Are the Hedges of Funds Green?

Huan Kuang, Bing Liang, Tianyi Qu, and Mila Getmansky Sherman*

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 green stock selection and green factor timing. Additionally, we observe that investors have directed higher inflows to high-performing green funds, particularly after the 2015 Paris Agreement. Lastly, we show that political alignment, climate news shock, and participation in the United Nations Principles for Responsible Investment (UNPRI) significantly influence hedge funds' commitment to green investing and investor flows.

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

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*Huan Kuang is at the School of Business, Bryant University; email: hkuang@bryant.edu. Bing Liang is at the Isenberg School of Management, University of Massachusetts Amherst; email: bliang@isenberg.umass.edu. Tianyi Qu is at the Hankamer School of Business, Baylor University; e-mail: tianyi_qu@baylor.edu. Mila Getmansky Sherman is at the Isenberg School of Management, University of Massachusetts Amherst; e-mail: msherman@isenberg.umass.edu. We thank Lina Han, Nikunj Kapadia, Hossein Kazemi, Xi Liu, Wenting Ma, Marco Macchiavelli, Anya Mkrtchyan, Loriana Pelizzon, Brooke Wang, and seminar participants at Baylor University, Miami University, the University of Mannheim, and the University of Massachusetts Amherst for their insightful comments. All errors remain ours.

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 financial institutions tackle the challenges of climate change and carbon-related risks. Although much has been written about the green investing practices of mutual funds (Ceccarelli et al., 2021, 2023; Choi et al, 2021; Kim and Yoon, 2023), venture capitals (Barber et al., 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 environmental, social, and governance (ESG) considerations in their investment process. In this paper, we concentrate on the "E" component of the ESG and aim to answer the following questions. First, how does a hedge fund's engagement in green investing impact fund performance and risk, and what underlying mechanisms contribute to these effects? Second, which factors contribute to the heterogeneity among hedge funds regarding their willingness to engage in green investing? Third, do investors recognize and respond to hedge funds that engage in green investing?

Hedge funds have historically been more hesitant to adopt green investing compared to other institutional investors.[2] The relatively short investment horizon and lifespan of many hedge funds, combined with their intense focus on generating alpha in a highly competitive environment, create challenges for supporting environmental initiatives that may deliver benefits only in the long term. 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

[1] A report from the Global Sustainable Investment Alliance showed that sustainable investments reached $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 bfinance's ESG Asset Owner Survey of 256 investors, only 7% of all investors (and 13% of large investors with more than $25 billion in assets under management) reported that their hedge funds currently offer "high integration" of ESG principles in the investment processes. See: https://www.bfinance.com/insights/from-laggards-to-leaders-hedge-funds-slowly-embrace-esg/

corporate behavior while hoping to do so in a guiltless way that does not sacrifice returns" (Pedersen et al., 2020). 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 abnormal returns. Simultaneously, in light of growing client concerns, the lack of consideration for ESG factors in investment strategies is increasingly viewed as a risk factor. According to a J.P. Morgan Advisory Group survey in December 2020, more than half of hedge fund managers considered ESG to be a source of alpha, 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.

We argue that the hedge fund industry provides an important context for studying green investing practices due to several unique factors. Unlike other responsible 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 et al., 2021; Aragon et al., 2022), hedge funds are natural arbitrageurs and prioritize profitability due to private ownership and the incentive fee structure. Whereas other institutional investors may be more "ESG-motivated" and willing to trade off ESG goals against portfolio Sharpe ratio (Pedersen et al., 2021), hedge funds may tend to be more "ESG-aware" and incorporate ESG information into their risk management and return assessments, enhancing their portfolio's reward-to-risk ratio beyond what could be achieved using only non-ESG information. This distinction raises the important question of whether hedge funds can achieve their green objectives without compromising returns. Moreover, hedge funds play a key role in improving market efficiency by identifying and capitalizing on market anomalies (Cao et al., 2018b). If environmental factors influence company performance but are not fully reflected in market prices (Lindsey et al., 2022), hedge funds can capitalize on these mispricing and, in doing so, contributing to more accurate pricing of these factors (Cao et al., 2018a). Finally, hedge funds use complex strategies with lower transparency and regulatory oversight than mutual funds. They engage in both long and short positions and often use leverage. These unique characteristics make hedge funds an ideal setting to examine green investments with unique challenges and opportunities.

We start our analysis by describing the overall green investing practices within the hedge fund industry. We first look at hedge funds' aggregate ownership and document that hedge funds are increasingly attentive to carbon risk and have actively rebalanced their portfolios toward lower-carbon exposure. Specifically, hedge funds have consistently increased allocations to low-carbon-risk (green) industries while reducing exposure to high-carbon-risk (brown) industries. We then investigate 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 holdings in green companies, without completely divesting from brown companies. This finding is 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 identify an asymmetrical trading pattern between green and brown companies. Hedge funds exhibit proficiency in identifying even more environmentally friendly companies within green industries. However, when it comes to brown industries, hedge funds make fewer distinctions and are less selective regarding companies' carbon risk.

Next, we study the impact of hedge funds' greenness on fund performance. To facilitate this analysis, we introduce a novel methodology to quantify 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 developed by Pástor et al. (2022).[3] 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 fund management firm level which is noisier as a fund management firm consists of several funds with different strategies. 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

[3] Pástor et al. (2022) construct the green factor as a "zero-cost" long-short factor. They create a portfolio by assigning each stock a weight based on its degree of greenness, with green stocks receiving positive weights and brown stocks receiving negative weights. The green factor is the weighted average market-adjusted portfolio return.

long and short positions, providing a comprehensive assessment of the impact of green investing on hedge fund performance across their entire portfolios.

Utilizing fund-level green beta, we investigate the relationship between hedge fund green beta, fund performance, and risk. Starting with performance, our portfolio sorting and regression results reveal that green beta positively predicts hedge funds' excess returns and factor-adjusted alphas. The observed outperformance of green hedge funds underscores the notion that hedge funds can "do well by doing good" (Bénabou and Tirole, 2010).[4] In other words, hedge funds can participate in green investing without compromising fund performance. In terms of fund risk, we document that green beta is negatively associated with both total risk and tail risk. This finding is contrary to Ceccarelli et al., (2021), who argue that green portfolios may suffer from less diversification and risk-sharing due to high industry concentration. Our result suggests that green hedge funds exhibit superior risk management skills and effectively incorporate the low-risk properties of green companies to the fund level without sacrificing the diversification benefit.[5]

Having documented that green hedge funds outperform other hedge funds in our sample, we further investigate the reasons behind their outperformance. 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 stock-picking skills, we first evaluate fund managers' general stock-picking skills following Kacperczyk et al. (2014) using 13F holdings data. Our analysis shows that green hedge fund managers demonstrate superior stock-picking skills. The stocks selected by these managers outperform other stocks, and the outperformance is positively associated with fund green beta. Next, we explore whether green hedge fund managers leverage their stock-picking skills in picking better green stocks. Given the market's failure to fully reflect ESG factors in stock price (Pedersen et al., 2021) and uncertainty around ESG ratings (Avramov

[4] Throughout this paper, we employ the term "green hedge fund(s)" or "green fund(s)" 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. We employ the term "green hedge fund managers" or "green managers" to refer to the fund managers of green hedge funds.

[5] 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).

et al., 2021), we argue that green managers may identify companies whose sustainability potential is undervalued. Consistently, we find that green fund managers tend to favor companies with a high potential for future carbon risk reduction and green patent generation. These are companies whose sustainability-related information may be undervalued or undiscovered, as the market struggles to incorporate information about future green initiatives into prices. Our findings reveal that the outperformance of green hedge funds is driven not only by their greater exposure to green stocks but also by the fact that green fund managers are able to identify companies with undervalued green potential.

To evaluate fund managers' green factor timing skills, we structure our analysis around two conjectures. First, we develop a model following Henriksson and Merton (1981) to calculate hedge funds' dynamic exposure to the green factor in anticipation of their performance. We define this competency as a fund manager's green factor timing skill and examine whether such skill is positively associated with fund green beta. Second, we test whether such green timing skill contributes to green hedge funds' superior performance. Our analysis supports both conjectures. We document that green managers exhibit better green factor timing skills. Funds with higher green beta are able to increase their green beta in anticipation of a more bullish green factor and outperformance of green assets. Moreover, the green timing skill measure is positively associated with fund performance after controlling green beta and other fund characteristics. Green timing skill thus helps explain the outperformance of high green beta funds.

