Green Transmission: Monetary Policy in the Age of ESG

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Abstract

Green firms (with high environmental performance ratings) experience a less pronounced reduction in stock prices compared to brown firms (with low environmental performance ratings) in response to monetary policy tightening. Using a stylised theoretical framework and comprehensive empirical analysis, I show that this is driven by investors' preferences for sustainable investing. When interest rates rise, expected future dividends are discounted more heavily, reducing both green and brown asset prices. However, investors favouring sustainable investments are less likely to unwind their green portfolio positions in response to contractionary monetary policy shocks, thereby mitigating the impact on green asset prices.

Keywords: Monetary Policy, Heterogeneity, Sustainable Investing, ESG, Climate Change.

JEL Codes: E52, G12, G14, G30

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1 Introduction

How sensitive are green firms to monetary policy? This question has gained significant attention in policy discussions, as firms that engage in green investments hold a pivotal role in expediting the transition towards a Net-Zero Economy. Given that substantial investments in technological advancements, renewable energy and green innovation are susceptible to fluctuations in the cost of credit, higher interest rates may threaten these firms' efforts to decarbonise (Aghion et al., 2024). However, the recent decade has also been characterised by a substantial increase in Environmental, Social and Governance (ESG) investing, driven in large part by preferences for sustainable investing (Pastor et al., 2021). If these investments continue to favour greener firms, this could mitigate the impact of tighter monetary policy on their funding conditions. Consequently, it is unclear how monetary policy affects green firms. This paper fills this gap.

I look at a particular dimension of firm greenness that aims to capture a firm's resilience to both physical and transitional (regulatory) climate change risks. In this vein, green (brown) firms refer to those who score highly on the Environmental Pillar of the ESG scoring system. Given the significant rise in ESG investing over the last decade, these scores reflect what financial markets perceive as green, which has important implications for how individual firms' equity prices may react to monetary policy. I show that stock prices of green firms experience a dampened sensitivity to monetary policy relative to brown firms, and posit that this is a result of preferences for sustainable investing. When interest rates rise, expected future dividends are discounted by a larger factor, leading to a decline in both green and brown asset prices. However, when investors have a preference for sustainability, they are more reluctant to unwind their green portfolio positions in the face of a contractionary monetary policy shock. This behaviour then attenuates the impact of changes in interest rates on green asset prices.

I proceed in three parts. In the first part of the paper, I characterise how firms' sensitivity to monetary policy shocks depends on their environmental performance. Using stock market data from a sample of US publicly listed firms, firm-level environmental performance data from MSCI ESG IVA Ratings, and an exogenous monetary policy shock series from Bu et al. (2021), I find important heterogeneity in how firms' greenness affects the response of stock prices to monetary policy surprises.[1] Stock prices of green firms are considerably less responsive: following a 100 basis point surprise in monetary policy, stock prices of green (quintile 5) firms fall by around 10%, whereas the stock prices of their brown (quintile 1) counterparts fall by around 21%. This result cannot be explained by differences in observed firm-level characteristics or differences in sectoral sensitivities to monetary policy. This finding is robust to a battery of tests, including: (i) using alternative interest rate surprises; and (ii) assessing firm-level greenness based on other ESG score metrics. Additionally, this result is relatively symmetric and equally significant across contractionary and expansionary monetary policy episodes and holds in the Zero Lower Bound (ZLB) as well as in the post-ZLB period. Analysis of changes in CDS spreads also shows similar heterogeneity: green firms' CDS spreads appear less sensitive to monetary policy surprises.[2]

In the second part, I consider a stylized theoretical framework that is able to account for the observed heterogeneity in firms' responses to monetary policy. The key idea is that investors might value green assets for reasons other than expected return or risk, which may be important in determining asset prices. In the model, the semi-elasticity of green security prices with respect to monetary policy shocks is a composite of both pecuniary and non-pecuniary forces. The pecuniary force that is common across both green and brown assets results in a reduction of both of these asset prices. The non-pecuniary force, which is only present in the case of green stocks, dampens the pecuniary force because investors derive an additional utility from holding green assets. Consequently, the model suggests that (i) monetary policy has a dampened effect on green asset prices when these assets are held by environmentally conscious investors; (ii) this effect is even more pronounced in states of the world with stronger

[1] I use panel event study regressions based on high-frequency stock market data between 2008 to 2020.

[2] This is also consistent with the heterogeneous effect of monetary policy on green and brown firm's investment decisions. A complementary analysis at quarterly frequency is provided in Appendix B.1.

preferences for sustainable investing; and (iii) this effect is reflected in an increased portfolio weight of green securities in response to monetary policy tightening.

In the third part of the paper, I validate these three model predictions with causal evidence on how the sensitivity of green assets to monetary policy varies across the distribution of investors' preferences. To proxy for sustainable preferences, I leverage information from the CRSP survivorship-bias-free mutual fund database and identify a set of sustainable (ESG) index funds. In line with the first prediction, I show that green firms held by ESG funds exhibit a lower sensitivity to monetary policy shocks compared to green firms held by non-ESG funds. In line with the second prediction, I find that the heterogeneous response of green firms to monetary policy is more pronounced for green firms held by index funds that are located in: (i) regions with high exposure to natural disaster risk; (ii) US counties where climate change beliefs and risk perceptions are stronger; and (iii) times of heightened climate change concerns.

Lastly, to test the third prediction, I investigate whether there are differences in the funding behaviour of mutual funds that identify as ESG compared to those that do not. I find supporting evidence of a portfolio rebalancing channel. Notably, following a 100 basis point surprise increase in the federal funds rate, outflows from institutional non-ESG index funds surpass those from ESG index funds by approximately 7 percentage points. This points to a considerable reluctance of institutional investors to unwind their ESG portfolio positions in the face of adverse macro-financial shocks.

To summarise, the empirical results support the view that preferences for sustainable investing lower the sensitivity of green capital flows to monetary policy shocks. This enhances green firms' resilience to higher interest rates.

Literature Review. This paper contributes to two strands of the literature. First, there is a large literature examining the differential impact of monetary policy across firms. This literature has typically looked at proxies for financial constraints such as firm size, indebtedness, age, liquidity and distance to default (Ottonello and Winberry, 2020; Cloyne et al., 2023;

Jeenas, 2023; Ozdagli and Velikov, 2020). For instance, Cloyne et al. (2023) shows that young firms paying no dividends exhibit the largest and most significant change in capital expenditure following a monetary policy shock. This is driven by the fact that these firms' external finance is most exposed to the asset value fluctuations induced by monetary policy shocks. In a model of heterogeneous firms, which issue long-term debt subject to fixed issuance costs, Jeenas (2023) argues that a firm's liquid assets are a good predictor of lower future likelihood of debt issuance and insensitivity to borrowing rates. Similarly, Anderson and Cesa-Bianchi (2024) document that in response to monetary policy shocks, firms with low leverage experience a less pronounced increase in credit spreads than firms with high leverage. In contrast to these studies, I focus on an unexplored dimension of heterogeneity arising from firms' environmental performance, or 'greenness'. Consistent with these papers, I also find that some of these traditional firm characteristics, such as age, liquidity and distance to default are significant drivers of monetary policy heterogeneity. However, they cannot explain the dampened response of greener firms to tighter monetary policy. This suggests that greenness itself is a unique characteristic that matters for monetary policy transmission on firm-level outcomes.

Second, there is a rapidly growing literature on how financial markets price in climate risk. Barnett et al. (2020) provide novel theoretical insights into this topic by drawing from decision theory and tools from asset pricing under uncertainty to estimate the social cost of carbon. Under this framework, asset prices reflect the environmental damage of carbon emissions due to the uncertainty related to both the transmission mechanism and the resultant social damage of climate change. The empirical evidence supports these theoretical predictions and establishes that there is a risk premium associated with long-run climate change risks (Bolton and Kacperczyk, 2021). This implies that investors are willing to accept a lower return on green assets because they provide a hedge against climate change-related risks (Engle et al., 2020).

However, it is not clear whether climate risks are priced in correctly. Several studies show that investors do not pay attention to climate change risks and underreact to long-term climate trends (see for instance Hong et al. (2019); Krueger et al. (2020); Painter (2020)). Consequently, salient climate change events, such as abnormally hot days, attract investors' attention and result in firms with low carbon emissions underperforming those with high carbon emissions.

The characteristics of investors who hold the stock can also determine how climate change risks are priced in. For example Alok et al. (2020) show that fund managers based in regions with frequent climate change disasters overreact to negative climate change events and underweight stocks affected by climate change more heavily. Similarly, Pastor et al. (2021) develop a theoretical model where agents' taste for green holdings affects asset prices. In their model green assets outperform their brown counterparts when consumers' tastes for green products and investors' tastes for sustainable investing are hit by positive shocks. In a similar vein, van der Beck (2021) finds that the recent returns to ESG investing are strongly driven by the price impact from flows towards ESG funds. Consistently, Baker et al. (2022) find that investors are, on average, willing to pay an additional 0.2% in expense fees annually when investing in a fund with an ESG mandate. Relatedly, Gormsen et al. (2023) find that the cost of capital perceived by greener firms fell disproportionately after the post-2016 surge in sustainable investing. My paper contributes to this literature by identifying how preferences for sustainable investing do not just affect how climate change risks are priced in, but also play an important role in the transmission of shocks in financial markets. In particular, my findings highlight how attitudes towards sustainable investing can lead to heterogeneous capital flow responses to macro-financial shocks.

The remainder of the paper is structured as follows: Section 2 describes the data. Section 3 presents the main results. Sections 4 and 5 provide theoretical and empirical evidence in support of the investors' preferences for sustainable investing channel. Section 6 provides several robustness checks and additional results. Finally, Section 7 concludes.

2 Data

I compile my firm-level dataset by combining the following sources: annual firm-level environmental performance scores from MSCI ESG IVA Ratings; daily monetary policy surprise series from Bu et al. (2021); daily firm-level equity prices from the Centre for Research in Security Prices (CRSP); quarterly firm-level balance sheet data from Compustat; daily CDS spreads data from IHS Markit and quarterly forecasts on future company earnings from the Institutional Brokers' Estimate System (I/B/E/S) dataset.

The final dataset combines all the firm-level data into an event study dataset centered around FOMC announcement days. Specifically, I collect all available environmental performance data on a FOMC announcement day (t) and select all firms for which I can match both equity price and balance sheet data. The final dataset includes 102 FOMC announcements over the 2008 - 2020 period, has information on 2,014 firms and contains a total of 75,687 observations.

2.1 Environmental Performance

I compute stock-level environmental scores based on the Environmental Pillar (E_{score}) of MSCI ESG IVA (Intangible Value Assessment) Ratings.[3] The E_{score} is a number between 0 and 10 that measures a firm's weighted average performance across 13 environmental issues related to climate change, natural resources, pollution and waste, and environmental opportunities. Part of this score reflects information from a firm's Scope 1, Scope 2, and, where available, Scope 3 emissions, as well as its investment in and development of clean technologies. Another component assesses a company's strategies for mitigating and adapting to physical climate change events, including investments in resilient infrastructure, flood defenses, and other protective measures. As such, these scores are designed to measure a firm's resilience to both physical and transitional (regulatory) climate change risks.[4]

MSCI reports these scores on an industry-adjusted basis. This means, a heavy polluting (brown) firm could be classified as green simply because it pollutes less than its peers in

[3] To assess companies' exposure to and management of ESG risks and opportunities, MSCI collects data from multiple sources, which include macro data, company disclosures and government databases. It updates these ratings at least annually and provides a granular disaggregated score for each of the subcategories that make up the individual E, S, and G pillars.

[4] Several papers have used these scores to proxy for firms' climate risk exposure (Engle et al., 2020; Pastor et al., 2022). Berg et al. (2022) find that among the eight data vendors they examined, MSCI had the least noise.

the same industry. Following a methodology proposed by Pastor et al. (2022), I re-derive these scores and correct for their industry adjustment. To do this, I use the MSCI variables 'Environmental Pillar Score' (E_{score}) and 'Environmental Pillar Weight' (E_{weight}).

