ and all the independent variables are in quarter $t$. The sample period is from 2015 to 2021. The *t*-statistics are in parentheses. Standard errors are clustered by the fund and quarter. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table XII. Effect of Hedge Fund Endorsing UNPRI Difference in Difference Analysis**

Panel A: Difference in Difference Analysis of Fund Carbon Risk Exposure

| | Equal weighted | | Value weighted | |
|---|---|---|---|---|
| | Green beta | Carbon risk | Green beta | Carbon risk |
| | (1) | (2) | (3) | (4) |
| UNPRI*Post | 0.107* | -1.221** | 0.136* | -0.520* |
| | (-1.67) | (-2.16) | (-1.88) | (-1.92) |
| Log (size) | 0.026 | 0.036 | 0.004 | -0.057 |
| | (0.59) | (0.21) | (0.23) | (-0.37) |
| Fund age | -0.033 | -0.073 | 0.035 | 0.863*** |
| | (-1.53) | (-0.70) | (1.18) | (4.20) |
| Lock up period | 0.002 | 0.064 | 0.021 | 0.124 |
| | (0.78) | (0.49) | (1.48) | (1.18) |
| Management fee | 0.041 | -0.950 | 0.154 | -4.263* |
| | (0.12) | (-0.64) | (0.74) | (-1.85) |
| Incentive fee | 0.030 | 0.150 | 0.024 | 0.268 |
| | (1.03) | (1.00) | (1.01) | (1.64) |
| High water mark | -0.192 | -1.860 | -0.305 | -5.917* |
| | (-0.67) | (-1.16) | (-0.68) | (-1.82) |
| Leveraged | -0.113 | 1.836 | -0.497** | -2.147 |
| | (-0.40) | (1.01) | (-2.21) | (-1.11) |
| Year FE | YES | YES | YES | YES |
| Fund firm FE | YES | YES | YES | YES |
| Observations | 3,366 | 2,466 | 2,774 | 2,774 |
| *R*-squared | 0.0421 | 0.1033 | 0.0211 | 0.0801 |

Panel B: Difference in Difference Analysis of Fund Firm Flows

| | Firm flow (equal-weighted) | Firm flow (value-weighted) |
|---|---|---|
| | (1) | (2) |
| UNPRI*Post | 0.144** | 0.170* |
| | (2.21) | (1.81) |
| Past return | 0.436*** | 0.405*** |
| | (5.39) | (5.28) |
| Log (size) | -0.211*** | -0.237* |
| | (-2.62) | (-1.83) |
| Fund age | -0.130 | -0.119 |
| | (-1.05) | (-0.97) |
| Lock up period | 0.126 | -0.113 |
| | (0.27) | (-0.26) |
| Management fee | -0.810 | -0.952* |
| | (-0.61) | (-1.94) |
| Incentive fee | -0.147 | 0.231 |
| | (-0.50) | (1.40) |
| High water mark | 0.542 | -0.510 |

| | | |
|---|---|---|
| | (0.37) | (-1.26) |
| Leveraged | 0.528** | 0.543 |
| | (2.43) | (1.10) |
| Year FE | YES | YES |
| Fund firm FE | YES | YES |
| Observations | 2,225 | 2,229 |
| *R*-squared | 0.0876 | 0.0769 |

Panel A reports the regression results from regressions examining hedge fund carbon risk exposure prior to and post endorsing the UNPRI. The dependent variable in models (1) and (2) is the fund's green beta, which is measured as the coefficient of the green factor (Pástor et al., 2022) when regressing the fund's monthly return on the green factor and Fung and Hsieh (2004) seven-factor. The dependent variable in models (3) and (4) is the fund carbon risk score, which is measured as the value-weighted average carbon risk score of hedge fund total stock holdings. UNPRI takes a value of 1 if the hedge fund firm has signed the UNPRI and 0 otherwise. Post takes a value of 0 prior to the firm signing the UNPRI and 1 post signing. The control variables include the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for the fund with high water mark, and a dummy variable for the fund with leverage. Standard errors are clustered by fund and month. Panel B reports the regression of fund firm flows prior to and post endorsing the UNPRI. The dependent variable in model (1) is hedge fund firm-level annual flows calculated as the equal-weighted average fund annual flows of all the hedge funds in the same firm. The dependent variable in model (2) is hedge fund firm annual flows calculated as the value-weighted average fund annual flows of all the hedge funds in the same firm. All the other control variables are aggregated at the fund firm level. The sample period is from 2015 to 2021. The *t*-statistics are in parentheses. Standard errors are clustered by the fund and quarter. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Appendix I: Air pollution exposure and sustainable investment**