We also explore the factors influencing hedge funds' engagement in green investing. Specifically, we examine two potential channels: political alignment and climate news shock. The role of political alignment has increasingly shaped individuals' attitudes toward climate change risk (Baldauf et al., 2020; Hong and Kostovetsky, 2012; Di Giuli and Kostovetsky, 2014). In our analysis, we find that hedge funds located in Republican-leaning states exhibit lower green beta. Conversely, funds located in Democrat-leaning states exhibit a greater willingness to adopt greener portfolios. Additionally, we find that hedge funds actively increase their exposure to greener assets following unexpected climate news shocks. Our findings support the hypothesis that hedge fund managers are influenced by political ideology and increased concerns about climate change.

We then shift our focus to examine whether hedge fund investors recognize and reward green investing practices. We first regress fund flows on fund green beta, controlling for factors such as past performance and other fund characteristics. Our findings indicate that, on average, green hedge funds tend to attract greater investor flows. Next, to test whether investors' attitudes toward green funds differ depending on fund performance, we categorize hedge funds into high- and low-performing groups based on their alphas. We find that the incremental green flows are present only among funds with high alphas. These findings shed light on hedge fund investors' distinctive attitude toward green investing. 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 green investing. Instead, they reward green funds with higher inflows only when those funds are capable of achieving superior alphas. Lastly, we examine factors influencing the incremental green flows, focusing on the 2015 Paris Agreement, climate news shocks, and political alignment.[6] We find that the incremental green flows emerged only after the 2015 Paris Agreement, suggesting that hedge fund investors have become increasingly aware of climate-related risks in the post-Paris Agreement era. Additionally, investor flows toward green hedge funds increase after the climate news shock. Political alignment also plays a role, with green funds attracting higher flows in Democrat-leaning states, whereas no comparable incremental green flows are observed in Republican-leaning states.

Finally, we extend the work of Liang et al. (2022) and provide evidence on whether hedge funds change their investment practice after joining the United Nations Principles for Responsible Investment (UNPRI). Using a Difference-in-Difference (DiD) setting, we reveal that hedge fund firms increase their exposure to green stocks and decrease their holdings of high-carbon-risk stocks after becoming signatories to the UNPRI. We also observe a positive response from investors following hedge funds' UNPRI signatory status. Building on the study of Liang et al. (2022), our

[6] 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.

results indicate that global initiatives such as the UNPRI can play an important role in driving substantive changes in the hedge fund industry. These initiatives do more than serve as symbolic gestures or window-dressing tools, but instead actively encourage meaningful shifts toward more sustainable investment practices.

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 of climate transition risk (Ceccarelli et al., 2021), especially after natural disasters (Alok et al., 2020) or extreme heat events (Alekseev et al., 2021). Venture capitalists are willing to accept lower financial returns for "impact investments" (Barber et al., 2021). University endowments are also adopting responsible investment policies (Aragon et al., 2022). Our study analyzes green investing practices and their implications within the hedge fund industry. We provide evidence that the hedge fund industry has pivoted towards low-carbon assets and become greener over the past decade.

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 strategies have been a subject of debate among researchers. 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 responsible investment could carry no associated costs (Lindsey et al., 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 green investing can be advantageous to hedge funds, leading to higher alpha and lower risk. These findings are consistent with Ceccarelli et al. (2023), who find that ESG integration at the institutional level positively impacts financial performance.

Third, our study contributes to the literature by identifying a new source of hedge fund performance linked to hedge fund managers' investment skills. While previous research has extensively explored 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 et al., 2014; Chen et al., 2021; Chen et al., 2022), we provide evidence to show the positive impact of hedge fund managers' green investment skills on fund performance. Specifically, we decompose these skills into two aspects: green stock picking and green factor timing. Our results demonstrate that green hedge funds are able to identify undervalued green stocks and successfully time the green factor. This study highlights green investment skills as a unique and valuable driver of hedge fund alpha.

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 manager skills of the entire hedge funds sector and attribute this outperformance to the aggregate portfolio of green stocks held by all hedge funds outperforming the market portfolio of green stocks, our research pinpoints the unique green investing skill within green hedge funds and establishes a direct relationship between fund green beta and fund performance. We demonstrate that the outperformance of green hedge funds is driven by their green stock picking and green factor timing skill—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 is organized as follows: Section 2 describes the data and outlines the methodology for measuring hedge fund greenness. Section 3 presents the empirical results, followed by the robustness analysis in Section 4. Finally, Section 5 concludes the study.

2. Data and Methodology

In this section, we summarize various datasets used in our empirical analysis. Additionally, 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. The merged dataset has a total of 1,963 hedge funds, of which 890 are live funds and 1,073 are dead (defunct) funds. Our final sample contains 11,512 fund-year observations spanning January 2012 to December 2021. 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 became greener after joining the UNPRI, we obtain a complete list of signatories from the UNPRI website and manually match the UNPRI signatories to hedge fund management firms by name and headquarter location. The UNPRI 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, 312 hedge fund management firms joined the PRI in our final sample, and 51% of the funds joined the PRI after 2019.[7]

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

[7] 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.

databases to attract investment capital. As such, backfilled returns tend to be higher than actual returns realized post-listing, which may lead to an overestimation of the fund's performance (Liang, 2000; Fung and Hsieh, 2009; Bhardwaj et al., 2014). To reduce the potential impact of backfilling bias on our analysis, we follow Liang et al. (2022) and include only hedge fund returns that were reported after the fund's listing date in the database. 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 follow Liang et al. (2022) and exclude the first 24 months of return data.[8]

Panel A in Table 1 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 1 about here]

2.2 Other data

Company-level carbon risk scores are from Sustainalytics. Sustainalytics is a leading company in ESG research, ratings, and analysis. It provides Carbon Risk Ratings to assess how well companies are equipped to manage transition risks. 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 companies 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

[8] We first remove the first 24 months return to address incubation bias. Then if there are still returns that were reported before the fund's listing date in the database, we remove them to address backfill bias.

and 100, where lower scores indicate companies with lower carbon risk (green companies), while higher scores indicate companies with higher carbon risk (brown companies). Unlike carbon emission data, which represents a static measurement of a company's current carbon intensity, this approach takes a forward-looking stance and gauges the company'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. For example, 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 the Online Appendix tabulates the companies' average carbon risk scores by industry. It shows that the average carbon risk score across all companies 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).

Hedge fund holdings data are from the Thomson Reuters CDA/Spectrum Institutional (13F) Holdings Database. Firm green innovation data are from the United States Patent and Trademark Office (USPTO) Bulk Data Storage System.[9] Stock return data are from the Center for Research in Security Prices (CRSP), and the firms' financial data are from Compustat. The risk factors for the Fama–French (1993) three-factor model, the Fama–French–Carhart (1997) four-factor model, and the Fama–French (2015) five-factor model are from Kenneth French's data library.

2.3 Measure 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 model:

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

where $r_{i,t}$ is the 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). β_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

[9] Please refer to Kuang and Liang (2024) on how we identify green innovation from the patent data.

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. 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 2 reports the distribution of green beta among diverse hedge fund investment strategies. Long-only hedge funds have the highest green beta, with a value of 0.49, followed by multi-strategy and long-short strategy.[10] Contrarily, hedge fund strategies such as short bias, emerging market, and sector-focused funds exhibit the lowest green beta. These hedge funds face more challenges incorporating ESG into their investment approaches due to their fundamental strategy differences from conventional equity funds.[11]

Panel B of Table 2 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

[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.

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 3.6 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 2 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 capture the same information as market beta. To address this issue, we investigate the correlation between the green beta and each of the betas in the seven-factor model including the market beta. As demonstrated in Table A6 of the Online Appendix, 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. The correlations between the green beta and other betas are even smaller. As a result, 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 portfolio 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 companies, whereas lower scores indicate greener companies, which is opposite to the measure of

green beta. We argue that our green beta methodology offers several advantages over this alternative measure. First, the cross-sectional coverage of our measure surpasses that of the hedge fund firm-level carbon risk measure. Our method enables the estimation of sensitivity 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. Second, 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 fund 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 calculate hedge fund holding-based carbon risk measure and substitute it for green beta in our main analysis, and the main results are consistent. We describe the robustness results in Section 4.