E_{weight}, which is typically constant across firms in the same industry is a number between 0 and 100 measuring the importance of environmental issues relative to social and governance issues.[5] To convert the industry-adjusted scores to unadjusted scores, I transform the MSCI (adjusted) environmental scores according to the following equation:

$$G_{i,t} = -(10 - E_{score,i,t}) \times E_{weight,i,t})/100 \tag{1}$$

where $E_{score,i,t}$ and $E_{weight,i,t}$ are from company i's most recent MSCI ratings date. The quantity $10 - E_{score,i,t}$ measures how far the company is from a perfect environmental score of 10. The product $(10 - E_{score,i,t}) \times E_{weight,i,t}$ measures how brown the firm is, by interacting how poorly the firm scores on environmental issues with how large the environmental concerns are for the industry it is part of (i.e. $E_{weight,i,t}$). The minus sign at the beginning converts the brown score to a greenness score. To mitigate errors in firm environmental scores caused by discontinuous breaks resulting from changes in ESG models, I cross-sectionally demean the $G_{i,t}$ scores in equation (1) as follows:

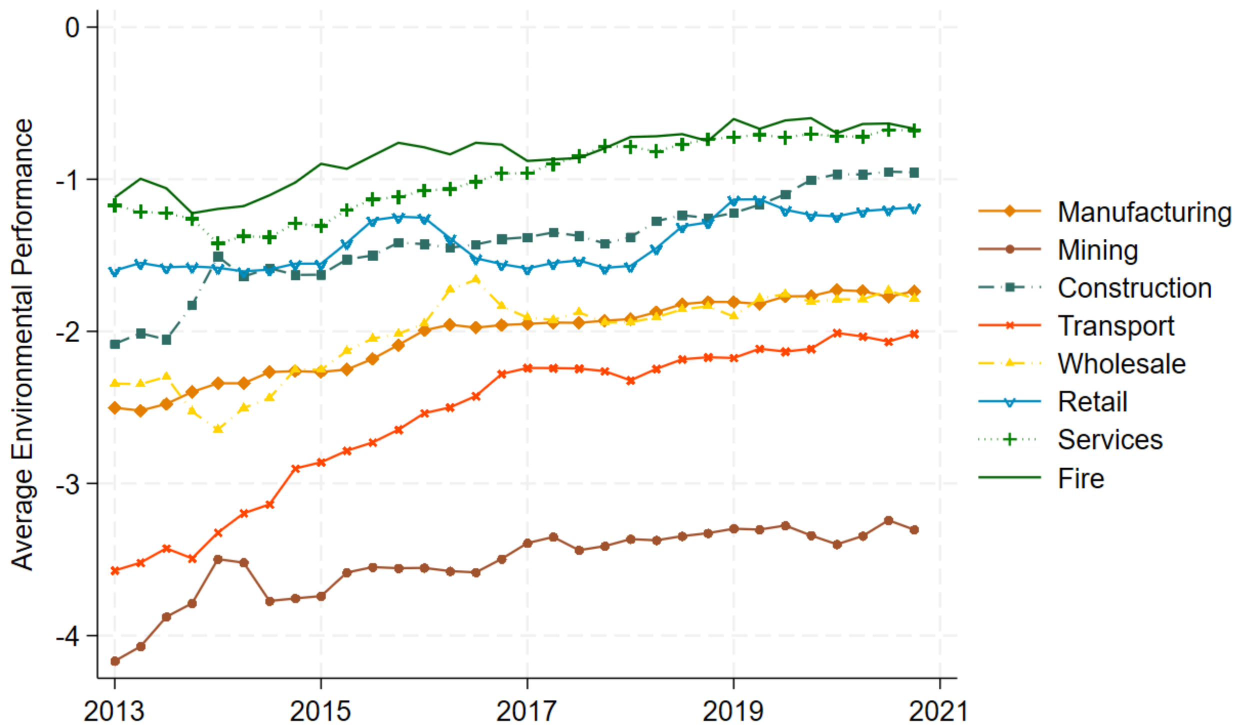
$$\text{Env score}_{i,t} = G_{i,t} - \bar{G}_t \tag{2}$$

where $\bar{G}_t$ is the value-weighted average of $G_{i,t}$ across all firms in the sample. Since I subtract $\bar{G}_t$, Env $\text{score}_{i,t}$ measures a company's cross-sectionally demeaned greenness score consistent with Pastor et al. (2021).

My sample extends from January 2008 to December 2020, consistent with MSCI ESG data availability. Figure 1 details average firm unadjusted environmental scores over time on a per industry basis.[6] Two important stylized facts emerge. First, the lowest ranked industries appear to be mining and transport and the highest ranked industries include services,

[5]See Appendix A.1 for more detail on how MSCI scores firms based on their environmental performance.
[6]Figure 1 begins in November 2012 because MSCI's coverage increases substantially in October 2012, when MSCI began covering small U.S. stocks.

Figure 1. Upward trend in environmental performance across industries



Notes: Time evolution of the cross-sectional average firm environmental scores by industry, constructed using MSCI ESG IVA ratings, following the green score construction methodology proposed by Pastor et al. (2022).

finance, insurance and real estate (fire). Second, there is an upward trend in average firm level-greenness. This upward trend is common across all major industries, indicating a significant transformation of firms in the economy. In the context of the Net-Zero transition, this has the potential to change the environment in which monetary policy may be operating in the future, thereby impacting its transmission.

2.2 Monetary Policy Surprises

The literature on identification of monetary policy shocks typically uses high frequency identification techniques. Monetary policy surprises are measured as the difference in market participants' expectations of the federal funds rate around FOMC press releases, as pioneered by Kuttner (2001). The high frequency identification ensures that monetary policy surprises are orthogonal to the state of the economy and unrelated to contemporaneous macro-financial conditions. This is because changes in expectations about monetary policy in a narrow window around a press release should be mainly influenced by new information on monetary policy, that could not have been anticipated before the announcement.

However, while the Kuttner surprise is really effective at capturing the monetary policy stance in the pre-GFC crisis period, it is not as relevant in the post-GFC period. This is because the post-GFC period is characterised by monetary policy surprises concerning the future course of policy rates, and not changes in the immediate policy (Gürkaynak et al., 2022). To capture the unconventional nature of the conduct of monetary policy in the post-GFC period, I use Bu et al. (2021) measures, henceforth BRW. BRW shocks utilise information on interest rates at different maturities and are constructed using a Fama and MacBeth (1973) two-step regression procedure to estimate the unobservable component of monetary policy.[7]

The application of this methodology gives rise to three appealing features that differentiate these shocks from other shocks in the literature. First, these shocks bridge periods of conventional and unconventional monetary policy-making, allowing for a good comparison with studies that focus on the pre-GFC period only. Second, they are largely unpredictable, which is key for ensuring exogeneity to macroeconomic outcomes. Third, they contain no central bank information effects. Romer and Romer (2000); Nakamura and Steinsson (2008); Miranda-Agrippino (2016); Jarociński and Karadi (2020) show that the existence of central bank information effects not only confounds identification, but also reveals a tendency for private sector expectations to go in the opposite direction of what economic models would predict.[8]

The monetary policy surprise series begins on 31 January 2008, when the (one-year lagged) ESG data becomes available and ends in 31 December 2020. During this time, there were 102 monetary policy surprises with a mean of approximately zero and standard deviation of

[7]First step involves running time series regressions to estimate the sensitivity of interest rates at different maturities to FOMC announcements. In the second step, all outcome variables are regressed onto the estimated sensitivity index from step one, for each time period.

[8]The presence of central bank information effects may lead to instances where a contractionary monetary policy surprise drives asset prices up. Information effects refer to the idea that when the FOMC makes announcements, they not only convey information about policy actions but also include potentially significant updates about the state of the economy, which can impact public expectations.

Table 1. Summary Statistics of Monetary Policy Surprises

	Mean	Median	Std. dev.	Min	Max	Observations
MP surprise	-0.005	-0.007	0.051	-0.189	0.186	102
Contractionary MP surprise	0.037	0.027	0.037	0.000	0.186	43
Expansionary MP surprise	-0.036	-0.029	0.034	-0.189	-0.001	59

Notes: Summary statistics of monetary policy surprises for the period 31/01/2008 to 31/12/2020. Monetary policy surprises are collected from Bu et al. (2021) and expressed in percentage points.

approximately 5 basis points.[9] Table 1 also details the number of instances when the BRW monetary policy surprises were contractionary vs. expansionary (i.e. positive vs negative). Their occurrence appears to be relatively symmetric with 43 contractionary episodes and 59 expansionary episodes.

2.3 Firm Characteristics Data

To provide evidence on how FOMC announcements affect financial markets' assessments of individual firms' exposures to long-term risks associated with climate change, I construct a panel dataset. The cross-sectional dimension of the panel corresponds to a sample of Compustat US publicly listed firms. The time (event) dimension of the panel is represented by the FOMC announcement dates. Appendix A summarises variable definitions. The sample comprises of Compustat firms, whose environmental performance is covered by MSCI ESG IVA Ratings and spans the time period from 31 January 2008 to 31 December 2020. This gives a total of 2,014 firms. The stock return data is obtained from the Center for Research in Security Prices (CRSP) database. I define the stock return around an FOMC announcement as the percentage change of the closing quotes of stock prices between the day before and the day after an FOMC announcement.

The standard balance sheet items, explained in detail in Table A.1, come from the Compustat database. Table 2 provides the summary statistics for different financial variables conditional on firm level greenness. I define as green (brown) firms those whose environmental

[9]The BRW monetary policy shock series excludes the unscheduled FOMC meetings of March 2020.

Table 2. Summary Statistics

	Green Firms (Quintile 5)				
	Mean	Median	Std. dev.	P25	P75
Env. performance	-0.291	-0.190	0.269	-0.420	-0.140
Size	8.074	7.962	1.758	6.840	9.222
Leverage	0.454	0.402	1.220	0.236	0.608
Short term financing	0.029	0.011	0.074	0.002	0.033
Long term debt share	0.871	0.953	0.208	0.852	0.990
Profitability	0.028	0.030	0.041	0.019	0.042
Retained earnings to assets	-0.028	0.158	1.191	-0.114	0.390
Divs. per share	0.134	0.000	0.322	0.000	0.185
Cash to assets	0.171	0.100	0.184	0.038	0.235
Market to book ratio	2.175	1.534	2.058	1.025	2.484
Age (since CRSP incorp)	25.262	21.750	17.089	12.500	33.500
D2default	9.067	8.187	5.853	4.960	12.257
Transparency	49.251	37.500	39.560	20.000	75.000
Observations	11388				

	Brown Firms (Quintile 1)					
	Mean	Median	Std. dev.	P25	P75	**Difference**
Env. perfomance	-4.089	-3.975	0.882	-4.489	-3.519	3.798***
Size	8.170	8.138	1.540	7.052	9.243	-0.096***
Leverage	0.485	0.470	0.677	0.309	0.601	-0.031*
Short term financing	0.030	0.012	0.069	0.002	0.037	-0.001
Long term debt share	0.888	0.955	0.185	0.871	0.992	-0.017***
Profitability	0.027	0.027	0.037	0.018	0.039	0.002**
Retained earning to assets	0.055	0.146	1.359	-0.002	0.331	-0.083***
Divs. per share	0.227	0.140	0.401	0.000	0.345	-0.093***
Cash to assets	0.073	0.039	0.094	0.010	0.098	0.098***
Market to book ratio	1.316	1.046	0.995	0.811	1.490	0.859***
Age (since CRSP incorp)	33.397	27.500	23.204	13.500	50.500	-8.135***
D2Deafult	7.161	6.356	5.343	3.516	9.917	1.905***
Transparency	28.766	20.000	29.066	10.345	33.333	20.486***
Observations	11368					

Notes: Green (Brown) firms are classified according to the top (bottom) quintiles of the environmental score distribution. Sample spans from 2007Q1 to 2020Q4. Difference refers to the difference in the means between Green and Brown firms. The asterisks denote statistical significance (*** for $p < 0.01$, ** for $p < 0.05$, * for $p < 0.1$).

scores fall within the top (bottom) quintile of the firm-level greenness distribution.[10] Despite considerable heterogeneity between green and brown firms, it is not immediately clear from these summary statistics whether green firms should be more or less responsive to monetary

[10] The results are not sensitive to this cutoff of firm-level greenness and remain consistent when the distribution is divided into quartiles or terciles.

policy. On the one hand, Table 2 shows that greener firms are smaller and younger on average, pay lower dividends and are mostly classified as 'growth' companies (i.e. companies whose future cash flows are anticipated to grow at a higher rate than the market). According to existing literature, young firms that do not pay dividends experience the most significant changes in capital expenditure following a monetary policy shock (Cloyne et al., 2023), largely because their external financing is highly susceptible to asset value fluctuations induced by such shocks. On the other hand, Table 2 also reveals that greener firms tend to have lower leverage, higher liquidity, and a greater distance to default compared to brown firms. Literature typically associates these characteristics with looser financial constraints, which have been shown to dampen the response to monetary policy (Jeenas, 2023; Anderson and Cesa-Bianchi, 2024).

3 Monetary Policy and Green Firms

In this section, I test the joint hypothesis that monetary policy affects green firms differently from brown and that this heterogeneity is reflected in asset prices at high frequency windows. First, I estimate the heterogenous impact on stock prices using event-study panel regressions. Second I investigate whether a similar finding is supported using firm-level CDS spreads data.