We examine whether a hedge fund's exposure to local air pollution affects a fund's exposure to green assets. Previous literature on mutual funds has shown that a fund's local air pollution experience causes the fund to underweight stocks of high-emission firms (Huynh, Li, and Xia, 2021) and increases its propensity to vote in support of shareholders' environmental proposals (Foroughi, Marcus and Nguyen, 2021; Giuli et al., 2022). Their findings reveal that mutual fund managers' experience with air pollution can lead to behavioral biases in their decision-making process. In this section, we test whether hedge fund managers, who are arguably the most sophisticated investors, are also influenced by their exposure to polluted air when making investment decisions.

We assess state-level air pollution by utilizing the Air Quality Index (AQI) data sourced from the Environmental Protection Agency's (EPA) Air Quality System (AQS) database. Monthly AQI values are computed for each state and employed as a proxy for a fund manager's air pollution exposure, contingent upon the fund's geographical location. An Air Quality Index (AQI) value below 50 signifies favorable air quality conditions, while an AQI exceeding 300 denotes hazardous levels of air pollution.

We first examine whether hedge fund managers, similar to mutual fund managers, tend to shift their portfolios toward low-carbon firms when exposed to poor air quality conditions. Specifically, we regress each hedge fund's green beta and carbon risk score on the air quality index and include the control variables that are the same as those in equation (2). As we can see in Panel A of Table A4 in Appendix II, the coefficient for AQI is insignificant in all columns from (1) to (4). This result indicates that hedge fund managers do not suffer from this bias as they are not affected by the exposure to air pollution when they make investment decisions. Next, we examine whether local air pollution also influences investors' attitudes toward green funds. As can be seen in Panel B, the coefficients for the interaction term of AQI and green beta are not significant. Hence, we find no evidence that investors reward greener funds with greater net inflows when they are exposed to bad air conditions.

## Appendix II: Additional tables

**Table A1. Carbon risk scores by firm industry**

| Fama-French industry code (12 industries) | Carbon risk |
|---|---|
| Oil, Gas, and Coal Extraction and Products | 46.513 |
| Utilities | 24.599 |
| Consumer Durables -- Cars, TV's, Furniture, Household Appliances | 20.632 |
| Manufacturing -- Machinery, Trucks, Planes, Off Furn, Paper, Com Printing | 17.729 |
| Chemicals and Allied Products | 17.066 |
| Other -- Mines, Constr, BldMt, Trans, Hotels, Bus Serv, Entertainment | 14.728 |
| Finance | 11.133 |
| Consumer NonDurables -- Food, Tobacco, Textiles, Apparel, Leather, Toys | 7.808 |
| Wholesale, Retail, and Some Services (Laundries, Repair Shops) | 7.421 |
| Telephone and Television Transmission | 4.406 |
| Business Equipment -- Computers, Software, and Electronic Equipment | 4.328 |
| Healthcare, Medical Equipment, and Drugs | 3.109 |
| Total | 12.159 |

This table shows the average carbon risk scores of firms by industry. The industry is classified according to Fama-French 12 industries code based on firms' four-digit SIC code.

**Table A2. Correlation matrix between green beta and the other betas**

| | $\beta$_green | $\beta$_market | $\beta$_PTFSBD | $\beta$_PTFSFX | $\beta$_PTFSCOM | $\beta$_size | $\beta$_bdm | $\beta$_credit |
|---|---|---|---|---|---|---|---|---|
| $\beta$_green | 1 | | | | | | | |
| $\beta$_market | 0.16*** | 1 | | | | | | |
| $\beta$_PTFSBD | -0.14*** | -0.08*** | 1 | | | | | |
| $\beta$_PTFSFX | 0.14*** | 0.10*** | -0.44*** | 1 | | | | |
| $\beta$_PTFSCOM | 0.00 | 0.01*** | 0.05*** | -0.24*** | 1 | | | |
| $\beta$_size | 0.00 | 0.21*** | 0.01*** | -0.12*** | 0.07*** | 1 | | |
| $\beta$_bdm | -0.04*** | -0.01* | 0.29*** | -0.31*** | 0.05*** | -0.01*** | 1 | |
| $\beta$_credit | 0.09*** | 0.25*** | -0.15*** | -0.06*** | 0.11*** | -0.03*** | 0.37*** | 1 |