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 green investing practices into their investment strategies. We first analyze hedge funds' ownership based on their 13F fillings. Figure 1 illustrates the trends in hedge funds' holdings of green industry companies and brown industry companies over time. It shows that hedge funds tend to allocate a larger proportion of their investments toward companies in green industries, with an average of 35% of their capital invested in companies belonging to the lowest carbon risk quartile, as opposed to the 15% allocated to companies 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 provide us with initial evidence that hedge funds care about carbon risk and that 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 companies and the decrease in ownership of brown companies 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 companies divided by the total holding value of hedge funds in each quarter. It shows that over the past ten years, hedge funds have consistently favored the green industry, with the net purchases in green industry peaking in 2015 and again in 2020 due to COVID-19. Previous researchers find that institutional shareholders have started to move away from high-carbon risk companies 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 companies each quarter. 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 their presence in the 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 at the stock level. To achieve this, we employ a double-sorting methodology. Each year, we begin by categorizing companies into three ranks based on the industry's average carbon risk score. Companies 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 companies into three groups based on their carbon risk scores. This double sorting results in two ranks for each company: 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 within the green industry, hedge funds demonstrate the ability to identify and select companies with even higher relative green rankings. However, when picking stocks from the brown industry, hedge funds do not appear to differentiate among companies 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 companies within the green industry.

[insert Figure 3 about here]

Overall, these findings on hedge funds' holding and trading behaviors provide clear evidence that hedge funds genuinely consider carbon risk in their investments. 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 away 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 fund 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 3 reports the results. We observe a monotonic increase in hedge fund performance with the fund's green beta. 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 the fund's 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 regression model:

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

where fund performance represents hedge fund excess return or the seven-factor alpha in the next month. Fund green beta is obtained from equation (1). Size refers to a fund's assets under management (AUM), measured 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 3 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, one standard deviation increase in fund green beta will result in a 0.832% per annum (=0.99*0.07%*12) increase in fund alpha and a 1.734% (=0.99*0.146%*12) 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 3.4.

[insert Table 3 about here]

3.3. Hedge fund 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 (Kuang and Liang, 2021). Given their sophisticated nature, ability to attract top talent, and access to advanced technology, the hedge fund industry provides an interesting laboratory to explore this matter further.

To test whether the aggregate risk properties at the fund level behave 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 estimate 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 4 reports the regression results. The dependent variables in Models (1) and (2) are fund total risk, which is the standard deviation of the monthly 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 and tail risks. Specifically, one standard deviation increase in fund green beta is associated with a 0.07% 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 1, 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. This finding carries a significant implication for investing and portfolio management. It underscores green investing as a crucial strategy for investors to mitigate a novel source of risk that the traditional portfolio approaches may not address.

[insert Table 4 about here]

3.4. What explains the green beta-fund performance relation?

Having established that green hedge funds generate better performance and exhibit lower risk, we continue to investigate what drives their outperformance. Previous studies have shown

that green stocks have outperformed brown stocks over the past decade, a phenomenon often referred to as the "green premium" (Garvey et al., 2018; Berkman et al., 2019; Choi et al., 2020; Pástor et al., 2022; Ardia et al., 2023). This raises the question of whether green hedge funds' outperformance is simply due to their exposure to high-return green assets or if it reflects certain investment skills of green fund managers. In this session, we explore two potential channels that contribute to the success of green hedge funds: (green) stock picking skill and green factor timing skill. It is important to emphasize that the two explanations are not mutually exclusive.

3.4.1. Stock picking skills

First, we focus on fund managers' stock-picking skills. We start by assessing whether green hedge fund managers demonstrate superior general stock picking skills. To test this conjecture, we follow Kacperczyk et al. (2014) and utilize hedge fund holding data from their 13F filings. Specifically, we measure hedge fund managers' general stock picking skills as follows:

$$Stock\ picking\ skill_{j,t} = \sum_{k=1}^{N^j} \left(w_{k,t}^{j} - w_{k,t}^{m}\right)\left(R_{t+1}^{k} - \beta_{k,t} R_{t+1}^{m}\right) \quad (4)$$

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

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

$$\begin{aligned} Stock\ picking\ skill_{j,t+1} = {} & \beta_0 + \beta_1 * Green\ beta_{j,t} + \beta_2 * Log(size)_{j,t} + \beta_3 * Age_{j,t} \\ & + \beta_4 * Lockup_{j,t} + \beta_5 * Management\ fee_{j,t} + \beta_6 * Incentive\ fee_{j,t} \\ & + \beta_7 * High\ water\ mark_{j,t} + \beta_8 * Leveraged_{j,t} + \varepsilon_{j,t} \end{aligned} \quad (5)$$

Table 5, Panel A reports the regression results. The coefficient of the variable of interest is positive and significant across all models. It shows that hedge fund green beta is positively associated with better stock picking skills. The stocks selected by green managers outperform other stocks, indicating that managers of green hedge funds exhibit exceptional stock selection abilities.

Next, we explore whether green hedge fund managers apply their stock picking skills in picking better green stocks. Specifically, we examine whether green fund managers can identify companies possessing sustainability-related information not yet discovered by the market. We analyze this information across two dimensions: carbon risk reduction and green innovation. We estimate the following regression model:

$$\Delta Firm\ Sustainbility\ Potential_{k,n} = \beta_0 + \beta_1 * Overweight_{k,t} + \beta_2 * BMratio_{k,t} + \beta_3 * Return_{k,t} + \beta_4 * Log(size)_{k,t} + \beta_5 * ROA_{k,t} + \varepsilon_{j,t} \quad (6)$$

where $\Delta Firm\ Sustainbility\ Potential_{k,n}$ represents the change in company *k's* carbon risk score or change in the number of green patents company issues *n* years from year *t*. We let *n* take the values of 1, 2, and 3 years. $Overweight_{k,t}$ is defined as the difference between firm *k*'s weight in the aggregate portfolio of green hedge funds and its weight in the overall market portfolio. Green hedge funds are defined as funds in the top quintile of green beta. A positive value of $Overweight_{k,t}$ indicates that green hedge funds allocate more to firm *k* than the market does, while a negative value indicates underweighting. We control for company book-to-market ratio, return, log of asset size, and return-to-asset ratio. We also control for year and industry fixed effects and cluster standard errors at the company level.

Table 5, Panel B presents the regression results. We observe that green hedge funds are inclined to favor companies poised for future carbon risk reduction or an increase in green innovation. Specifically, a 10% overweight by green hedge funds is associated with a reduction in carbon risk by 48.85% in the short term (three years) and 63.73% in the longer term (five years). Additionally, these companies generate, on average, 8.16 (three consecutive years) to 7.46 (five years) more green patents. These findings imply that companies selected by green hedge funds hold sustainability-related 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 companies whose green attributes are undervalued 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. Rather, it also results from their ability to identify companies whose green value is underestimated. This edge is derived from managers' deep understanding and exploitation of companies' uncovered sustainability-related information, demonstrating hedge fund managers' sophisticated investment skills.

Our findings reveal that green hedge fund managers possess the skill to identify and invest in companies whose sustainability-related information has not yet been fully priced by the market. This conclusion aligns with Ceccarelli et al. (2023), who highlight that "proactive" fund managers will generate private information about firms' ESG characteristics and trade according to this information to improve fund performance. Together, these findings underscore the existence of the specialized investment acumen of hedge funds in green and ESG-focused investing.

[insert Table 5 about here]

3.4.2. Green timing skills

Another explanation attributes the outperformance of green hedge funds to their green timing skills. 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 et al., 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 hedge fund managers possess better green timing skills. Second, we test whether these green timing skills contribute to fund performance. We expect hedge funds with positive green timing skills to produce higher alpha.

We develop a green timing model following Henriksson and Merton (1981) to assess whether managers can predict green assets' performance and time the green factor accordingly. Specifically, for each hedge fund, we perform the following regression using data from a 24-month backward-looking rolling window:

$$r_{i,t} = \alpha + \beta_g f_{green,t} + \gamma f_{green,t} \times \boldsymbol{I}(GMB_t - \overline{GMB_t}) + \sum_{j=1}^{J} \beta_j f_{j,t} + \varepsilon_{i,t} \quad (7)$$

where $r_{i,t}$ is the excess return on fund *i* in month *t*, β_g is the hedge fund green beta, $f_{green,t}$ is the green factor, GMB_t is the green-minus-brown stock portfolio return from Pástor et al., (2022) and $\boldsymbol{I}$(.) is a dummy variable equal to 1 when GMB_t is greater than its time series mean, and 0 otherwise. The coefficient γ in regression (7) picks up the fund manager's green factor timing skill. A fund manager with the ability to time the green factor would dynamically adjust the fund's exposure to the green factor and increase the fund's exposure to the green factor when the return of green assets is high, leading to a positive γ.