3.1 Empirical Design

I proceed by employing panel event-study regressions based on high-frequency stock market data. The high-frequency approach is particularly useful for my analysis for three reasons. First, it is free of aggregation bias.[11] Second, unlike at lower frequencies where FOMC decisions may be influenced by stock market movements, no such endogeneity concerns exist with daily data (Rigobon and Sack, 2004; D'Amico and Farka, 2011). Additionally, the pro-

[11]Lower-frequency analysis, which usually is conducted at a quarterly or annual frequency, requires aggregating interest rate surprises over the relevant quarter. Ramey (2016) argues that such aggregation might induce serial correlation in the series of the aggregated surprises.

cess of "greenification" itself could be an endogenous choice, since tighter credit conditions could disproportionally affect green innovation (Aghion et al., 2024). The high-frequency approach adopted here addresses this issue, as it is unlikely that companies would change their environmental performance immediately after a monetary policy shock. Third, due to their forward-looking nature, stock prices are likely to reflect stock market participants' beliefs about the effect of monetary policy on real outcomes such as investments and employment (more quickly than the variables themselves). The high-frequency approach, therefore, delivers a much neater identification (Anderson and Cesa-Bianchi, 2024). The baseline specification I estimate is as follows:

$$\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \Gamma' Z_{i,t-1} + e_{i,t} \tag{3}$$

where i indexes a firm, s indexes major economic sectors and t indexes the FOMC announcements. $\Delta p_{i,t}$ is the log difference of the closing quotes of stock prices the day before and the day after an FOMC announcement, ε_t^m is the BRW monetary policy shock, $g_{i,t-1}$ is a firm i's environmental score computed as described in Section 2.1. Drawing from previous work by Gürkaynak et al. (2022) and Ottonello and Winberry (2020), $Z_{i,t-1}$ is a vector of controls that include size, profitability, book leverage, market-to-book ratio, cash holdings, short term liabilities, retaining earnings, dividend per share and distance to default.

All variables in the regression other than the monetary policy shock and the stock price change are lagged by one quarter to ensure that the relevant variables are in the market participants' information set. The environmental score is lagged by one year, since the the MSCI ESG IVA Ratings are usually updated at an annual frequency. Equation (3) includes both firm level fixed effects and industry-by-time fixed effects. The firm level fixed effects, α_i control for any firm-specific time invariant unobservables, whereas the sector-by-time fixed effects, α_i will capture differences in how economic sectors respond to aggregate shocks. The main coefficient of interest is β, which measures how the sensitivity of stock returns with respect to monetary shocks depends on firms' environmental performance. Throughout, I cluster

Table 3. Baseline Results

	(1)	(2)	(3)	(4)
	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$
MP shock (ε_t^m)	-16.22***	-16.31***		
	(3.999)	(4.013)		
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)		3.091***	3.500***	2.975***
		(1.069)	(0.946)	(0.867)
Env. score ($g_{i,t-1}$)		-0.0427	-0.0123	0.0109
		(0.0637)	(0.0457)	(0.0370)
Firm FE	Yes	Yes	Yes	Yes
Sector_time FE	No	No	No	Yes
Controls	Yes	Yes	Yes	Yes
R-squared	0.0666	0.0676	0.299	0.328
Observations	75931	75931	75931	75687

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

standard errors at the time level to account for correlation of error terms within an FOMC event.[12]

Table 3 presents the baseline findings of this paper. The first column shows that a contractionary monetary policy shock of 100 basis points reduces stock prices by 16%. Column (2) shows that stock prices of firms with better environmental performance are less affected. In particular, a one standard deviation increase in firm-level environmental performance dampens the sensitivity of stock prices to monetary policy shocks by about 3 percentage points. Adding sector-by-time fixed effects in column (3) further demonstrates that this result is not driven by differences in how economic sectors respond to aggregate shocks.[13] Overall, I find strong and robust evidence that an increase in environmental performance dampens the effect that monetary policy has on stock prices.

[12] Results are robust to double clustering at both the firm and time level as well as applying Driscoll-Kraay (1998) standard errors to control for serial correlation.

[13] Table B.5 in the Appendix shows the results from the baseline specification on a per-industry basis.

One concern is that "greenness" is correlated with other firm characteristics. Indeed the summary statistics in Table 2 show that greener firms tend to have lower leverage, higher liquidity and a greater distance to default compared to brown firms. To investigate whether the differential sensitivity of green firms to monetary policy surprises is capturing the heterogenous effects of these other characteristics, I augment equation (3) with an additional term:

$$\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \gamma(\varepsilon_t^m \times c_{i,t-1}) + \Gamma' Z_{i,t-1} + e_{i,t} \tag{4}$$

where $\varepsilon_t^m \times c_{i,t-1}$ is a double interaction term of monetary policy surprises and firm-level characteristics as summarized in Table 2. The interpretation of the β coefficient now changes slightly. Consider the case of $c_{i,t-1}$ being firm leverage. Then β captures the relative response of asset prices for greener firms, controlling for the interaction of monetary policy with firm leverage. In effect, I am double sorting firms based on their firm-level performance, as well as their book leverage ratio. If the dampened sensitivity of green firms to monetary policy surprises is driven by underlying differences in firm characteristics, then we should expect the addition of these double interaction terms to render the β coefficient insignificant.

Table 4 shows the degree to which green firms' differential response to monetary policy shocks may be driven by underlying firm financial characteristics. For comparison with the baseline results, column (1) of Table 4 reports the results from specification (3), i.e. the specification including sector-time fixed effects, firm-level controls and a single interaction based on the firm-level greenness score. Columns (2) to (9) report the results from specification (4), where $c_{i,t-1}$ is based on firm-level proxies for financial constraints, typically used in the literature. In particular, I consider book leverage, firm size, age (measured as time since CRSP incorporation), distance to default, liquidity ratio, profitability, short-term debt share, dividends per share and market-to book ratio respectively.[14]

Results in Table 4 show that the estimated β coefficient is similar and statistically significant in all columns. This result suggests that firm level greenness is not simply capturing

[14] See Appendix A for a detailed description on how these variables were computed.

the effect of other firm-level characteristics.[15] Moreover, the interaction effects of firm-level characteristics with monetary policy generally have the expected sign. I find that larger firms react less strongly to monetary policy shocks. Additionally, consistent with Cloyne et al. (2023), results in column (4) show that younger firms are less responsive to monetary policy shocks. Similar to Anderson and Cesa-Bianchi (2024), but in contrast to Ottonello and Winberry (2020), I find that distance to default dampens a firm's sensitivity to monetary policy shocks.

Additionally, following research that suggests that socially responsible firms commit to a higher standard of transparency and provide more financial disclosure (Kim et al., 2014), I also investigate whether the differential response to monetary policy shocks is driven by differences in valuation uncertainty between green and brown firms. I leverage information on firm earnings' announcements from the Institutional Brokers' Estimate System (I/B/E/S). This dataset collects quarterly forecasts made by financial analysts on future earnings for publicly traded companies. Following Casella et al. (2023), under the assumption that more transparent firms have fewer disagreements among financial analysts, I define firm financial transparency as:

$$\text{transparency}_{i,t} \equiv \frac{1}{std.\,dev.(EPS_{i,t})} \tag{5}$$

where $std.\,dev.(EPS_{i,t})$ is the standard deviation of analysts' forecasts on firm i's earnings per share in the last 30 calendar days before the earnings announcement.

Column (9) of Table 4 presents the results from the inclusion of the double interaction term, $\varepsilon_t^m \times 1/\text{std.(EPS)}$. The coefficient before this terms in column (9) suggests that, while it is true that monetary policy affects financially transparent firms less than their financially opaque counterparts, this is not enough to justify the dampened sensitivity of green firms to monetary policy surprises.

[15] In addition to the double interaction terms shown in Table 4, I also double sort firms according to their firm-level greenness, cyclicality (defined as correlation of sales growth with GDP growth), long term debt ratio and retained-earnings. The baseline result remains largely unchanged.

Table 4. Double-sorting based on firm-level environmental performance and financial characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.975***	2.972***	2.864***	3.152***	2.567***	2.980***	2.877***	2.977***	3.051***	3.002***	2.797***	2.692***
	(0.867)	(0.868)	(0.861)	(0.872)	(0.806)	(0.819)	(0.851)	(0.866)	(0.935)	(0.868)	(0.746)	(0.771)
MP shock × Leverage ($\varepsilon_t^m \times c_{i,t-1}$)		-2.670										0.735
		(5.035)										(4.819)
MP shock × Size ($\varepsilon_t^m \times c_{i,t-1}$)			1.433									0.705
			(0.894)									(0.736)
MP shock × Age ($\varepsilon_t^m \times c_{i,t-1}$)				1.698***								1.009**
				(0.603)								(0.419)
MP shock × D2default ($\varepsilon_t^m \times c_{i,t-1}$)					3.593***							3.185***
					(1.208)							(0.913)
MP shock × Liquidity ($\varepsilon_t^m \times c_{i,t-1}$)						-0.0356						0.159
						(0.783)						(0.553)
MP shock × Profitablity ($\varepsilon_t^m \times c_{i,t-1}$)							3.774**					1.112
							(1.796)					(1.604)
MP shock × Short-term debt ($\varepsilon_t^m \times c_{i,t-1}$)								0.980				1.717**
								(0.630)				(0.662)
MP shock × Transparency ($\varepsilon_t^m \times c_{i,t-1}$)									1.880***			1.315**
									(0.561)			(0.506)
MP shock × Dividends ($\varepsilon_t^m \times c_{i,t-1}$)										1.789		-0.168
										(1.150)		(0.664)
MP shock × Market-to-Book ($\varepsilon_t^m \times c_{i,t-1}$)											1.667	0.0121
											(1.872)	(1.687)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector_time FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.328	0.328	0.328	0.329	0.329	0.328	0.328	0.328	0.333	0.328	0.328	0.335
Observations	75687	75687	75687	75687	75687	75687	75687	75687	69746	75687	75687	69746

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default, all standardised. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for $p < 0.01$, ** for $p < 0.05$, * for $p < 0.1$).

3.2 Evidence from Credit Default Swap Spreads

In this subsection, I document that the heterogeneous impact of monetary policy on green vs. brown firms goes beyond equity markets, and also affects firms' external financing costs. Combining a dataset on CDS spreads from IHS Markit with firm-level balance sheet information, I show that monetary policy has heterogeneous effects on firms' external funding costs conditional on firm-level greenness. This dataset covers daily information on conventional CDS spreads and their implied probabilities of default (for the underlying bond) for 313 firms during the period of 2008 - 2021. The conventional CDS spread (or CDS premium) is the market price of credit risk, as it denotes the amount paid by the Protection Buyer to the Protection Seller to insure against the risk of default by a reference entity. I consider the following event study specification:

$$\Delta y_{i,t} = \alpha_i + \beta_1(g^{high}_{i,t-1} \times \epsilon^m_t) + \beta_2(g^{low}_{i,t-1} \times \epsilon^m_t) + \delta_1 g^{high}_{i,t-1} + \delta_2 g^{low}_{i,t-1} + \Phi' Z_{i,t-1} + e_{i,t} \tag{6}$$

where $\Delta y_{i,t}$ denotes the change in the CDS spread or implied probability of default of firm i at time t, ϵ^m_t is the monetary policy shock, $g^{high}_{i,t-1}$ and $g^{low}_{i,t-1}$ are two dummy variables. Specifically, $g^{high}_{i,t-1}$ ($g^{low}_{i,t-1}$) equals 1 when the environmental score of firm i lies above (below) the median of the greenness distribution in the year proceeding the monetary policy surprise (and zero otherwise).[16] As before, $Z_{i,t-1}$ is a vector of controls that include size, profitability, book leverage, market-to-book ratio, cash holdings, short term liabilities, retaining earnings, dividend per share and distance to default. Coefficients β_1 and β_2 capture the impact of monetary policy on CDS spreads for green and brown firms respectively.

The results are reported in Table 5. They show that CDS spreads rise in response to contractionary monetary policy shocks. This is because an interest rate rise depresses asset prices and reduces a firm's net present value. The fall in net worth, in turn increases a firm's leverage and its expected default probability. This is associated with an inward shift in the credit

[16] Here the greenness cutoff is chosen to be the median of the distribution because of the relatively small sample of firms for which I have information on CDS spreads.

Table 5. Event Study - Credit Default Swap Spreads

	(1) ΔCDS	(2) ΔCDS	(3) $\Delta prob^{default}$	(4) $\Delta prob^{default}$
MP shock (ε_t^m)	21.47**		1.692**	
	(9.350)		(0.734)	
MP shock × Green ($\varepsilon_t^m \times g_{i,t-1}^{high}$)		16.21*		1.403*
		(8.716)		(0.721)
MP shock × Brown ($\varepsilon_t^m \times g_{i,t-1}^{low}$)		26.62**		1.982**
		(10.39)		(0.766)
Firm FE	Yes	Yes	Yes	Yes
Sector_time FE	No	No	No	No
Controls	Yes	Yes	Yes	Yes
R-squared	0.0335	0.0340	0.0393	0.0398
Observations	19610	19610	18352	18352

Notes: The dependent variable in columns (1) and (2) is the two-day change in CDS spreads bracketing an FOMC announcement (in basis points). The dependent variable in columns (2) and (3) is the two-day change in the implied probability of default over the next 5 years (in percentage points). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. ε_t^m is the BRW monetary policy shock (in percent). Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

supply schedule, which pushes up on credit risk (Anderson and Cesa-Bianchi, 2024). In line with this mechanism columns (1) and (3) show that in response to a contractionary monetary policy surprise of 100 basis points, firms' CDS spreads and their implied probabilities of default increase by 21 basis points and 1.7 percentage points respectively. However, columns (2) and (4) show that the response in credit risk is much more dampened in the case of green firms, which experience only a 16 basis point increase in CDS spreads in the aftermath of the shock.[17] This is consistent with the heterogeneous equity price responses shown in Table 3, suggesting a smaller credit supply contraction for green firms compared to brown firms. The next section delves deeper into these credit supply differences and offers a mechanism that rationalises these results.