This table shows the correlation between green beta and the other seven betas in Fung and Hsieh (2004) seven-factor model. Green beta ($\beta$_green) is measured as the coefficient of green factor (Pástor et al., 2022) when regressing fund monthly return on the green factor and Fung and Hsieh (2004) seven-factor model. Market beta ($\beta$_market) is the coefficient of the market factor. $\beta$_PTFSBD is the coefficient of the excess returns on portfolios of lookback straddle options on bonds. $\beta$_PTFSFX is the coefficient of the excess returns on portfolios of lookback straddle options on currencies. $\beta$_PTFSCOM is the coefficient of the excess returns on portfolios of lookback straddle options on commodities. $\beta$_size is the coefficient of small minus big factor. $\beta$_bdm is the coefficient of the change in the constant maturity yield of the US ten-year Treasury bond. $\beta$_credit is the coefficient of the change in the credit spread of Moody's BAA bond over the ten-year treasury bond.

**Table A3. Persistence of Green Beta**

| | | Panel A: Subsequent 1-Month Horizon | | | | |
|---|---|---|---|---|---|---|
| | | 1 (low) | 2 | 3 | 4 | 5 (high) |
| Initial | 1 (low) | 84.1 | 11.5 | 1.6 | 0.6 | 0.4 |
| Rank | 2 | 11.9 | 67.1 | 15.8 | 3.0 | 0.7 |
| | 3 | 1.5 | 16.1 | 63.5 | 15.7 | 1.6 |
| | 4 | 0.6 | 2.9 | 16.0 | 67.0 | 11.9 |
| | 5 (high) | 0.3 | 0.6 | 1.5 | 12.1 | 83.6 |
| | | Panel B: Subsequent 6-Month Horizon | | | | |
| | | 1 (low) | 2 | 3 | 4 | 5 (high) |
| Initial | 1 (low) | 56.6 | 17.7 | 6.9 | 4.5 | 3.3 |
| Rank | 2 | 17.6 | 36.4 | 20.8 | 10.9 | 4.7 |
| | 3 | 6.9 | 20.5 | 35.4 | 20.3 | 7.1 |
| | 4 | 5.1 | 10.5 | 20.0 | 36.4 | 18.5 |
| | 5 (high) | 3.9 | 4.7 | 7.2 | 18.2 | 55.7 |
| | | Panel C: Subsequent 12-Month Horizon | | | | |
| | | 1 (low) | 2 | 3 | 4 | 5 (high) |
| Initial | 1 (low) | 40.5 | 15.8 | 8.7 | 7.2 | 6.7 |
| Rank | 2 | 15.7 | 25.6 | 19.1 | 13.3 | 7.7 |
| | 3 | 8.4 | 18.7 | 26.3 | 18.4 | 8.9 |
| | 4 | 8.0 | 12.7 | 18.1 | 25.5 | 17.3 |
| | 5 (high) | 8.1 | 7.7 | 8.8 | 16.5 | 39.1 |

This table presents transition matrices of green beta over one-, six-, and 12-month horizons. Each month, we assign individual hedge funds into 5 quintiles portfolios based on their green beta (estimated from a 24-month rolling window). We then track their future re-assignments based on green beta. The reported numbers are in percentages.

**Table A4. Hedge Fund Exposure to Air Pollution**

Panel A: Hedge Fund Exposure to Air Pollution and Carbon Risk Exposure

| | Green beta | Green beta | Carbon risk | Carbon risk |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Air quality index (AQI) | 0.0022 | 0.0015 | 0.0176 | 0.0068 |
| | (0.96) | (0.58) | (0.87) | (0.30) |
| Observations | 48,917 | 35,246 | 41,548 | 28,781 |
| *R*-squared | 0.0343 | 0.0582 | 0.0820 | 0.0997 |
| Control variables | NO | YES | NO | YES |
| Year-month FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |

Panel B: Hedge Fund Green Beta, Fund Flow and Exposure to Air Pollution

| | Flow | Flow |
|---|---|---|
| | (1) | (2) |
| Green beta | 0.009 | 0.011 |
| | (0.79) | (0.96) |
| Green beta $_{t-1}$*Air quality index | -0.000 | -0.000 |
| | (-0.34) | (-0.55) |
| Air quality index | 0.000 | 0.000 |
| | (1.07) | (1.16) |
| Past alpha rank | 0.014*** | |
| | (13.03) | |
| Past return rank | | 0.007*** |
| | | (8.67) |
| log (size) | -0.004*** | -0.002** |
| | (-3.89) | (-2.41) |
| Fund age | -0.002*** | -0.002*** |
| | (-7.31) | (-9.92) |
| Lock up period | 0.000** | 0.000* |
| | (2.09) | (1.94) |
| Management fee | -0.007* | -0.003 |
| | (-1.81) | (-0.78) |
| Incentive fee | 0.000 | 0.001 |
| | (0.20) | (1.34) |
| High water mark | -0.006 | -0.005 |
| | (-0.84) | (-0.79) |
| Leveraged | 0.003 | 0.004 |
| | (0.93) | (1.11) |
| Observations | 11,786 | 11,786 |
| *R*-squared | 0.0565 | 0.0354 |
| Year FE | YES | YES |
| Investment style FE | YES | YES |

Panel A reports the regression results of fund carbon risk exposure on air quality index and other characteristics. The dependent variable in models (1) and (2) is the fund's green beta, which is measured as the coefficient of the green factor (Pástor et al., 2022) when regressing the fund's monthly return on the green factor and Fung and Hsieh (2004) seven-factor. The dependent variable in models (3) and (4) is the fund carbon risk score, which is measured as the value-weighted average carbon risk score of hedge fund total stock holdings. The variable of interest is the air quality index (AQI), which is the monthly average aggregate AQI across all monitoring stations in the state where the hedge fund is located. The control variables include the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for funds with high water mark, and a dummy variable for the fund with leverage. Standard errors are clustered by fund and month. Panel B reports the regression of fund flows on the lagged fund green beta and other fund characteristics. The dependent variable is in quarter $t + 1$ and all the independent variables are in quarter $t$. The sample period is from 2015 to 2021. The $t$-statistics are in parentheses. Standard errors are clustered by the fund and quarter. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table A5. Robustness Test**

| | Performance | | Risk | |
|---|---|---|---|---|
| | Alpha | Excess return | Total risk | Tail risk |
| | (1) | (2) | (3) | (4) |
| Carbon risk score | -0.006** | -0.003* | 0.019*** | 0.026*** |
| | (-2.13) | (-1.71) | (3.86) | (2.66) |
| Log (size) | 0.048*** | 0.038*** | -0.042* | -0.078* |
| | (5.83) | (4.38) | (-1.73) | (-1.66) |
| Fund age | -0.015*** | 0.002 | 0.008 | 0.021 |
| | (-6.60) | (0.99) | (1.24) | (1.64) |
| Lock up period | 0.000 | 0.001 | 0.008 | 0.012 |
| | (0.07) | (0.52) | (1.19) | (1.03) |
| Management fee | 0.204*** | 0.032 | -0.022 | -0.092 |
| | (5.70) | (0.87) | (-0.22) | (-0.48) |
| Incentive fee | 0.006** | -0.004 | -0.019** | -0.035** |
| | (2.13) | (-1.29) | (-2.04) | (-1.99) |
| High water mark | 0.080 | -0.001 | 0.195 | 0.365 |
| | (1.48) | (-0.02) | (1.16) | (1.16) |
| Leveraged | -0.030 | -0.040 | -0.048 | -0.179 |
| | (-0.96) | (-1.16) | (-0.49) | (-0.97) |
| Observations | 48,295 | 53,485 | 48,295 | 48,295 |
| *R*-squared | 0.1048 | 0.2822 | 0.2503 | 0.2413 |
| Year-month FE | YES | YES | YES | YES |
| Investment style FE | YES | YES | YES | YES |

This table reports the regression results from regressions of hedge fund performance or risk on fund carbon risk score. The dependent variables in models (1) and (2) are Fung and Hsieh (2004) seven-factor alpha (%) and fund monthly excess return respectively. The dependent variables in models (3) and (4) are fund total risk and tail risk respectively. Fund carbon risk score is the value-weighted average carbon risk score of hedge fund total stock holdings. The regression includes the following control variables: the natural logarithm of fund size, fund age, fund lock-up period (in months), management fee (%), incentive fee (%), a dummy variable for funds with high water mark and a dummy variable for the fund with leverage. The *t*-statistics are in parentheses. The dependent variable is in month $t+1$ and all the independent variables are in month $t$. Standard errors are clustered by fund and month. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.