To test whether green hedge fund managers possess better green timing skills, we regress the green factor timing skill on fund green beta and control for other characteristics in the following regression model:

$$\begin{aligned}\text{Green timing skill}_{i,t+1} = {} & \beta_0 + \beta_1 * Green\ beta_{i,t} + \beta_2 * Log(size)_{i,t} + \beta_3 * Age_{i,t} \\ & + \beta_4 * Lockup_{i,t} + \beta_5 * Management\ fee_{i,t} + \beta_6 * Incentive\ fee_{i,t} \\ & + \beta_7 * High\ water\ mark_{i,t} + \beta_8 * Leveraged_{i,t} + \varepsilon_{i,t} \quad (8)\end{aligned}$$

Table 6 reports the regression results. We find a significant positive correlation between a fund manager's green factor timing skill and the fund's green beta. Green fund managers can adjust their exposures to the green factor, increasing green beta when there is a favorable shift in the green factor leading to subsequent superior performance of green assets. Our findings reveal that although green hedge funds have higher green beta and larger allocation to green stocks, their exposure to the green factor is not constantly high at all 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 6 about here]

Finally, to investigate whether a manager's green factor timing skill contributes to fund performance, we regress one-month-ahead fund performance (excess return or alpha) on the green factor timing coefficient estimated from equation (8). Table 7 reports the regression results. Across all models, the coefficients of the green factor timing skill are positive and statistically significant. Meanwhile, fund green beta continues to exhibit a strong relation with fund performance. Consistent with our second conjecture, we find that the green timing coefficient significantly contributes to hedge fund performance.

[insert Table 7 about here]

Bringing together our findings on green fund managers' skills in stock picking and green factor timing, we show that green hedge funds' outperformance is not merely a result of luck, but rather a reflection of their distinct expertise in green investing. We document that green hedge fund managers have better general stock picking skills. More importantly, they leverage their investment expertise in green investing and demonstrate exceptional abilities to identify and prioritize green companies whose sustainability potential is not fully recognized by the market. Additionally, green hedge fund managers can effectively adjust their green investment to time the green factor. Both stock picking skills and factor timing skills contribute to green hedge funds' superior performance.

3.5. What affects hedge fund greenness?

We now turn to investigate what factors influence the hedge fund's exposure to green assets. We test two potential channels: political alignment and climate news shock. This analysis aims to uncover how these influences shape hedge funds' green investment strategies and account for differences in green asset exposure across funds.

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

3.5.1. Political Alignment

The role of political alignment has increasingly become a salient factor in shaping individuals' attitudes toward climate change. Studies have shown that Republican-leaning voters are more likely to exhibit resistance toward climate issues (Hong and Kostovetsky, 2012; Di Giuli and Kostovetsky, 2014). Additionally, researchers have documented that areas with a larger Republican presence tend to be less inclined to believe in the occurrence of climate change (Baldauf et al., 2020). Furthermore, studies show that mutual fund families located in pro-environmental states demonstrate a significantly greater reduction in emissions after signing the UNPRI compared to fund families in states with less environmental concerns (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 climate change than those located in Democrat-leaning states.

To test whether hedge funds share their local public views about climate change, we regress each hedge fund's greenness on a dummy variable that equals one if the hedge fund is in a Republican-leaning 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 2020 presidential election and vice versa. We also include the control variables that are the same as those in equation (2). Table 8, Panel A reports the regression results. The coefficients are significantly negative, indicating that funds located in Republican-leaning states have less exposure to green assets. These findings align with the notion that hedge funds located in pro-environmental states (i.e., Democratic-leaning) are more inclined to incorporate environmentally friendly investments and transition toward a low-carbon economy.

3.5.2. Climate news shock

Next, we examine how climate news shock influences the behavior of hedge fund managers. 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.[13] 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. Hedge funds may also need to adjust their holdings so that they can hedge against climate news, particularly during periods of pronounced negative climate news sentiment. 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.[14] Each month, we regress the fund greenness measure - fund level green beta on the WSJ climate news shock in the previous month[15] and include other control variables. Table 8, Panel B shows the regression results. As expected, the coefficients are significantly positive, suggesting that hedge funds increase their portfolio exposure to greener assets after unexpected climate news shocks.

[insert Table 8 about here]

3.6. Do investors recognize green hedge funds?

Our findings so far indicate that greener hedge funds achieve superior performance and display lower risk. In this section, we explore whether hedge fund investors recognize these green funds and reward them with greater capital inflows.

3.6.1. Green beta and fund flows

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

$$Fund\ flows_{i,t} = \frac{[TNA_{i,t} - TNA_{i,t-1}(1+R_{i,t})]}{TNA_{i,t-1}} \quad (9)$$

[13] Sautner et al. (2021) offer corroborating evidence indicating an intensification of climate concerns subsequent to 2012. The authors assess companies' 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.

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

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

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:

$$\begin{aligned} Fund\ flow_{i,t+1} = {} & \beta_0 + \beta_1 * Green\ fund_{i,t} + \beta_2 * Log(size)_{i,t} + \beta_3 * Age_{i,t} + \beta_4 * Lockup_{i,t} \\ & + \beta_5 * Management\ fee_{i,t} + \beta_6 * Incentive\ fee_{i,t} + \beta_7 * \\ & High\ water\ mark_{i,t} + \beta_8 * Leveraged_{i,t} + \beta_9 * \\ & Past\ performance\ rank_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (10)$$

where the dependent variable $Fund\ flow_{i,t+1}$ is defined in equation (9). $Green\ fund_{i,t}$ is a dummy variable that equals 1 if the green beta is above the median in the previous quarter and 0 otherwise. $Past\ performance\ rank_{i,t}$ is calculated as either the past 12-month fund return rank (past return rank) or alpha rank (past alpha rank).[16] All the other control variables are the same as in previous regressions.

Table 9 Panel A reports the regression results. It shows that green hedge funds attract greater investor flows after controlling for past fund performance and a variety of fund characteristics. Specifically, the green funds are associated with a 0.745% increase in the next quarter's investor flows. This effect is economically significant, equivalent to an inflow of $2.58 (0.745%*346.63) 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.

To gain deeper insight into investors' perspectives on the green investing practices of hedge funds, we divide our sample into two groups based on fund performance: high-alpha funds and low-alpha funds. We then re-estimate equation (10) for each group separately. Table 9 Panel B presents the regression results. The results show that the incremental investor flows for green hedge funds documented in Panel A only exist in the high-alpha sample. This suggests that hedge

[16] Past return and alpha ranks are assigned by sorting hedge fund returns and alphas into deciles, with ranks reflecting their positions within the distributions.

fund investors approach green investing differently compared to other investors. They prioritize performance and reward green funds with higher inflows only when these funds also demonstrate strong returns. This finding underscores hedge fund investors' balanced approach toward sustainable investing, valuing both financial performance and green investing practices.

[insert Table 9 about here]

3.6.2. Other factors affecting green fund flows

The incremental investor flows associated with green 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 encourage 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 investor flows for green funds following the agreement. To test this hypothesis, we estimate the regression model in equation (10) separately for two sub-periods: 2012-2014 (pre-Paris Agreement) and 2015-2021 (post-Paris Agreement). Furthermore, we show investors' attitudes toward green funds 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 Table 10, Panel A. We find that the incremental investor flows are only significant for funds with high alpha within the subsample period after the 2015 Paris Agreement. 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. Additionally, the results reaffirm that investors are unwilling to compromise returns for green investments. They reward green funds with higher inflows only when these funds can generate superior performance.

We next examine whether increased climate news concerns have an impact on investors' behavior. Specifically, we augment our regression analysis in equation (10) 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 10, the coefficient of the interaction term is positive and significant. This finding indicates that investors actively allocate more capital toward green funds when experiencing climate news shock, likely reflecting heightened awareness of climate-related risks and a preference for funds aligned with green investment strategies.

Lastly, we examine how investors' political alignment affects fund flows. For investors' political alignment, we run the same regression as in equation (10) in two subsamples: funds in Republican-leaning states and funds in Democrat-leaning states. We focus our analysis only on post 2015 Paris Agreement period from 2015 to 2021. Panel C of Table 10 reports the results. We observe that the coefficient for green funds is positively significant in column (4), where hedge funds are located in Democrat-leaning states and achieve high alphas. In all other columns, the coefficients are not significant. These findings suggest some evidence that greener funds attract greater investor flows in Democrat-leaning states, but only when they also deliver superior performance. Conversely, there is no evidence of incremental green flows for funds in Republican-leaning states. However, given the relatively small sample size of hedge funds in Republican-leaning states, these results should be interpreted with caution.