[17] In Table B.6 in the Appendix I show that the results are robust to considering an alternative specification where I interact the continuous firm-level environmental performance score with the monetary policy shock.

4 Investors' Green Preferences: A Stylised Theoretical Model

In this section, I assess whether the dampened sensitivity of green firms to monetary policy shocks can be explained by investors' preferences for sustainable investing using a stylized theoretical framework. The key idea is that investors might value green assets for non-pecuniary reasons other than expected return or risk. This has the general implication that such preferences can become important in asset price determination, as investors derive an additional utility from their holdings of green assets.

Accounting for investors' preferences for sustainable investing in a simple stylized model can help to justify the differential response of green vs. brown equity prices to monetary policy shocks. In particular, I incorporate a preference for sustainable investing into a representative household's utility function and show that: (i) the semi-elasticity of equity prices to interest rates is lower for green firms compared to brown; (ii) the differential response of green-vs-brown firms to interest rates is amplified in states of the world with stronger preferences for sustainable investing; (iii) a contractionary monetary policy shock generates an increase in the portfolio weight of green securities.

4.1 A Simple Two-Period Model with Green Preferences

Time is discrete and there are only two periods. There is no aggregate or idiosyncratic uncertainty. The household can invest in three riskless assets, namely bonds, "green" securities and "brown" securities, $b_1, s_{G,1}, s_{B,1}$ respectively. One unit of bonds purchased in period one returns with certainty (1+r) units of the consumption good in period two. In addition, one unit of green (brown) stocks purchased in period one at a price $q_{G,1}$ ($q_{B,1}$), returns with certainty a payoff π_G (π_B) in period two. The household is endowed with income y in period one, receives no income in period two and makes portfolio decisions in period one, subject to a budget constraint. In addition, I assume investors exhibit a preference for sustainable investing. In other words, investors derive a utility of $f(s_{G,1})$ from their holdings of green securities. The household/investor then maximizes the following utility function:

$$\max_{c_t, b_1, s_G s_B} \left(\sum_{t=1}^{2} \beta^{t-1}\big(u(c_t) + f(s_{G,1})\big)\right), \text{ subject to,}$$

$$c_1 + b_1 + q_{G,1}s_{G,1} + q_{B,1}s_{B,1} \leq y \text{ in period one,} \tag{7}$$

$$c_2 \leq (1+r)b_1 + \pi_G s_{G,1} + \pi_B s_{B,1} \text{ in period two.} \tag{8}$$

The internal solution of the utility maximisation problem yields the following no-arbitrage conditions:

$$q_{B,1} = \frac{\pi_B}{1+r}; \quad q_{G,1} = \frac{\pi_G}{1+r} + \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \tag{9}$$

Assuming for simplicity that green and brown securities give an equal payoff in period two (i.e. $\pi_G = \pi_B$), the expressions above reveal that green preferences result in higher prices for green securities compared to their brown counterparts. Another way to think about this result is in terms of returns, whereby with 'sustainable investing' preferences investors require a lower return (compensation) for holding green stocks.

With the main conditions of the model specified, now I seek to demonstrate how a change in the real interest rate, proxying for a change in monetary policy, affects investors' portfolio choice between green and brown stocks, as well as their equilibrium prices. For exposition purposes, I now focus on a model with a log utility function, where $u(c_t) = log(c_t)$ and a linear preference for 'green' investing, where $f(s_{G,1}) = \alpha s_{G,1}$. A more general specification is provided in Appendix C. Solving for equilibrium prices, I can derive an expression for both $q^*_{B,1}$ and $q^*_{G,1}$ in terms of pre-determined parameters:

$$q^*_{B,1} = \frac{\pi_B}{1+r}, \quad q^*_{G,1} = \frac{\pi_G}{1+r} + \frac{\alpha}{1+\alpha}y \tag{10}$$

These expressions show that investors do not value green stocks purely for their pecuniary benefit, the first term, but also because they derive an additional utility from their holdings of green assets, the second term. In contrast to green securities, brown assets are only valued for their pecuniary benefit, and as such, the price of brown securities is equivalent to the discounted present value of their future payoff.

The question I now want to address is the extent to which these asset prices change in response to monetary policy shocks. Empirically, I address this by looking at the percentage change in the stock prices of an average firm in the aftermath of an unanticipated monetary policy surprise (where the dependent variable is defined as the log difference of the closing quotes of stock prices the day before and the day after an FOMC announcement). By taking logs to the expressions in (10) and differentiating with respect to r, I obtain the semi-elasticity of green and brown asset prices with respect to interest rates, which is what I estimate in Section 3.1.

4.2 Model Predictions

PROPOSITION 1: *Green security prices have a lower semi-elasticity with respect to monetary policy shocks, given* $\alpha > 0$.[18]

$$|\frac{dln(q^*_{G,1})}{dr}| < |\frac{dln(q^*_{B,1})}{dr}| \tag{11}$$

To make sense of this proposition, note that investors value green stocks both for their pecuniary returns, but also because they derive some additional utility from holding them. Assuming for simplicity that $\pi_G = \pi_B$, changes in interest rates affect the pecuniary returns for green and brown assets to the same degree. However, since investors also value green stocks because of their 'sustainable' preferences, which are unaffected by the interest rate, the semi-elasticity of green stocks with respect to interest rates is attenuated. In other words, the effect of an increase in interest rates to green stock prices is a composite of two forces. The pecuniary force that is common across both green and brown assets results in a reduction of both of these asset prices. The non-pecuniary force, which is only present in the case of green

[18] $|\frac{dln(q_{B,1})}{dr}| = \frac{1}{1+r}$; $\quad |\frac{dln(q_{G,1})}{dr}| = \frac{1}{1+r} - \frac{(q^*_{G,1} - q^*_{B,1})}{q^*_{G,1}}\frac{1}{1+r}$, assuming $\pi_B = \pi_G$. The differential response in the semi-elasticities of green-vs-brown stocks is: $\left(|\frac{dln(q_{G,1})}{dr}| - |\frac{dln(q_{B,1})}{dr}|\right) = -\frac{\frac{\alpha}{1+\alpha}y}{\frac{\pi_G}{1+r} + \frac{\alpha}{1+\alpha}y}\frac{1}{1+r} < 0$

stocks, dampens the first force because investors derive an additional utility from holding green assets. [19]

COROLLARY 1: *The differential response of green-vs-brown firms to interest rates is amplified in states of the world with stronger preferences for sustainable investing (given $\alpha > 0$).*

$$\frac{d\left(|\frac{dln(q^*_{G,1})}{dr}| - |\frac{dln(q^*_{B,1})}{dr}|\right)}{d\alpha} < 0 \tag{12}$$

Equation (12) shows that the non-pecuniary force intensifies with the degree of environmental consciousness. In other words, the semi-elasticity of green asset prices with respect to an increase in interest rates is lower in states of the world with stronger preferences for sustainable investing.

Finally, to investigate the implications for the portfolio weights, let us define the portfolio weight of green securities in equilibrium as the fraction of green securities to total securities (i.e. $w^*_{G,1} = \frac{q^*_{G_1} s^*_{G,1}}{q^*_{G,1} s^*_{G,1} + q^*_{B,1} s^*_{B,1}}$). Let us also assume for simplicity that the supply of both green and brown securities is fixed (i.e. $s^*_{G,1} = s^*_{B,1} = 1$). This assumption is reasonable due to limited equity issuance typically observed within a narrow window surrounding a monetary policy announcement.

COROLLARY 2: *A contractionary monetary policy shock generates an increase in the portfolio weight of green securities.*

$$\frac{dln(w_{G,1})}{dr} > 0 \tag{13}$$

This can be explained by the fact that when a contractionary monetary policy shock occurs, the (log) prices of green securities exhibit a smaller decline compared to the (log) prices of

[19] In Appendix C I do not impose a functional form on the utility function and show that dampened semi-elasticity of green asset prices to interest rates will also depend on income and substitution effects. Due to the log utility, the case I show here is a special case where income and substitution effects have a net-zero effect on period one consumption.

brown securities. Consequently, the relative weight of green securities in investors' portfolio increases.

5 Empirical Evidence: Asset Price Responses and Green Preferences

This section aims to empirically test the theoretical results outlined in section 4.2. In particular, it assesses whether preferences for sustainable investing affect the sensitivity of green asset prices to monetary policy. In line with the predictions of the theoretical framework, we would expect shocks to monetary policy to affect green asset prices less when these firms are held by environmentally conscious investors. Additionally, Corollary 1 emphasises that the heterogeneous response of green firms to monetary policy should be even more pronounced the stronger the preferences for sustainable investing. To test these hypotheses, I employ a proxy for sustainable investing preferences by analysing a set of index funds that adhere to ESG criteria. Subsequently, I investigate whether green firms exhibit a reduced sensitivity to monetary policy when they are primarily held by investors that prioritise ESG criteria. The findings corroborate the predictions of the model. However, accurately measuring preferences for sustainable investing can be challenging, and ESG mandates may not always capture them perfectly. To overcome this issue, I employ a range of alternative indicators, which exploit granular geographical and temporal variation in climate change exposures, beliefs, and perceptions. The findings confirm the theoretical predictions.

5.1 Evidence from ESG-labelled Index Funds

The last decade has been characterised by a significant expansion in ESG investment. This has been especially the case for index funds whose investment strategies incorporate environmental, social, and governance (ESG) factors.[20] Typically, index funds with ESG mandates construct their portfolios by selecting investments that meet their specific ESG criteria. As such, they constitute a reliable proxy for capturing investors' preferences for sustainable investing. To this end, I begin by identifying a set of sustainable index funds using a methodology proposed in van der Beck (2021). Using the CRSP survivorship-bias-free mutual funds database, I match index funds names with a list of sustainability keywords, as described in van der Beck (2021).[21] Specifically, I define an ESG fund as an index fund that includes at least one sustainability keyword in its name. This procedure allows me to identify around 127 ESG index funds.[22] I then match this information with the funds' portfolio holdings to account for the type of investor that is likely to hold firm i at each point in time.

Specifically, I calculate the proportion of ownership in company i attributed to index funds that identify as ESG, relative to investments made by all index funds. Let $\tilde{w}_{i,m,t}$ denote the fraction of investments in firm i that are made by index fund m at time t. Then, the proportion of firm i at time t that is held by ESG funds (relative to investments by all index funds) is given by:

$$\text{ESG fund fraction}_{i,t} = \sum_{m \in \Omega(i)} \tilde{w}_{i,m,t} \times \text{ESG}_{m,t} \tag{14}$$

where $\Omega(i)$ denotes the set of index funds that hold firm i in their portfolio and $\text{ESG}_{m,t}$ is an indicator that takes a value of one for ESG index funds and zero otherwise.

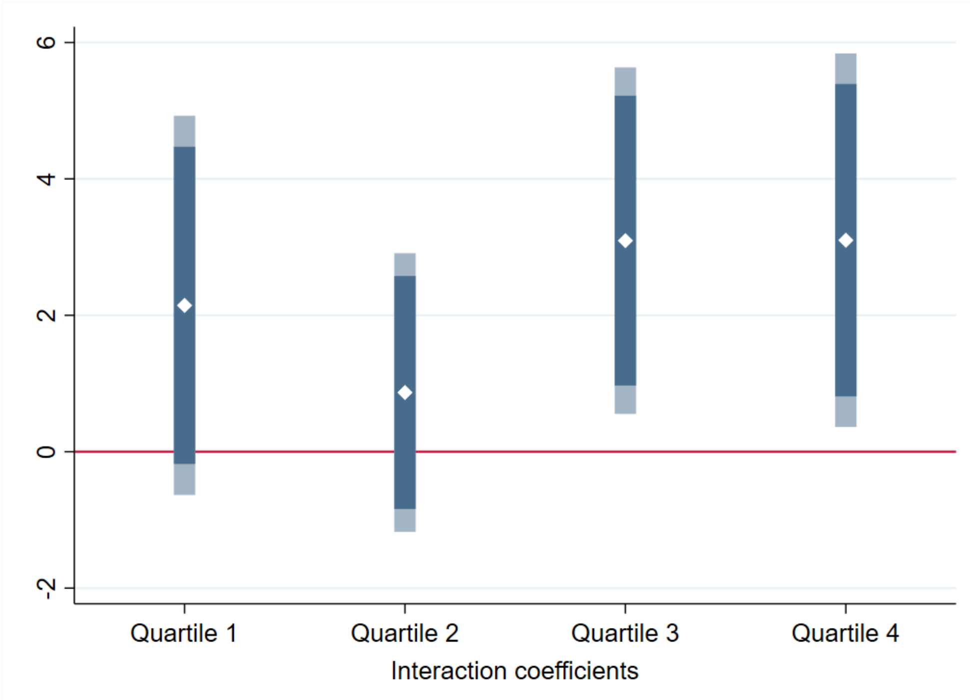
As a last step, I split the distribution of firms into four different bins based on the fraction of the firm held by ESG labelled funds (i.e. ESG fund fraction$_{i,t}$ in equation 14). This allows me to assess how investors' preferences affect the sensitivity of green asset prices to monetary policy. To minimise endogeneity concerns, I look at the ESG fund fraction as of a quarter

[20] Index funds are a type of mutual fund that aims to replicate the performance of a specific market index, such as the S&P 500 or the Dow Jones Industrial Average. The main characteristic of index funds is that they passively manage their investments rather than relying on active stock picking.