[insert Table 10 about here]

3.7. Effect of joining the UNPRI

In recent years, there has been a notable increase in the number of hedge funds becoming signatories to the UNPRI. 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 UNPRI 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 became signatories to the UNPRI exhibit significantly reduced portfolio emissions following their commitment to the initiative compared to non-signatory counterparts. On the other hand, Liang et al. (2022) argue that hedge funds mainly use the UNPRI as a window-dressing narrative, and their cross-sectional analysis shows that hedge funds that are UNPRI signatories exhibit higher ESG risk compared to non-UNPRI signatories.

In the last section of our analysis, we use a DiD model to further explore whether joining the UNPRI leads hedge funds to change their green investing practices and increase their exposure to green assets. Since the signatories are assigned at the hedge fund management firm level, we aggregate fund green beta, carbon risk score, and other control variables at the firm level and use the following specification:

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

where the dependent variable $Greenness$ is either the hedge fund green beta or firm-level carbon risk score. $UNPRI$ takes a value of 1 if a hedge fund management firm is an UNPRI signatory and 0 otherwise. $Post$ takes a value of 1 after the hedge fund management firm signs the UNPRI 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 in previous equations.

Panel A of Table 11 reports the regression results. The coefficient of the interaction term is positive and significant. This indicates that after signing the UNPRI initiative, hedge fund management firms actively increase their exposure to green assets, as reflected in higher green beta. Our results extend the findings of Liang et al. (2022), where they focus on the cross-sectional comparison between UNPRI hedge funds and non-UNPRI hedge funds. Our analysis focuses on the time-series differences in hedge fund firms' behavior and examines the effects of joining the

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

UNPRI within a DiD framework. Our findings establish the causal effects of joining the UNPRI on increasing hedge funds' sustainable investing practices.

We further examine how investors respond to hedge funds' decision to join the UNPRI. Previous studies have documented incremental flows for signatory mutual funds compared to non-signatory funds (Humphrey and Li, 2021; Kim and Yoon, 2023). In this analysis, we test whether a similar effect exists among hedge funds. To do so, we adapt the regression model in equation (10) to a DiD framework and use annual fund flows aggregated at the firm level as the dependent variable. Panel B of Table 11 presents the results. The coefficients for the interaction term are all positive and significant. This indicates that investors react favorably to hedge fund firms after they sign the UNPRI. While these findings are consistent with those of Liang et al. (2022), when considered alongside the results in Panel A, our evidence suggests that hedge funds do not engage in window-dressing by merely using UNPRI affiliation to superficially enhance their green credentials. Instead, their behavior reflects genuine integration of green investing practices.

[insert Table 11 about here]

4. Robustness

An alternative method to 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 management firms (Liang et al., 2022). Since the carbon risk score can only be calculated at the hedge fund management firm level, we assign the same carbon risk score to each fund within the same hedge fund management firm. To investigate whether the results are sensitive to our measurement of green beta, we reproduced the main analysis using a holdings-based carbon risk score. We discuss the methodology to construct hedge fund management firm-level carbon risk score in Online Appendix A1. We report the results in Table A2 of the Online Appendix. The results are consistent with our main findings.

We also construct an alternative measure of hedge fund green beta by adding more traditional risk factors in equation (1). To eliminate the concerns that the green factor is a proxy for firm profitability or firm investment policy, we add the profitability factor (RMW) and the

investment factor from the Fama–French (2015) five-factor model. We also add the momentum factor from Fama–French–Carhart's (1997) four-factor model.[18] We substitute the new green beta for the original green beta in our main analysis, and the main results are consistent. The results are reported in Table A3 and Table A4 of the Online Appendix. They are consistent with our main findings.

5. Conclusion

This study explores various crucial aspects of green investing practices within the hedge fund industry. Through the development of a unique metric, green beta, to assess the extent to which hedge fund returns align with green factor returns, we can measure hedge funds' involvement in green investments at the individual fund level. Our analysis offers the first empirical evidence on how hedge funds address climate change risk and demonstrates their active transition toward a low-carbon investment profile. We provide robust evidence that hedge funds with greater exposure to green assets not only outperform their peers but also exhibit reduced risk levels. This challenges the conventional view that environmentally sustainable investing comes at the expense of returns, as managers must sacrifice performance for nonpecuniary benefits. Instead, our findings support the notion that skilled managers can enhance fund performance by "doing well by doing good," achieving superior returns while managing risk through green investments.

We also find that green hedge funds' superior performance is driven by the advanced green investing skills of their managers. Specifically, green fund managers demonstrate exceptional abilities in both stock picking and green factor timing. They can effectively analyze complex and uncertain sustainable information to identify undervalued green stocks. Additionally, skilled green fund managers capitalize on fluctuations in green factor returns by predicting changes in green stock performance. These abilities in stock picking and green factor timing not only boost fund

[18] MOM_t is the return difference between the monthly portfolios of stocks with high and low past returns, RMW_t is the return difference between the monthly portfolios of stocks with robust and weak profitability, and CMA_t is the return difference between the monthly portfolios of stocks that invest conservatively and that invest aggressively. All the risk factors are obtained from Kenneth French's Data Library.

performance but also enable hedge funds to align their portfolios with a more sustainable investment strategy.

We also examine investor reactions to green hedge funds and find that funds with higher green beta attract greater investor flows, particularly in the post-2015 Paris Agreement era. However, this extra green flow is observed only when funds deliver high performance, suggesting that investors prioritize financial performance alongside sustainability. These findings highlight the multifaceted nature of hedge fund investors' utility, balancing social preferences and financial motives in their sustainable investment decisions.

Finally, our study unveils the impact of political beliefs, climate news shocks, and participation in the UNPRI on hedge funds' engagement in sustainable investing and investor flows. We find that hedge funds based in Republican-leaning states exhibit lower green beta compared to those in Democrat-leaning states. Additionally, both hedge fund managers and investors are significantly affected by prevailing climate change news sentiment. Climate news shock prompts fund managers to allocate more assets toward green stocks and leads to increased fund flows to greener funds from investors. Furthermore, we provide evidence that hedge funds actively adjust their portfolios after signing the UNPRI initiative, increasing their exposure to green assets while reducing holdings of high-carbon-risk stocks. Hedge fund investors respond positively to these changes, channeling greater fund flows to firms demonstrating a commitment to sustainable practices.

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Figure 1. Hedge Fund Holdings by Industry

This figure plots the trends in hedge funds' holdings of green industry companies and brown industry companies over time. Each year, we calculate the average carbon risk score for each industry based on the carbon risk scores of its constituent companies. Industries are then sorted into quartiles based on the industry's carbon risk score. Green industries are defined as those in the lowest carbon risk quartile, while brown industries are those in the highest quartile. Green industry companies are defined as companies in the green industries. Brown industry companies are defined as companies in the brown industries. Weight is defined as the holding value of companies 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 from 2012 to 2021.