[21] The considered keywords are: environment, social, governance, green, sustainable, responsible, SRI, ESG, climate, clean, carbon, impact, fair, gender, solar, renewable, ethical, thematic, and conscious.

[22] My dataset consists of 3,156 index funds, which are managed by 228 distinct companies. Among these funds, 127 of them incorporate an ESG keyword in their name, and they are managed by 37 different investment companies.

Figure 2. Investors' Preferences Channel



Notes: This graph plots the beta coefficients from the following specification: $\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \Gamma' Z_{i,t-1} + e_{i,t}$, for four different quartiles based on the fraction of firm i held by ESG-labelled index funds. Quartile 1 refers to securities that are held by investors with 'brown' preferences, as of a quarter before the monetary policy shock. Quartile 4 refers to securities that were held by index funds investors with 'green' preferences, as of a quarter before the monetary policy shock. White diamonds denote the point estimates. The light and dark blue shaded columns denotes the 90% and 95% confidence intervals, respectively. Standard errors are clustered at the time level.

before the monetary policy shock. Firms in quartile 1 (quartile 4) have the lowest (highest) share of their equity held by ESG-labelled index funds. To address how the sensitivity of green asset prices depends on preferences for sustainable investing, I proceed by estimating the baseline specification of equation (3) for the four different bins of investor types:

Figure 2 plots the beta coefficients before the interaction term of firm-level greenness with monetary policy for four different bins of the ESG fund fraction distribution. Greener firms are less sensitive to monetary policy when they are being held by investors that prioritise ESG criteria. Crucially, the beta coefficients for firms being held by "brown" investors (quartiles 1 and 2) are not statistically different from zero. Conversely, the dampened sensitivity of greener firms to monetary policy is only observed for firms held by environmentally conscious investors (quartiles 4 and 5). In a similar vein, Appendix C.2 looks at a larger group of institutional investors and confirms that the differential sensitivity of green firms to monetary policy is driven by the type of institutional investor who holds the firm.[23]

To summarise, these results confirm the theoretical predictions implied by Proposition 1 in Section 4.1. They show that preferences for sustainable investing can explain the differential response of green firms (compared to brown) to monetary policy.

5.2 Geographical and Temporal Variation in Preferences for Sustainable Investing

While ESG investment criteria are a reliable indicator of investors' preferences for sustainable investing, they typically focus on a specific set of factors related to sustainability. However, investors' priorities regarding sustainability can differ significantly. For instance, more environmentally conscious investors may prioritise investments in low-emission companies and place a lower emphasis on social and governance issues. With this in mind, I extend the analysis of the previous section with additional proxies for investors' propensity to hold green assets. This enables me to more rigorously test one of the main theoretical predictions outlined in Section 4.2. Namely, the extent to which the differential response of green asset prices (compared to brown) is amplified in states of the world with stronger preferences for sustainable investing.

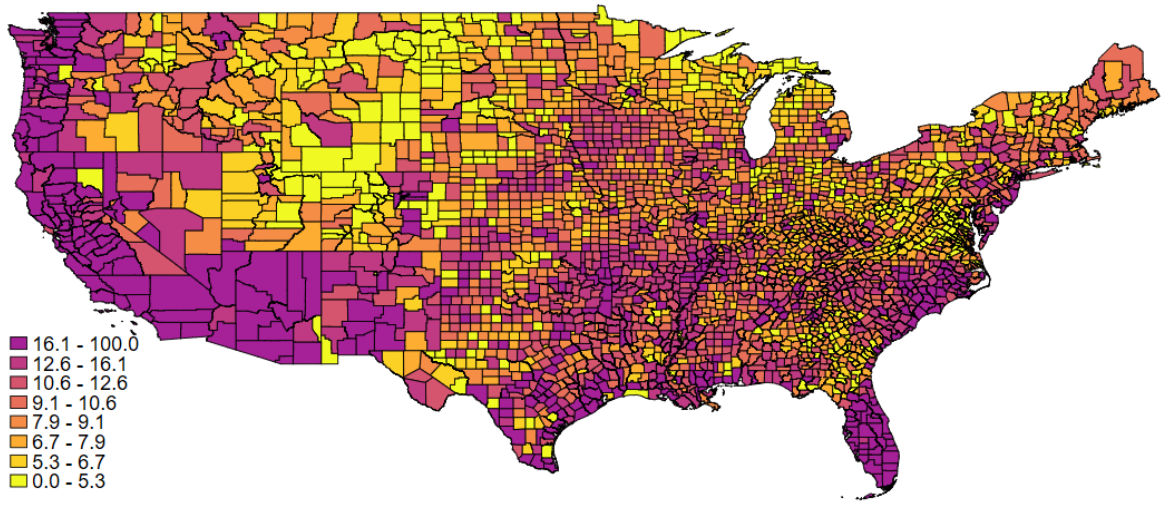
Data

I account for investors' propensity for sustainable investing by employing three measures of climate consciousness.[24] Namely, (i) the National Risk Index from the Federal Emergency

[23] Appendix C.2 runs a similar exercise to the one shown in Figure 2 and considers not just index funds, but also banks, insurance companies, investment advisories and any other US institution with assets under management of more than $100 million.

[24] Some of these measures have also been used in previous research to proxy for sustainable preferences. See for example Pastor et al. (2022); Baldauf et al. (2020); Engle et al. (2020); Correa et al. (2022).

Figure 3. National Risk Index



Notes: Map of the National Risk Index by Zuzak et al. (2022) at the county level.

Management Agency in the US, (ii) the Yale Climate Change Opinion Survey and, (iii) the Media Climate Change Concern Index by Ardia et al. (2023).

The first measure I adopt, The National Risk Index (NRI), is a composite measure of natural hazard risk at the county level in the US, which combines hazard exposure, frequency and historic loss data for 18 different natural hazards with social vulnerability and community resilience data to calculate a standardised risk value for every U.S. county.[25] The NRI is publicly available and sufficiently granular to enable identification of regions in the US that are particularly vulnerable to natural disaster risk.[26] Figure 3 shows considerable variation across counties in their exposure to natural disaster risk.

However, not all natural disasters are the result of climate change.[27] Hence the national risk index may not necessarily be capturing "green" preferences. To address this concern, I consider another set of measures, which proxy for climate change beliefs, risk perceptions,

[25] The 18 natural hazards include Avalanche, Coastal Flooding, Cold Wave, Drought, Earthquake, Hail, Heat Wave, Hurricane, Ice Storm, Landslide, Lightning, Riverine Flooding, Strong Wind, Tornado, Tsunami, Volcanic Activity, Wildfire, and Winter Weather.

[26] In this setup, NRI proxies for exposure to physical risks that emerge due to climate change. This is because the most recent IPCC reports find strong evidence of a link between climate change, heat waves, wildfires, Atlantic hurricanes and extreme precipitation (IPCC, 2022).

[27] For example earthquakes, volcano eruptions, tsunamis and dry mass movements are geophysical events that are not related to climate change.

and policy support in different regions in the US. This set of variables comes from the Yale Climate Change Opinion Survey (2021). One of the benefits of using this dataset is its high spatial resolution, which provides us with climate change beliefs data at the county level. I look at a group of variables, which include whether respondents (i) believe climate change is happening; (ii) are worried about climate change; (iii) believe to be personally affected by climate change; (iv) and support stetting strict limits on CO_2 emissions.[28] Figure C.1 maps the degree to which the respondents of the Yale Climate Opinion Survey (YCOS) believe to be 'personally' affected by climate change.[29]

The third and final measure, the Media Climate Change Concerns (MCCC) Index by Ardia et al. (2023), is a daily index of news about climate change published by major U.S. newspapers and newswires.[30] This index captures the number of climate news stories each day associated with a negative sentiment (i.e, articles that focus on present and future risks from climate change). Drawing from previous work by Pastor et al. (2022), I measure the cumulative level of climate change concerns using a distributed lag model that assumes individuals' memory of climate news stories decays gradually over time. Denoting by MCCC_t the value of the index at date t, I define the level of climate concerns at the end of day t as:

$$MCCC_t^{cumulative} = \sum_{\tau=0}^{T} \rho^{\tau} MCCC_{t-\tau} \tag{15}$$

where ρ reflects the rate at which past news is discounted. I set the half-life of news stories to one year, which implies $\rho = 0.9981$.[31] T is set to 36 months (1095 days). As it is clear from Figure C.2, climate change concerns, as measured by the news index have risen markedly

[28] These variables are highly correlated with each other.

[29] This represents the fraction of respondents in each county who answered 'Yes' to the following question. "Global warming will harm me personally. How much do you think global warming will harm you personally? (i) Not at all, (ii) Only a little, (iii) A moderate amount, (iv) A great deal, (v) Don't know".

[30] These include the Los Angeles Times, New York Times, Wall Street Journal, USA Today, and two major newswires: Associated Press Newswires and Reuters News.

[31] I experiment with other half-life durations, such as 6 months, 3 months, 1 month and 15 days to ensure that my results are not driven by the choice of ρ.

since 2013.

Empirical Specification and Results

To investigate the extent to which the differential response of green asset prices (compared to brown) is amplified in states of the world with stronger preferences for sustainable investing, I augment the baseline specification in Equation (3) with a triple interaction term:

$$\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \gamma(\varepsilon_t^m \times g_{i,t-1} \times s_{i,t-1}) + \Gamma' Z_{i,t-1} + e_{i,t} \tag{16}$$

where $s_{i,t}$ is a variable that aims to capture investors' preference for sustainable investing. $Z_{i,t-1}$ includes a set of firm-level controls as before, and all the double interactions of $s_{i,t}$ with the monetary policy surprises and firm-level greenness. To construct $s_{i,t}$, I combine information from firm i's mutual fund investors' holdings from CRSP with climate change awareness measures at the county level. As before, I restrict my attention to those mutual funds identified in CRSP as index funds. Specifically, let $\tilde{w}_{i,j,t}$ denote the fraction of total investments in firm i that are made by index fund investor j at time t. The investor-based sustainable preference score for firm i at time t, $\mathrm{s}_{i,t}$ is then given by:

$$\mathrm{s}_{i,t} = \sum_{j \in \Gamma(i)} \tilde{w}_{i,j,t} \times \text{Investor Sustainable Preference}_j \tag{17}$$

where $\Gamma(i)$ denotes the set of index fund investors that hold firm i in their portfolio and the Investor Sustainable Preference$_j$ is a variable that proxies for fund j's propensity to engage in sustainable finance. To proxy for this propensity, I exploit the geographical variation in index fund locations at the county level. In particular, I assume that index funds located in regions with stronger beliefs about climate change are more likely to exhibit a green preference.[32]

[32] Previous literature has shown that county-level attitudes towards climate change are highly correlated with the availability of investment options with ESG mandates. In particular, Baker et al. (2022) find that a 10 percentage point increase in the share of the population that believes climate change is caused by humans is correlated with a 3 percentage point (8%) increase in the share of 401(k) plans with an ESG investment option.

Equation (17) therefore represents a weighted average of investors' green preferences at the firm level.

First, I consider the natural risk index (NRI), which measures exposure to natural disaster risk based on the county where mutual fund j is located at. The coefficient before the triple interaction term, MP shock $\times$ Env. Score $\times$ NRI in column (2) of Table 6 indicates that the dampened response of green firms to monetary policy surprises is higher for stocks held by mutual fund investors located in counties that are highly exposed to natural disaster risk. In particular, a one standard deviation increase in fund-level exposure to natural disaster risk dampens the sensitivity of green firms to monetary policy by an additional 1.548 percentage points. Assuming that climate change concerns are more pronounced in regions that are highly vulnerable to natural disasters, the significance of this triple interaction term is indicative of an investor "green" preference channel.

I then consider another set of measures, which proxy for climate change beliefs, risk perceptions, and policy support in different counties where firm i's index fund investors are located at. Column (2) - (6) in Table 6 present the results from the inclusion of these triple interactions terms. In particular, the sensitivity of green firms to monetary policy is even more attenuated when firm i's investors are located in regions where respondents: (i) believe climate change is happening, (ii) are worried about climate change, (iii) believe to be personally affected by climate change, (iv) support regulating CO_2 as a pollutant. These results support the notion that investor types influence how green asset prices respond to changes in interest rates.