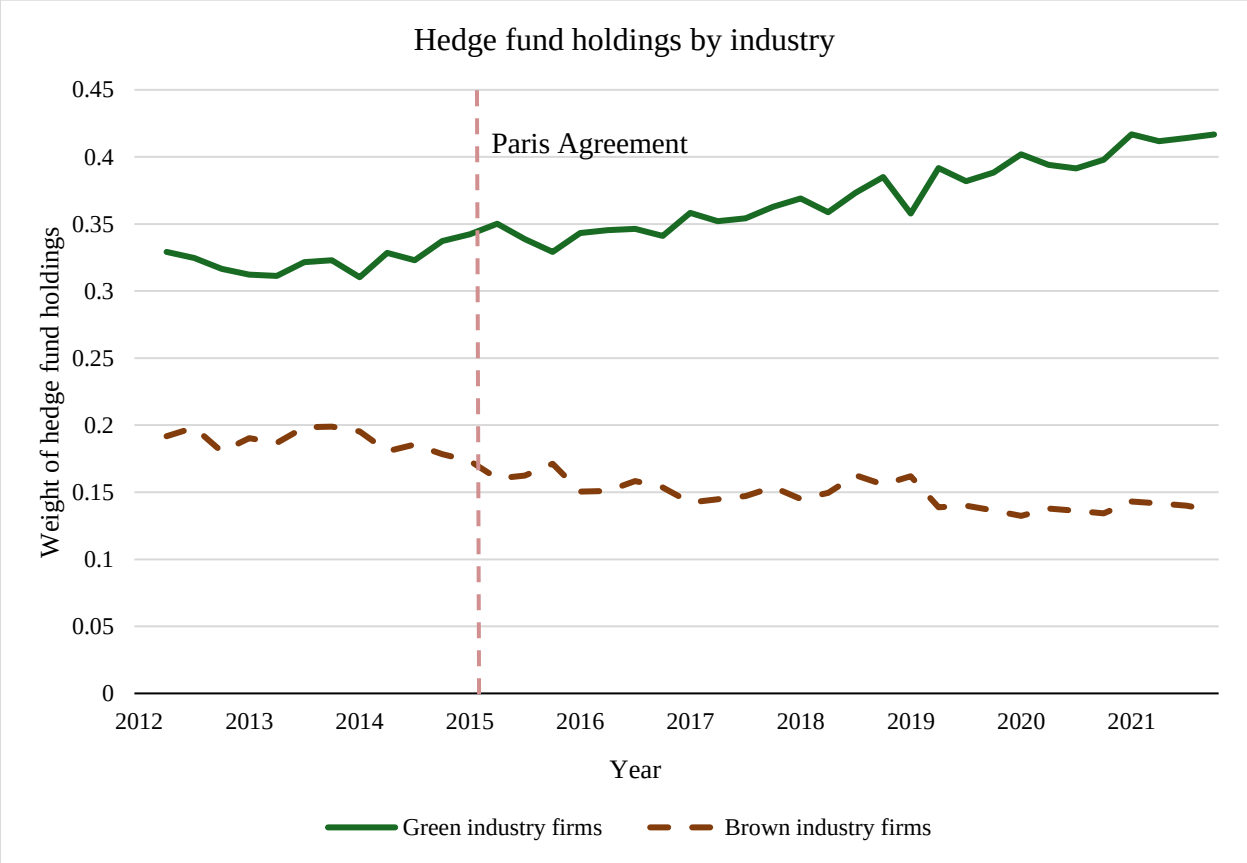

Figure 2. Hedge Fund Net Purchase by Industry

This figure plots the average weight of hedge fund quarterly net purchases (total purchase minus total sales) sorted by companies' industry. Each year, we calculate the average carbon risk score for each industry based on the carbon risk scores of its constituent companies. Industries are then sorted into three ranks based on the industry's carbon risk score. Green industries are defined as those in the lowest carbon risk quartile, while brown industries are those in the highest quartile. Green industry companies are defined as companies in the green industries. Brown industry companies are defined as companies in the brown industries. Weight is defined as the holding value of companies 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 from 2012 to 2021.

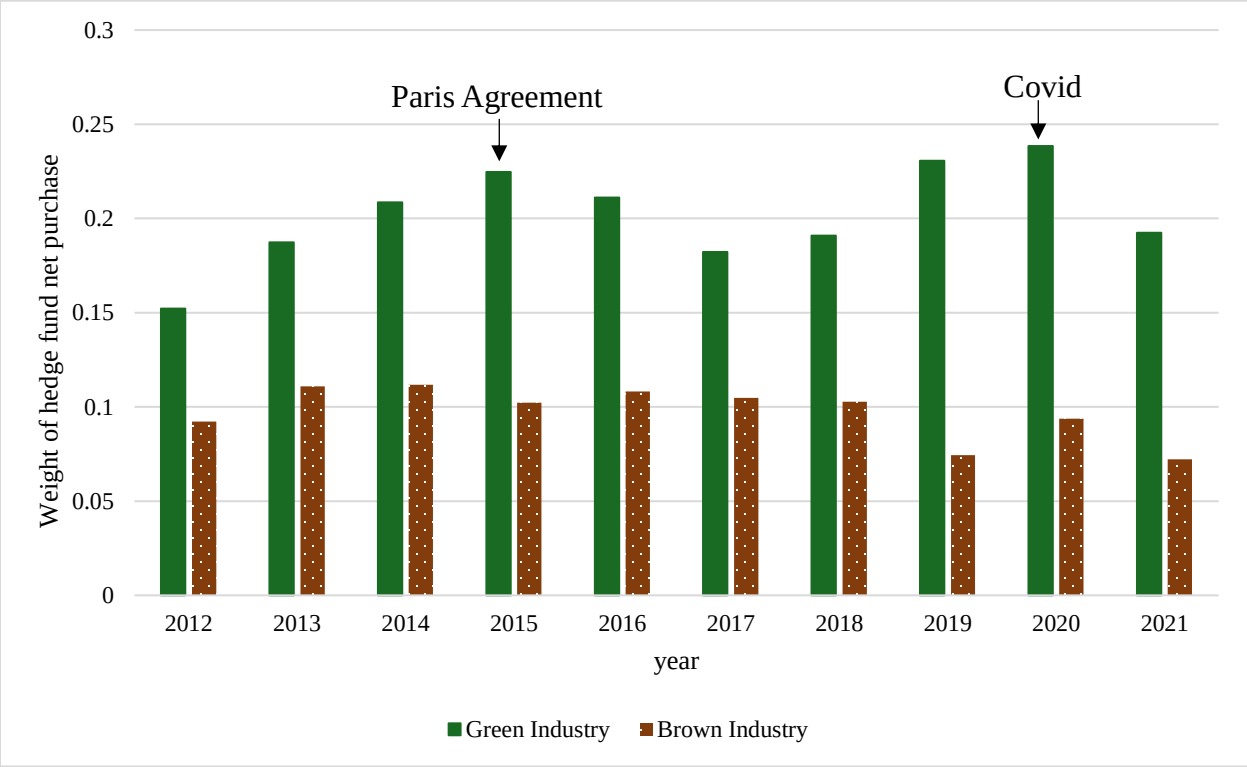

Figure 3. Hedge Fund Net Purchase by Companies and Industries

This figure plots the weight of hedge fund quarterly net purchase (total purchase minus total sales) sorted by companies' industry. Each year, we calculate the average carbon risk score for each industry based on the carbon risk scores of its constituent companies. Industries are then sorted into three ranks based on the industry's carbon risk score. Green industries are defined as those in the lowest carbon risk quartile, while brown industries are those in the highest quartile. Next, within each industry, companies are further sorted into another three 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 companies 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 from 2012 to 2021.

Figure A: Hedge fund net purchase in the green industry

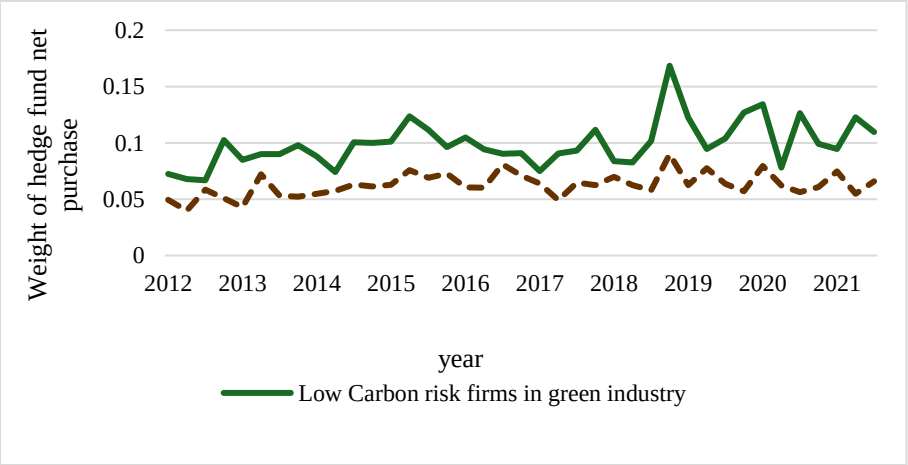

Figure B: Hedge fund net purchase in the brown industry

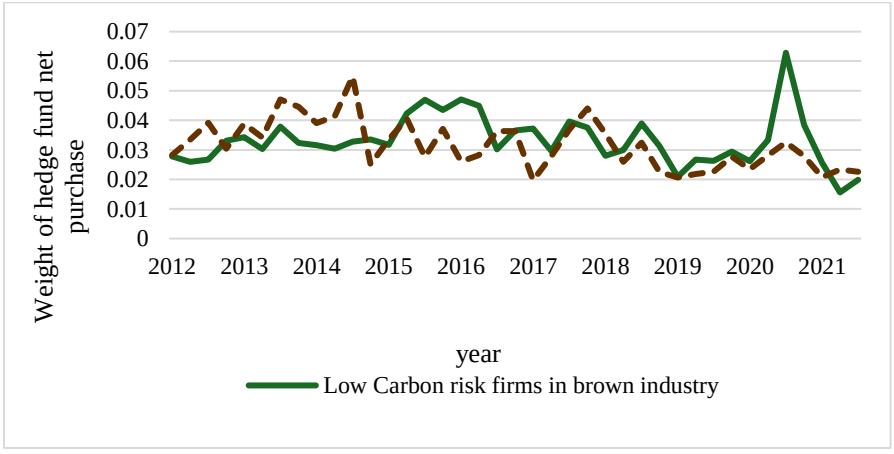

Table 1. Summary Statistics

	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

This table presents summary statistics for a sample of U.S. equity-oriented hedge funds over the period 2012–2021. *AUM* is the fund's reported assets under management at the end of each month ($ millions). *Management fee* and *Incentive fee* are reported in percentage. *High water mark* is a dummy variable equal to one if the hedge fund uses a high-water mark and zero otherwise. *Leveraged* is a dummy variable equal to one if the hedge fund uses leverage, and zero otherwise. *Redemption period* is the number of days' advance notice that an investor must give the fund to withdraw their capital. *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 scaled by fund assets. *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. *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 factors. The summary statistics are based on fund-month observations. All variables are winsorized at the 1% and 99% levels.