Additionally, I consider a third measure of climate change awareness that comes from news articles about climate change published by major U.S. news outlets. In so far as the arrival of such news increases environmental awareness, one would expect investors' propensity to hold green assets (above and beyond risk-return considerations) to strengthen in periods when news coverage of climate change events is amplified. The results in column (7) show that the differential response of green stocks to monetary policy shocks is exacerbated in periods when climate concerns are heightened. The coefficient before MP shock $\times$ Env. score

Table 6. Geographical and Temporal Variation in Sustainable Preferences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$
MP shock × Env. score	2.975***	2.817***	2.672***	2.806***	2.691***	2.861***	3.538***	1.987***
	(0.867)	(0.853)	(0.850)	(0.847)	(0.853)	(0.868)	(0.924)	(0.691)
MP shock × Env. score × NRI		1.548**						
		(0.704)						
MP shock × Env. score × Happening			1.172*					
			(0.613)					
MP shock × Env. score × Worried				1.676**				
				(0.748)				
MP shock × Env. score × Personal					1.492**			
					(0.658)			
MP shock × Env. score × CO_2 Limits						1.753**		
						(0.744)		
MP shock × Env. score × MCCC							1.890**	
							(0.778)	
MP shock × Env. score × Post Paris								3.683*
								(1.935)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector_time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.328	0.333	0.333	0.333	0.333	0.333	0.288	0.271
Observations	75687	68880	68880	68880	68880	68880	53658	67205

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parentheses are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

× MCCC thus serves as evidence that preferences for sustainable investing can have a significant impact on the transmission of monetary policy. Additionally, it is worth noting that climate change awareness has significantly risen since the implementation of the Paris Agreement in 2015.[33] Following the Paris Agreement, there has been a surge in climate change-related discussions and initiatives at various levels, including governments, businesses, and civil society. Therefore, column (8) employs a diff-in-diff analysis to explore whether the dampened sensitivity of green firms is even more prominent in the period following the agreement, when climate change awareness is more heightened. The results presented in

[33] The Paris Agreement is an international treaty adopted by the United Nations Framework Convention on Climate Change (UNFCCC) in 2015. It aims to address the issue of climate change by encouraging global cooperation and efforts to limit global warming to well below 2 degrees Celsius above pre-industrial levels.

column (8) confirm that this is indeed the case, providing further support for the theoretical predictions outlined in the previous section.

5.3 Evidence from Mutual Fund Flows

As discussed, a key prediction of the stylised model in Section 4.2 is that the weight of green assets in investors portfolios increases following an increase in interest rates. This is because environmentally conscious investors are relatively more reluctant to unwind their positions in green securities when faced with contractionary monetary policy shocks. In this subsection, I explore whether investors make conscious portfolio rebalancing decisions in response to changes in the interest-rate environment. In this vein, I investigate whether there are heterogeneities in the funding behaviour of mutual funds with and without ESG labels. Building on the intuition of the model, I anticipate that in response to monetary policy shocks the flows in and out of mutual funds that identify as sustainable (or ESG) may differ from those that do not identify as sustainable (or ESG). Evidence that flows out of non-ESG-labelled mutual funds exceed those from ESG-labelled funds would point to an active decision by investors to maintain their green holdings.

To address this question, I leverage information from the CRSP survivorship-bias-free mutual fund database, which contains data on a fund's monthly returns and total net assets, as well as information on the fund's portfolio holdings, expense ratios and fees. In addition, the database provides details on the fund's characteristics, including its investment objective, fund family, fund type (i.e., equity, bond, hybrid), and founding date. My final sample has information on 22,536 mutual funds and covers the period between January 2008 and December 2020. I compute mutual fund flows for mutual fund m in month t as the net growth in fund m's assets adjusted for price changes:

$$Flows_{m,t} = \frac{A_{m,t} - A_{m,t-1}(1 + r_{m,t})}{A_{m,t-1}} \tag{18}$$

where $A_{m,t}$ denotes total net assets of mutual fund m at time t and $r_{m,t}$ is mutual fund m's monthly return between t-1 and t. Note that equation (18) accounts for the fund's returns within the month, ensuring that $\text{Flows}_{m,t}$ accurately represents the net investments received by (or withdrawn from) the fund in that month, rather than capturing re-valuation effects.

I then study the effect of monetary policy shocks on mutual fund flows conditional on the type of mutual fund. In line with the theoretical predictions in Section 4.2, I expect investors to rebalance their portfolios differently when they invest in ESG-labelled funds.[34] To test this conjecture, I estimate the relative effect of monetary policy shocks on mutual fund flows for ESG-labelled funds. Specifically, I estimate the following panel regression:

$$Flows_{m,t+1} = \alpha_c + \alpha_{s,t} + \beta(\varepsilon_t^m \times ESG_{m,t-1}) + \delta ESG_{m,t-1} + \Gamma' Z_{m,t-1} + e_{m,t} \tag{19}$$

where ε_t^m is the BRW monetary policy shock aggregated to a monthly frequency; $\varepsilon_t^m \times ESG_{m,t-1}$ denotes the interaction of the monetary policy shock with the ESG label dummy. The set of control variables $Z_{m,t-1}$ includes fund return, fund return volatility, fund size, fund age, fund's expense ratio, and an interaction of the monetary policy shock with the fund's return volatility. α_c represents management firm fixed effects (e.g., Vanguard, Blackrock, etc.), and $\alpha_{s,t}$ controls for how funds of different types and with different investment strategies react to aggregate shocks. Fund types and investment strategies are defined according to the Lipper classification system. This controls for the fund type (e.g., ETF, Index, or Mutual Fund) as well as the fund's investment objective (e.g., US Mid Cap Blend, Global Large Cap Blend, etc.). I am interested in the coefficient on the interaction term, β, which measures the difference in mutual fund net-flows for ESG vs. non-ESG mutual funds in the aftermath of a shock to monetary policy.

Table 7 presents the average response in fund flows to monetary policy. As changes in the interest rates alter the relative returns between equity and bonds, I run the specification

[34] Here, I define ESG mutual funds in a similar fashion to the methodology outlined in Section 5.1 with respect to index funds. In particular, I classify a mutual fund as ESG-labelled if its name contains at least one sustainability keyword, consistent with van der Beck (2021)

outlined in Equation (19) separately for bond and equity funds. The results in columns (1) - (3) indicate that positive shocks to monetary policy (unexpected tightening) are met with net outflows from equity funds. As shocks to the interest rate increase uncertainty and volatility in financial markets, investors respond by reducing their investments in equity funds.[35] In particular, a tightening monetary policy surprise of 100 basis points is associated with an outflow of about 3% of assets under management (AUM) for equity funds. Furthermore, these results also hold true for index equity funds, predominantly driven by institutional investors.

Columns (7) - (9) show the effect of monetary policy shocks on bond fund flows. Bond fund flows are relatively unaffected a month after a tightening monetary policy surprise, compared to their equity counterparts. To the extent that higher interest rates raise the yields of fixed-income securities, these results lend support to a portfolio reallocation channel away from equity mutual funds to fixed income investments.

Table 8 shows that the response of equity fund flows to monetary policy is heterogeneous across types of funds. In particular ESG-labelled equity funds appear to be considerably less sensitive to monetary policy compared to non-ESG-labelled funds. This is especially true for index equity funds, where ESG mandates may be a more salient feature compared to actively managed funds.[36] In particular, within the same Lipper investment objective, investment flows in ESG index funds are about 7.56 percentage points less sensitive to a 100 basis point surprise increase in the federal funds rate.

Columns (5) and (6) split the sample of equity index funds between retail and institutional funds. The results show that the coefficient on the interaction term β is statistically significant only for institutional, and not for retail funds. This suggests that within an investment category, only institutional investors are relatively hesitant to unwind their ESG portfolio posi-

[35] This result is in line with Daniel et al. (2021) who show that equity funds receive significant inflows following a reduction in the federal funds rate. This is because a decrease in interest rates reduces investment income from bank deposits and short-term bonds. In response to this decline, some investors may move into higher income assets such as high-dividend stocks and high-yield bonds.

[36] Index funds are a subset of mutual funds, which generally follow a passive investment strategy. They typically track a benchmark index. As such, the fund managers' focus is on replicating the performance of the index, rather than selecting individual companies. This may make it easier for them to prioritise ESG objectives.

Table 7. Mutual Fund Flows - Average Response

	Equity			Index (equity)			Bond		
	(1) All	(2) Inst.	(3) Retail	(4) All	(5) Inst.	(6) Retail	(7) All	(8) Inst.	(9) Retail
MP shock	-0.0309***	-0.0354***	-0.0266***	-0.0228**	-0.0442***	0.0355	-0.0170	-0.0259	-0.0104
	(0.00267)	(0.00412)	(0.00346)	(0.00922)	(0.00929)	(0.0244)	(0.0130)	(0.0302)	(0.0122)
Mgmt Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lipper Class. FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0364	0.0348	0.0412	0.0376	0.0396	0.0491	0.0954	0.103	0.133
Observations	1000915	514135	484747	135379	105555	29676	32394	11263	21129

Notes: The dependent variable is mutual fund net flows as a fraction of mutual fund's assets under management. MP shock is the BRW monetary policy shock (in percent). Control variables are fund return, fund return volatility, fund size, fund age and fund's expense ratio. All control variables are lagged by a month. Mgmt Firm FE are fixed effects at the level of the firm that manages the mutual fund. Lipper Class. FE are fixed effects at the level of the investment strategy of the mutual fund. The regression coefficients of controls variables are not shown here for brevity. The numbers in parentheses are standard errors, which are clustered at the mutual fund level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

tions in the face of contractionary monetary policy shocks. This could be because institutional investors such as pension funds and insurance companies may be more likely to incorporate

Table 8. Mutual Fund Flows - Marginal Response

	Equity			Index (equity)			Bond		
	(1) All	(2) Inst.	(3) Retail	(4) All	(5) Inst.	(6) Retail	(7) All	(8) Inst.	(9) Retail
MP shock $\times$ ESG Mandate	0.0185	0.0559*	-0.0252	0.0756**	0.122**	-0.0424	0.103	0.152	0.106
	(0.0190)	(0.0288)	(0.0251)	(0.0372)	(0.0489)	(0.0633)	(0.234)	(0.533)	(0.242)
ESG mandate	0.00624***	0.00455**	0.00720***	0.00739*	0.00557	0.00406	0.0197	0.0400*	0.00243
	(0.00158)	(0.00216)	(0.00235)	(0.00381)	(0.00404)	(0.00905)	(0.0137)	(0.0218)	(0.0170)
Mgmt Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lipper_time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0803	0.0844	0.103	0.161	0.162	0.248	0.140	0.181	0.192
Observations	997769	513026	482799	133769	104312	28413	31954	10817	20948

Notes: The dependent variable is mutual fund net flows as a fraction of mutual fund's assets under management. MP shock $\times$ ESGis an interaction of the BRW monetary policy shock (in percent) with an ESG indicator that takes the value of 1 for sustainable (or ESG) mutual funds. Control variables are fund return, fund return volatility, fund size, fund age, fund's expense ratio and an interaction term of monetary policy and fund's return volatility. All control variables are lagged by a month. Mgmt Firm FE are fixed effects at the level of the firm that managed the mutual fund. Lipper_time FE are fixed effects at the level of the investment strategy of the mutual fund by time. The regression coefficients of controls variables are not shown here for brevity. The numbers in parentheses are standard errors, which are clustered at the mutual fund level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

ESG considerations into their investment strategies due to regulatory requirements, fiduciary duties, risk management, and stakeholder demands. Furthermore, these results are robust to considering alternative proxies for investment preferences. Appendix C.3 shows that only institutional index funds located in counties where climate perceptions are strong exhibit a reluctance to withdraw funding in the face of contractionary monetary policy shocks.

These results help explain the way in which preferences for sustainable investing affect the sensitivity of asset prices to monetary policy shocks. Specifically, when institutional investors prioritize ESG factors, their reluctance to withdraw funding from ESG-labelled index funds has a positive effect on the constituent ESG securities within the index.

6 Robustness

In this section, I present an extensive set of additional exercises demonstrating the robustness of my main result.

Effects across different quintiles of the greenness distribution. Table 9 presents the regression results without imposing linearity in the interaction of monetary policy and firms' environmental performance. Here I estimate equation (3) for different 'bins' of the distribution of firms based on firm level greenness, which allows for estimation of separate slopes for each group. Cloyne et al. (2023) argues that this is a non-parametric way of estimating the heterogeneous effects of monetary policy by different firm characteristics. I split the distribution of firms in the dataset into five groups, based on the five quintiles of firm-level greenness. While there is no conceptual reason to prefer one specific greenness cutoff over another, the results are not sensitive to the precise cutoff. The stock price responses by firm-level greenness are reported in Table 9. Quintile 1 refers to firms whose environemntal score falls in the bottom quintile (i.e. brown firms), whereas Quintile 5 refers to firms whose environmental score falls in the upper quintile (i.e. green firms). The results reported in Table 9 make it clear that stock prices of green firms are considerably less responsive to monetary policy surprises: following a 1

Table 9. Quintiles: Firm level

Dep. variable: $\Delta p_{i,t}$	(1) Quintile 1	(2) Quintile 2	(3) Quintile 3	(4) Quintile 4	(5) Quintile 5
MP shock (ε_t^m)	-21.21***	-19.44***	-16.25***	-13.98***	-11.17***
	(4.409)	(4.598)	(4.097)	(3.851)	(3.707)
Firm FE	Yes	Yes	Yes	Yes	Yes
Sector_time FE	No	No	No	No	No
Controls	Yes	Yes	Yes	Yes	Yes
R-squared	0.0851	0.100	0.0929	0.0952	0.0698
Observations	14766	15433	15325	15161	15187

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

percentage point surprise in monetary policy, stock prices of quintile 5 (green) firms fall by around 11%, whereas the stock prices of their quintile 1 (brown) counterparts fall by around 21%.