Table 2. 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. Panel B reports the univariate analysis of fund characteristics and fund green beta. Each month, funds are sorted into five quintiles based on fund green beta. Funds in the highest quintile (fifth quintile) are classified as *High green beta funds*, while those in the lowest quintile (first quintile) are classified as *Low green beta funds*. Fund characteristic variables are defined in Table 1.

Table 3. Hedge Fund Green Beta and Fund Performance

Panel A: Hedge Fund Performance Sorted by Fund Green Beta

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

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	0.060	0.109	0.260	0.251

Panel A reports the univariate analysis of fund performance and fund green beta. Each month, funds are sorted into five quintiles based on fund green beta. Fund green beta increases monotonically from the lowest quintile (Rank 1) to the highest quintile (Rank 5). Panel B reports results from the regression of fund performance on fund green beta and other characteristics, as specified in equation (2). 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's monthly excess return (%). All control variables are defined in Table 1.

Table 4. Hedge Fund Green Beta and Fund Risk

	Total 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	0.246	0.249	0.250	0.245

This table reports results from the regression of fund risk on fund green beta and other characteristics, as specified in equation (3). The dependent variables in Models (1) and (2) are fund total risk, which is the standard deviation of the monthly fund rate of returns. The dependent variables in Models (3) and (4) are fund tail risk, which is measured as a hedge fund's 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 watermarks, 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 5. Green Hedge Fund Stock Picking Skill

Panel A: Hedge Fund Management Firm Green Beta and General Stock Picking Skill

	Stock picking skill (Equally-weighted firm green beta)		Stock picking skill (Value-weighted firm green beta)	
	(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	0.046	0.047	0.045	0.047

Panel B. Green Hedge Fund Overweight and Company Sustainable Potential

	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

Panel A reports results from the regression of hedge fund stock picking skills on fund green beta and other characteristics, as specified in equation (5). Hedge fund stock picking skill is defined in equation (4) based on the 13F holding data. 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 factors. 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. In models (1) and (2), all variables are aggregated at the hedge fund management firm level using equal-weighted averages. In models (3) and (4), all variables are aggregated at the firm level using value-weighted averages. Panel B reports results from the regression examining the relationship between the change in green companies' environmental policy and the extent to which a company is favored by green hedge funds. Green companies are defined as companies 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 companies 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 companies 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 fund green beta. All columns control a company's book-to-market ratio (*BM Ratio*), annual return (*Return*), natural logarithm of company size (*Log(size)*), and return on asset (*ROA*). The *t*-statistics are in parentheses. Standard errors are clustered by firm. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Green Timing Skill and Fund Green Beta

	Green factor timing skill	
	(1)	(2)
Green beta	0.111**	0.110**
	(2.27)	(2.18)
Log (size)		0.062**
		(2.58)
Fund age		-0.014***
		(-2.70)
Lock up period		-0.010
		(-1.64)
Management fee		-0.124
		(-1.12)
Incentive fee		-0.005
		(-0.54)
High water mark		0.108
		(0.61)
Leveraged		0.035
		(0.40)
Time FE	YES	YES
Investment style FE	YES	YES
Observations	68,396	68,396
R-squared	0.048	0.052

This table reports results from the regression of hedge fund green factor timing skill on fund green beta and other characteristics, as specified in equation (8). The dependent variable is the hedge fund's green factor timing skill, which is defined as the green coefficient (γ) in equation (7). 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's (2004) seven factors. 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 a high water mark, and a dummy variable for the fund with leverage. The *t*-statistics are in parentheses. Standard errors are clustered at the hedge fund management firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Green Timing Skill and Fund Performance

	Green factor timing skill	
	Excess return	Alpha
	(1)	(2)
Green timing skill	0.034***	0.028***
	(4.70)	(3.13)
Green beta	0.142***	0.067***
	(9.69)	(4.67)
Log (size)	0.022***	0.041***
	(2.76)	(5.98)
Fund age	-0.004	-0.017***
	(-1.58)	(-8.72)
Lock up period	0.002	-0.000
	(1.15)	(-0.10)
Management fee	0.023	0.197***
	(0.64)	(6.31)
Incentive fee	-0.004	0.006**
	(-1.29)	(2.11)
High water mark	0.067	0.118**
	(1.14)	(2.21)
Leveraged	-0.034	-0.003
	(-1.07)	(-0.11)
Time FE	YES	YES
Investment style FE	YES	YES
Observations	68,396	68,396
R-squared	0.252	0.117

This table reports results from the regression of fund performance on fund green factor timing skill and other characteristics. The dependent variable in Model (1) is the fund's monthly excess return (%). The dependent variable in Model (2) is Fung and Hsieh (2004) seven-factor alpha (%). Green factor timing skill is defined as the green coefficient (γ) in equation (7). 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 factors. 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 8. Hedge Fund Green Beta, Political Alignment, and Climate News Shock

Panel A: Hedge Fund Political Alignment and Carbon Risk Exposure

	Green beta	Green beta
	(1)	(2)
Republican state	-0.137*	-0.253**
	(-1.66)	(-2.20)
Control variables	NO	YES
Year-month FE	YES	YES
Investment style FE	YES	YES
Observations	48,875	35,204
R-squared	0.0363	0.0639

Panel B: Hedge Fund Green Beta and Climate News Shock

	Green beta	Green beta
	(1)	(2)
WSJ climate news shock	0.080***	0.080***
	(3.92)	(2.67)
Control variables	NO	YES
Year-month FE	YES	YES
Investment style FE	YES	YES
Observations	67,896	42,744
R-squared	0.0299	0.0488

Panel A reports results from the regression of fund green beta on hedge fund political alignment and other characteristics. The dependent variable is the fund 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 factors. The variable of interest is a dummy variable that equals one if the hedge fund is located in a Republican-leaning state, and zero if the hedge fund is located in a Democrat-leaning state. Panel B reports results from the regression of fund green beta on climate news shock measured from the WSJ index and other characteristics. The dependent variable is the fund 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 factors. The variable of interest is WSJ climate news shock, which is calculated as the prediction errors from AR (1) models applied to the underlying WSJ climate change news index. 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 a high water mark, and a dummy variable for the fund with leverage. The sample period is from 2015 to 2021. The *t*-statistics are in parentheses. Standard errors are clustered by the fund and month. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 9. Hedge Fund Green Beta and Fund Flows

Panel A: Full Sample Analysis

	Flow	Flow	Flow
	(1)	(2)	(3)
Green fund	0.836***	0.745***	0.511**
	(3.80)	(3.39)	(2.43)
Past return rank		1.001***	
		(14.59)	
Past 7-factor alpha rank			1.661***
			(18.58)
log (size)		-0.300***	-0.419***
		(-4.37)	(-5.95)
Fund age		-0.230***	-0.169***
		(-12.09)	(-9.04)
Lock up period		0.020	0.021
		(1.21)	(1.24)
Management fee		0.026	-0.576**
		(0.09)	(-1.97)
Incentive fee		-0.019	-0.058**
		(-0.65)	(-2.03)
High water mark		0.240	0.051
		(0.49)	(0.11)
Leveraged		-0.053	-0.140
		(-0.20)	(-0.53)
Year-quarter FE	YES	YES	YES
Investment style FE	YES	YES	YES
Observations	26,764	22,845	22,845
R-squared	0.0132	0.0451	0.0654

Panel B: Fund Flow for Low Alpha Funds and High Alpha Funds

	Flow (Low alpha funds) (1)	Flow (Low alpha funds) (2)	Flow (High alpha funds) (3)	Flow (High alpha funds) (4)
Green fund	0.382	0.374	0.622**	0.631**
	(1.40)	(1.35)	(2.07)	(2.11)
Past return rank		0.899***		0.840***
		(11.11)		(8.80)
log (size)		-0.429***		-0.397***
		(-5.19)		(-3.63)
Fund age		-0.091***		-0.291***
		(-3.75)		(-10.86)
Lock up period		0.061***		-0.012
		(3.00)		(-0.54)
Management fee		-1.036***		0.321
		(-2.86)		(0.76)
Incentive fee		-0.077**		-0.031
		(-2.12)		(-0.74)
High water mark		0.7210		-0.744
		(1.20)		(-1.02)
Leveraged		-0.086		-0.094
		(-0.26)		(-0.24)
Year-quarter FE	YES	YES	YES	YES
Investment style FE	YES	YES	YES	YES
Observations	13,307	10,909	13,457	11,936
R-squared	0.0203	0.0471	0.0157	0.0526

Panel A reports results from the regression of fund flows on the lagged fund green beta and other characteristics, as specified in equation (10). The dependent variable is fund quarter flow, which equals the percentage change in TNA after adjusting for the fund's total return, as defined in equation (9). The variable of interest is the green fund, which is a dummy variable that equals 1 if the green beta is above the median in the previous quarter and 0 otherwise. The dependent variable is in quarter $t + 1$ and all the independent variables are in quarter t. Panel B reports the sub-sample results on the low-alpha funds and high-alpha funds. Low alpha funds are defined as funds with an alpha below the median in the previous quarter. High alpha funds are defined as the funds with alpha above the median in the previous quarter. All regression models include 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. 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 10. Other factors affecting fund flows

Panel A: Fund Flow before and after the 2015 Paris Agreement

	Year<2015		Year>=2015	
	Flow (Low alpha funds) (1)	Flow (High alpha funds) (2)	Flow (Low alpha funds) (3)	Flow (High alpha funds) (4)
Green fund	0.277	0.486	0.348	0.777**
	(0.66)	(0.95)	(1.04)	(2.32)
Past return rank	1.056***	1.164***	0.791***	0.642***
	(7.66)	(7.11)	(8.11)	(5.73)
log (size)	-0.342***	-0.491**	-0.479***	-0.332***
	(-2.63)	(-2.48)	(-4.63)	(-2.65)
Fund age	-0.143***	-0.382***	-0.077***	-0.270***
	(-3.52)	(-7.10)	(-2.72)	(-8.70)
Lock up period	0.053	-0.059	0.066***	0.010
	(1.51)	(-1.52)	(2.91)	(0.37)
Management fee	-0.718	-0.634	-1.237***	0.936*
	(-1.15)	(-0.97)	(-3.01)	(1.80)
Incentive fee	-0.197***	-0.041	0.004	-0.052
	(-3.81)	(-0.56)	(0.08)	(-0.96)
High water mark	1.658**	-0.432	-0.356	-0.666
	(2.09)	(-0.35)	(-0.43)	(-0.71)
Leveraged	0.183	-0.195	-0.175	-0.008
	(0.38)	(-0.28)	(-0.44)	(-0.02)
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	0.0545	0.0676	0.0456	0.0478

Panel B: Fund Flows and Climate News Shock

	Flow	Flow
	(1)	(2)
Green fund	0.596	0.188
	(1.49)	(0.49)
WSJ climate news shock	-0.736***	-0.715***
	(-4.75)	(-4.69)
High green beta * WSJ climate news shock	0.909***	0.818***
	(4.45)	(4.08)
Past return rank	0.984***	
	(8.43)	
Past alpha rank		1.851***
		(12.47)
log (size)	-0.384***	-0.500***
	(-2.98)	(-4.05)
Fund age	-0.246***	-0.174***
	(-6.99)	(-5.19)
Lock up period	-0.007	0.002
	(-0.23)	(0.06)
Management fee	0.229	-0.142
	(0.43)	(-0.28)
Incentive fee	0.041	-0.014
	(0.75)	(-0.25)
High water mark	0.135	-0.023
	(0.14)	(-0.02)
Leveraged	0.243	0.096
	(0.48)	(0.20)
Year-quarter FE	YES	YES
Investment style FE	YES	YES
Observations	6,354	6,354
R-squared	0.0481	0.0768

Panel C: Fund Flows and Political Alignment

	Republican state		Democratic state	
	Flow (Low alpha funds)	Flow (High alpha funds)	Flow (Low alpha funds)	Flow (High alpha funds)
	(1)	(2)	(3)	(4)
Green fund	1.775	0.269	0.398	0.748*
	(1.67)	(0.22)	(1.08)	(1.95)
Past return rank	-0.028	1.269***	0.708***	0.559***
	(-0.06)	(3.22)	(6.65)	(4.60)
log (size)	-0.392	-0.439	-0.406***	-0.335**
	(-0.67)	(-0.75)	(-3.18)	(-2.21)
Fund age	-0.177*	-0.408***	-0.093***	-0.232***
	(-1.90)	(-3.49)	(-2.96)	(-6.75)
Lock up period	0.037	0.148*	0.066**	0.013
	(0.37)	(1.94)	(2.52)	(0.45)
Management fee	-1.016	0.718	-1.815***	0.770
	(-0.71)	(0.44)	(-3.70)	(1.23)
Incentive fee	0.173	0.328	0.040	-0.044
	(0.84)	(1.40)	(0.85)	(-0.69)
High water mark	-4.489	-8.624*	-0.285	-0.889
	(-0.89)	(-1.75)	(-0.34)	(-0.87)
Leveraged	0.452	0.844	0.115	0.650
	(0.36)	(0.67)	(0.25)	(1.44)
Year-quarter FE	YES	YES	YES	YES
Investment style FE	YES	YES	YES	YES
Observations	548	543	5,099	5,582
R-squared	0.0583	0.1434	0.0477	0.0455

Panel A reports results from the regression of fund flows on the lagged fund green beta and other characteristics, before and after the 2015 Paris Agreement. The variable of interest is the green fund, which is a dummy variable that equals 1 if the green beta is above the median in the previous quarter and 0 otherwise. Panel B reports results from the regression of fund flows on the lagged fund green beta, climate news shock, and other characteristics. The variables of interest is fund green beta, the WSJ climate news shock, and the interaction between fund green beta and the WSJ climate news shock. The WSJ climate news shock is calculated as the prediction errors from AR (1) models applied to the underlying WSJ climate change news index. Panel C reports the regression of fund flows on the lagged fund green beta with a sample split by funds that are located in Republican states and funds that are located in Democratic states. 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. All regression models include the control variables defined earlier.

Table 11. Effects of Hedge Funds Joining the UNPRI on Green Investing and Flow

Panel A: Hedge Fund Management Firm Green Beta before and after Joining UNPRI

	Equally-weighted	Value-weighted
	(1)	(2)
UNPRI*Post	0.107*	0.136*
	(-1.67)	(-1.88)
Log (size)	0.026	0.004
	(0.59)	(0.23)
Fund age	-0.033	0.035
	(-1.53)	(1.18)
Lock up period	0.002	0.021
	(0.78)	(1.48)
Management fee	0.041	0.154
	(0.12)	(0.74)
Incentive fee	0.030	0.024
	(1.03)	(1.01)
High water mark	-0.192	-0.305
	(-0.67)	(-0.68)
Leveraged	-0.113	-0.497**
	(-0.40)	(-2.21)
Year FE	YES	YES
Fund firm FE	YES	YES
Observations	3,366	2,774
R-squared	0.0421	0.0211

Panel B: Hedge Fund Management Firm Flows before and after Joining UNPRI

	Firm flow (equally-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 results from the difference-in-difference (DiD) regression examining hedge fund management firm green beta prior to and post-endorsing the UNPRI. The dependent variables are hedge fund management firm green beta, which is aggregated from individual funds within the same management firm. In model (1), all variables are aggregated at the hedge fund management firm level using equal-weighted averages. In model (2), all variables are aggregated at the firm level using value-weighted averages. UNPRI takes a value of 1 if the hedge fund management firm has signed the UNPRI and 0 otherwise. Post takes a value of 0 before the firm signs the UNPRI and 1 post-signing. Panel B reports results from the DiD regression examining hedge fund management firm flows before and post-endorsing the UNPRI. The dependent variables are hedge fund management firm annual flows, which are aggregated from individual funds within the same management firm. In model (1), all variables are aggregated at the hedge fund management firm level using equal-weighted averages. In model (2), all variables are aggregated at the firm level using value-weighted averages. UNPRI takes a value of 1 if the hedge fund management 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. All regression models include the control variables defined earlier.