Fama-French Regressions. Next, to ensure that the panel-level results are not driven by any firm-specific outliers, I proceed by taking a cross-sectional average of returns for each FOMC announcement at the quintile level of the environmental score distribution. This is equivalent to constructing 5 different equally-weighted portfolios that consist of, in order from Columns (1) to (5), Quintile 1, 2, 3, 4 and 5 firms. I then run a simple time series OLS regression to examine the impact of FOMC surprises on portfolio returns. Results in Table 10 are based on the Fama-French 5 Factor model, where returns of each portfolio are regressed onto the unanticipated BRW monetary policy shocks and the Fama-French 5 factors. Next, I construct a portfolio that goes long in Quintile 5 (green) firms and short in Quintile 1 (brown) firms (i.e. Green-minus-Brown). Consistent with the differential response in stock prices from the baseline regressions, the Green-minus-Brown portfolio delivers high returns during periods

Table 10. Portfolio Event Study - Equally-weighted

Dep. variable: Δp_t	(1) Quintile 1	(2) Quintile 2	(3) Quintile 3	(4) Quintile 4	(5) Quintile 5	(6) Green-minus-Brown
MP shock (ε_t^m)	-15.87***	-14.61***	-11.02***	-8.725**	-5.965*	9.906***
	(3.466)	(3.751)	(3.592)	(3.450)	(3.155)	(1.977)
mktrf	0.612***	0.786***	0.868***	0.863***	0.818***	0.206*
	(0.193)	(0.184)	(0.198)	(0.210)	(0.181)	(0.112)
smb	0.930**	0.887*	0.755*	0.638	0.462	-0.469**
	(0.454)	(0.455)	(0.408)	(0.414)	(0.337)	(0.181)
hml	0.307	0.193	0.0827	0.128	-0.0494	-0.356***
	(0.484)	(0.494)	(0.462)	(0.481)	(0.427)	(0.131)
rmw	0.426	0.602	0.782	0.723	0.611	0.184
	(0.554)	(0.554)	(0.564)	(0.584)	(0.489)	(0.262)
cma	0.976	1.088	0.962	0.666	0.286	-0.689*
	(0.685)	(0.767)	(0.710)	(0.702)	(0.628)	(0.357)
R-squared	0.492	0.485	0.473	0.438	0.403	0.426
Observations	102	102	102	102	102	102

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Columns (1) to (5) split the distribution of firms in the dataset into 5 groups, based on the 5 quintiles of firm-level environmental performance. Column (6) constructs a portfolio that goes long in quintile 5 firms and short in quintile 1 firms. Control variables are the Fama-French factors mktrf, smb, hml, rmw and cma. ε_t^m is the BRW monetary policy shock (in percent). The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

of contractionary monetary policy innovations.[37]

Alternative interest rate surprises. Table 11 shows that the heterogeneity identified in the baseline results is robust to using alternative interest rate surprises. Columns (2) to (6) of Table 11 report the coefficient estimates from specification (3), with alternative monetary policy shocks following Kuttner (2001), Gürkaynak et al. (2005), Jarociński and Karadi (2020), Swanson (2021) and Rogers et al. (2018), respectively. In Column (7) I report the result from an instrumental variable (IV) approach, where I use the BRW monetary policy surprise as an instrument for the change in the 2-year US Treasury yield around FOMC announcements. The results are largely unchanged.

[37] Results are quantitatively and qualitatively unchanged when considering a value-weighted Green-minus-Brown portfolio.

Table 11. Robustness: Alternative monetary policy shock measures

Dep. variable: $\Delta p_{i,t}$	(1) Baseline	(2) Kuttner	(3) GSS	(4) JK	(5) Swanson	(6) RSW	(7) IV
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.209***	3.272**	0.824***	2.565*	0.867**	2.395***	2.776***
	(0.506)	(1.317)	(0.278)	(1.392)	(0.352)	(0.898)	(0.756)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry_time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.359	0.358	0.329	0.358	0.325	0.349	0.000239
Observations	37928	37928	30761	37928	32758	26536	37928

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the FOMC event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Alternative metrics of firm-level environmental performance. Table 12 reports the results obtained from running specification (3) with alternative proxies for firm-level greenness. The result in column (2) suggests that monetary policy heterogeneity conditional on firm-level greenness is not specific to the Pastor et al. (2022) methodology, but is also observed when one uses the raw environmental scores from MSCI IVA Metrics. The raw firm-level environmental score adjusts for environmental considerations at the sector level and assigns firms an environmental score relative to their sectoral peers (i.e. A high E (raw) score describes a firm whose environmental performance is high within a particular sector, but not necessarily in the cross-section). In column (3) I look at a subcategory of the aggregate MSCI score, which is particularly relevant for climate change. Specifically, column (3) reports the results from measuring firm-level greenness based on a firm's emissions score, where a higher score indicates lower levels of GHG emissions.[38] The interaction coefficient (measuring the relative responsiveness of low polluting firms relative to high polluting firms) is still positive and significant.

[38] Here I have applied the same greenness score construction methodology that was proposed by Pastor et al. (2022) and is detailed in Section 2.1. The aim of this transformation is to assign firms a score that reflects their 'true' greenness regardless of which sector they operate in.

Table 12. Robustness: Alternative metrics of environmental performance

Dep. variable: $\Delta p_{i,t}$	(1) MSCI Baseline	(2) MSCI Raw Score	(3) MSCI Emissions	(4) SUS Env. Policy	(5) SUS Env. Mgmt.	(6) SUS Renew. Energy
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.975***	2.726***	2.960***	0.832*	1.092**	1.692***
	(0.867)	(0.779)	(1.026)	(0.440)	(0.548)	(0.620)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector_time FE	Yes	No	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.328	0.299	0.319	0.337	0.337	0.365
Observations	75687	75931	64844	61602	61602	32220

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Columns (3) to (6) use firm-level environmental performance scores from a different ESG database provider called Sustainalytics. This database has been used in previous research and comes with the advantage that the environmental scores are updated at a monthly frequency, thus potentially providing more variation in firm-level greenness (Engle et al., 2020). To determine a firm's environmental performance, Sustainalytics evaluates firms on a number of indicators, including efforts to reduce greenhouse gas emissions, increase renewable energy use, and reduce water use. Columns (4) to (6) in Table 12 report that the heterogeneous sensitivity to monetary policy shocks is also observed when using Sustainalytics based scores of environmental performance instead of MSCI. Additionally, Table B.3 in the Appendix shows that the heterogeneous impact of monetary policy on firm-level returns arises only as a result of firm's environmental performance and not due to their social responsibility or corporate governance scores.

Additional analysis of the data. The third set of results includes some additional analysis of the data. First, Columns (2) and (3) in Table 13 show that the heterogeneous response of green vs. brown firms to monetary policy shocks is relatively symmetric across episodes of expan-

Table 13. Robustness: Additional analysis of the data

	(1) Baseline	(2) Contractionary	(3) Expansionary	(4) Post- GFC	(5) ZLB	(6) Post ZLB
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.975***	2.778*	- 4.615*	2.566***	1.555**	4.846**
	(0.867)	(1.539)	(2.375)	(0.899)	(0.681)	(1.855)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector_time FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.328	0.401	0.262	0.326	0.365	0.324
Observations	75687	36036	39471	72670	28954	43741

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

sionary and contractionary monetary policy shocks.[39] In other words, while contractionary monetary policy depresses average asset prices, this reaction tends to be less pronounced for greener firms as shown in column (2). While expansionary monetary policy increases average asset prices, this positive reaction is slightly dampened in the case of greener firms as shown in column (3). Column (4) shows that the results are robust to only considering the post GFC period, which alleviates concerns that the results are driven by a handful of influential events, such as the unscheduled FOMC meetings during the GFC. Columns (5) and (6) split the sample between ZLB announcements and post ZLB announcements. The ZLB is the period starting on 16 December 2008, when FOMC lowered the federal funds rate to zero and ending in 16 December 2015, when FOMC raised the federal funds rate for the first time since the GFC.

Results in Columns (5) and (6) indicate that the dampened sensitivity of green asset prices with respect to monetary policy shocks remains intact both in the ZLB and post ZLB period. Interestingly, column (6) reports a higher coefficient on the interaction between the MP shock

[39]Removing the industry-by-time fixed effects reveals that in response to a contractionary monetary policy shock of 100 bp average asset prices fall by around 14%, whereas in response to an expansionary monetary policy shock of 100 bp the average stock prices increase by 18%.

and firm-level greenness in the post ZLB period. This could be because conventional monetary policy was constrained in the ZLB period, which may have led to less powerful responses in asset prices.[40]

7 Conclusion

This paper shows that environmental performance and investors' preferences for sustainable investing matter for the transmission of monetary policy on firm-level outcomes. First, evidence from stock prices and credit risk data at the firm-level, shows that greener firms are considerably less responsive to monetary policy shocks than their brown counterparts. Second, stock holdings data at the institutional investor level, suggests that the dampened sensitivity of green firms to monetary policy shocks is the result of investors' preferences for sustainable investing. This is because investors are more reluctant to substitute away from green stocks following a contractionary monetary policy shock, when they derive a non-pecuniary benefit from holding green assets.

My findings highlight that attitudes towards sustainable investing play an important role in how capital is allocated in financial markets. In particular, green preferences lead to heterogeneous capital flow responses to macro-financial shocks, which improves the ability of green firms to withstand these shocks. These distributional effects have important implications for firms' cost of capital, their investment potential and their resilience to future shocks. My research informs the current policy debate on whether the recent monetary policy tightening may discourage firms' efforts to decarbonise. While green investments have relatively large upfront costs, my results suggest that green firms may not be as vulnerable to higher interest rates as previously believed.

[40] Removing the industry-by-time fixed effects in order to estimate the average monetary policy effect on asset prices, reveals that a contractionary surprise of 100 basis points led to a 12% reduction in average asset prices in the ZLB period, compared to 22% reduction in post-ZLB period. These average results are significant at the 5% and 1% significance level, respectively.

References

Aghion, Philippe, Antonin Bergeaud, Maarten De Ridder, and John Van Reenen, "Lost in transition: Financial barriers to green growth," *INSEAD Working Paper*, 2024.

Alok, Shashwat, Nitin Kumar, and Russ Wermers, "Do fund managers misestimate climatic disaster risk," *The Review of Financial Studies*, 2020, *33* (3), 1146–1183.

Anderson, Gareth and Ambrogio Cesa-Bianchi, "Crossing the credit channel: credit spreads and firm heterogeneity," *American Economic Journal: Macroeconomics*, 2024, *16* (3), 417–446.

Ardia, David, Keven Bluteau, Kris Boudt, and Koen Inghelbrecht, "Climate change concerns and the performance of green versus brown stocks," *Management Science*, 2023, *69* (12), 7607 – 7632.

Baker, Malcolm, Mark L Egan, and Suproteem K Sarkar, "How Do Investors Value ESG?," *National Bureau of Economic Research Working Paper, 30708*, 2022.

Baldauf, Markus, Lorenzo Garlappi, and Constantine Yannelis, "Does climate change affect real estate prices? Only if you believe in it," *The Review of Financial Studies*, 2020, *33* (3), 1256–1295.

Barnett, Michael, William Brock, and Lars Peter Hansen, "Pricing uncertainty induced by climate change," *The Review of Financial Studies*, 2020, *33* (3), 1024–1066.

Berg, Florian, Julian F Koelbel, Anna Pavlova, and Roberto Rigobon, "ESG confusion and stock returns: Tackling the problem of noise," *National Bureau of Economic Research Working Paper Nr. 30562*, 2022.

Bolton, Patrick and Marcin Kacperczyk, "Do investors care about carbon risk?," *Journal of Financial Economics*, 2021, *142* (2), 517–549.

Bu, Chunya, John Rogers, and Wenbin Wu, "A unified measure of Fed monetary policy shocks," *Journal of Monetary Economics*, 2021, *118*, 331–349.

Casella, Sara, Hanbaek Lee, and Sergio Villalvazzo, "Rising Intangible Capital and the Disappearance of Public Firms," *Finance and Economics Discussion Series Working Paper 2023-050*, 2023.

Cloyne, James, Clodomiro Ferreira, Maren Froemel, and Paolo Surico, "Monetary policy, corporate finance and investment," *Journal of the European Economic Association*, 2023, *21* (6), 2586–2634.

Correa, Ricardo, Ai He, Christoph Herpfer, and Ugur Lel, "The rising tide lifts some interest rates: Climate change, natural disasters and loan pricing," *International Finance Discussion Papers Nr. 1345*, 2022.

Daniel, Kent, Lorenzo Garlappi, and Kairong Xiao, "Monetary policy and reaching for income," *The Journal of Finance*, 2021, *76* (3), 1145–1193.

D'Amico, Stefania and Mira Farka, "The Fed and the stock market: An identification based on intraday futures data," *Journal of Business & Economic Statistics*, 2011, *29* (1), 126–137.

Engle, Robert F, Stefano Giglio, Bryan Kelly, Heebum Lee, and Johannes Stroebel, "Hedging climate change news," *The Review of Financial Studies*, 2020, *33* (3), 1184–1216.

Fama, Eugene F and James D MacBeth, "Risk, return, and equilibrium: Empirical tests," *Journal of Political Economy*, 1973, *81* (3), 607–636.

Gilchrist, Simon and Egon Zakrajšek, "Credit spreads and business cycle fluctuations," *American Economic Review*, 2012, *102* (4), 1692–1720.

Gormsen, Niels Joachim, Kilian Huber, and Sangmin Oh, "Climate capitalists," *Unpublished manuscript*, 2023.

Gürkaynak, Refet, Hatice Gökçe Karasoy-Can, and Sang Seok Lee, "Stock market's assessment of monetary policy transmission: The cash flow effect," *The Journal of Finance*, 2022, *77* (4), 2375–2421.

Gürkaynak, Refet S, Brian P Sack, and Eric T Swanson, "Do actions speak louder than words? The response of asset prices to monetary policy actions and statements," *International Journal of Central Banking*, 2005, *1* (1), 55–93.

Hong, Harrison, Frank Weikai Li, and Jiangmin Xu, "Climate risks and market efficiency," *Journal of Econometrics*, 2019, *208* (1), 265 – 281. Special Issue on Financial Engineering and Risk Management.

Howe, Peter D, Matto Mildenberger, Jennifer R Marlon, and Anthony Leiserowitz, "Geographic variation in opinions on climate change at state and local scales in the USA," *Nature Climate Change*, 2015, *5* (6), 596–603.

Jarociński, Marek and Peter Karadi, "Deconstructing monetary policy surprises— The role of information shocks," *American Economic Journal: Macroeconomics*, 2020, *12* (2), 1–43.

Jeenas, Priit, "Firm Balance Sheet Liquidity, Monetary Policy Shocks, and Investment Dynamics," *Barcelona School of Economics Working Paper Nr. 1409*, 2023.

Jordà, Òscar, "Estimation and inference of impulse responses by local projections," *American Economic Review*, 2005, *95* (1), 161–182.

Kim, Yongtae, Haidan Li, and Siqi Li, "Corporate social responsibility and stock price crash risk," *Journal of Banking & Finance*, 2014, *43*, 1–13.

Koijen, Ralph SJ and Motohiro Yogo, "A demand system approach to asset pricing," *Journal of Political Economy*, 2019, *127* (4), 1475–1515.

Krueger, Philipp, Zacharias Sautner, and Laura T Starks, "The importance of climate risks for institutional investors," *The Review of Financial Studies*, 2020, *33* (3), 1067–1111.

Kuttner, Kenneth N, "Monetary policy surprises and interest rates: Evidence from the Fed funds futures market," *Journal of Monetary Economics*, 2001, *47* (3), 523–544.

Miranda-Agrippino, Silvia, "Unsurprising shocks: information, premia, and the monetary transmission," *Bank of England Working Paper Nr.626*, 2016.

Nakamura, Emi and Jón Steinsson, "Five facts about prices: A reevaluation of menu cost models," *The Quarterly Journal of Economics*, 2008, *123* (4), 1415–1464.

Ottonello, Pablo and Thomas Winberry, "Financial heterogeneity and the investment channel of monetary policy," *Econometrica*, 2020, *88* (6), 2473–2502.

Ozdagli, Ali and Mihail Velikov, "Show me the money: The monetary policy risk premium," *Journal of Financial Economics*, 2020, *135* (2), 320–339.

Painter, Marcus, "An inconvenient cost: The effects of climate change on municipal bonds," *Journal of Financial Economics*, 2020, *135* (2), 468 – 482.

Pastor, Lubos, Robert F Stambaugh, and Lucian A Taylor, "Sustainable investing in equilibrium," *Journal of Financial Economics*, 2021, *142* (2), 550–571.

— , — , **and** — , "Dissecting green returns," *Journal of Financial Economics*, 2022, *146* (2), 403–424.

Peng, Lin, "Learning with information capacity constraints," *Journal of Financial and Quantitative Analysis*, 2005, *40* (2), 307–329.

Ramey, Valerie A, "Macroeconomic shocks and their propagation," *Handbook of Macroeconomics*, 2016, *2*, 71–162.

Rigobon, Roberto and Brian Sack, "The impact of monetary policy on asset prices," *Journal of Monetary Economics*, 2004, *51* (8), 1553–1575.

Rogers, John H, Chiara Scotti, and Jonathan H Wright, "Unconventional monetary policy and international risk premia," *Journal of Money, Credit and Banking*, 2018, *50* (8), 1827–1850.

Romer, Christina D and David H Romer, "Federal Reserve information and the behavior of interest rates," *American Economic Review*, 2000, *90* (3), 429–457.

Swanson, Eric T, "Measuring the effects of federal reserve forward guidance and asset purchases on financial markets," *Journal of Monetary Economics*, 2021, *118*, 32–53.

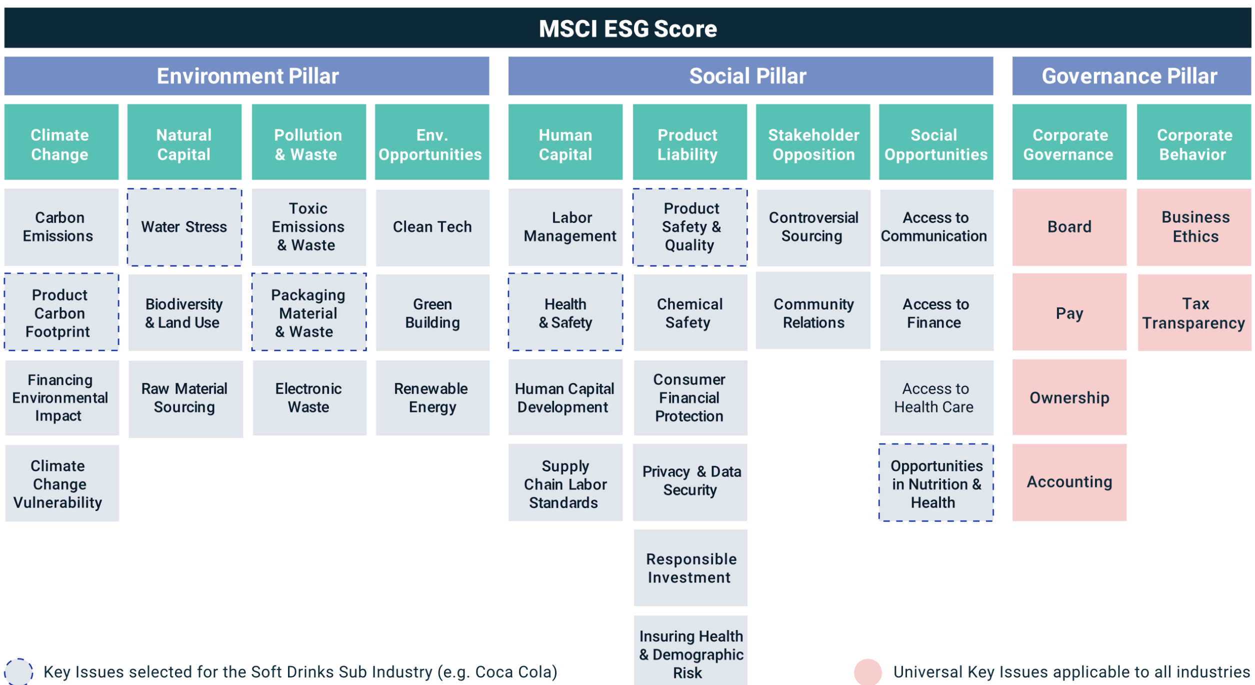
van der Beck, Philippe, "Flow-driven ESG returns," *Swiss Finance Institute Research Paper No. 21-71*, 2021.

Zuzak, Casey, Matthew Mowrer, Emily Goodenough, Jordan Burns, Nicholas Ranalli, and Jesse Rozelle, "The national risk index: establishing a nationwide baseline for natural hazard risk in the US," *Natural Hazards*, 2022, *114* (2), 2331–2355.

A Appendix

A.1 The 'E' in ESG

Figure A.1. MSCI ESG Pillars



Notes: This chart details the key issues that MSCI uses for evaluating companies' ESG performance. Source: MSCI ESG Key Issues Framework

MSCI, employs a comprehensive framework to assess a company's Environmental, Governance and Social (ESG) performance. To ensure a thorough evaluation, MSCI gathers an extensive range of data from diverse sources such as public records, company disclosures, industry reports, and regulatory filings. This data is then utilized to evaluate firms based on 35 key environmental, governance, and social issues.

To accurately reflect the specific industry context of each company, MSCI assigns weights to these issues based on their significance within the industry. For instance, for a company like Coca-Cola operating in the sub-industry of soft drinks, the critical issues highlighted within the dashed boxes in Figure A.1 outline the key concerns. Within this particular subindustry, the primary environmental risks involve product carbon footprint, water stress, and packaging waste. Consequently, when calculating Coca-Cola's environmental score, MSCI places greater emphasis on evaluating the firm's management of carbon footprint, exposure to water stress, and handling of packaging waste.

This approach ensures that Coca-Cola's final 'E' score is appropriately adjusted to account for the specific sub-industry/sector it operates in. Hence, the final 'E' score from MSCI effectively represents how well Coca-Cola addresses emvrionmental concerns compared to its industry peers.

A.2 Variable Definitions

Table A.1. Variable Definitions.

Variables	Description
Return	Percentage change of stock price between the day before and the day after an FOMC announcement, $log(P_{i,\tau+1}) - log(P_{i,\tau-1})$
Environmental score	The annual environmental score from MSCI ESG IVA ratings, following the green score construction methodology proposed by Pastor et al. (2022).
Firm Size	The logarithm of quarterly total assets (ATQ) deflated by US Implicit Price Deflator
Book leverage	The ratio of total debts (DLCQ + DLTTQ) to the sum of total debts and the book value of equity (DLCQ + DLTTQ + CEQQ)
Short-term debt	Short-term debt (DLCQ), expressed as a fraction of total assets (ATQ)
Long-term debt	Share of long term debt (DLTTQ) to total debt (DLCQ + DLTTQ).
Profitability	Operating income before depreciation (OIBDPQ), expressed as a fraction of total assets (ATQ)
Retained earnings	Retained earnings (REQ), expressed as a fraction of total assets (ATQ).
Dividend per share	Dividend per share (DVPSPQ).
Cash holdings	Cash holding (CHEQ), expressed as a fraction of total assets (ATQ).
Market-to-book ratio	The sum of the market value of equity and total debts (PRCCQ*CSHOQ + DLCQ + DLTTQ), expressed as a fraction of total assets (ATQ).
Age	Age since incorporation in CRSP (BEGDAT).
Distance to default	Distance to default measure following Gilchrist and Zakrajšek (2012).
1/std.(EPS)	1/standard deviation of the analysts' forecasts of EPS from Institutional Brokers' Estimate System (I/B/E/S)

B Additional Results

Controlling for investor inattention. One concern is that the results in Table 3 may be driven by the speed with which information is incorporated by financial market participants, which may vary across large versus small firms. For example Peng (2005) argues that there is a faster rate of information incorporation for large firms compared to small firms. To the extent that green firms tend to be younger and smaller in size than their brown counterparts, this would imply that monetary policy shocks may affect green firms at a slower speed compared to brown firms.[41] To assess whether the differential response of green firms to monetary policy shocks is not just a result of investor inattention, but persists at longer horizons, I consider a specification with cumulative stock price changes up to 10 days after an FOMC announcement. Columns (1) - (11) of Table B.1 show that the differential response of green firms compared to their brown counterparts is not just a transitionary adjustment in prices, but this effect is rather persistent for up to 3 days after the FOMC announcement. Additionally, Table B.4 repeats the baseline result for a subsample that consists of the constituents of the S&P500 Index, lending further support to the idea that the observed heterogeneity is not the result of investors' inattention.

Falsification test. Second, Table B.2 performs a falsification test in line with Gürkaynak et al. (2022), which looks at the two-day asset price changes up to 10 days before the FOMC announcements and finds no relationship between monetary policy shocks and firm-level greenness. Thus, it is not the case that green firms always behave differently from their brown counterparts for some reason unrelated to monetary policy. Rather, it is the unexpected change in monetary policy that generates the heterogenous response.

[41] Table 2 provides summary statistics on the differences in financial characteristics between green and brown firms.

Table B.1. Cumulative Returns

	(1) $\Delta_0 p_{i,t}$	(2) $\Delta_1 p_{i,t}$	(3) $\Delta_2 p_{i,t}$	(4) $\Delta_3 p_{i,t}$	(5) $\Delta_4 p_{i,t}$	(6) $\Delta_5 p_{i,t}$	(7) $\Delta_6 p_{i,t}$	(8) $\Delta_7 p_{i,t}$	(9) $\Delta_8 p_{i,t}$	(10) $\Delta_9 p_{i,t}$	(11) $\Delta_{10} p_{i,t}$
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	1.926***	2.975***	1.993**	1.603	1.474	1.641	1.940*	2.029	2.244*	1.968	1.857
	(0.581)	(0.867)	(0.891)	(1.070)	(1.052)	(1.049)	(1.124)	(1.410)	(1.278)	(1.327)	(1.309)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector_time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.303	0.328	0.299	0.320	0.282	0.265	0.262	0.269	0.269	0.248	0.271
Observations	75769	75687	75666	75031	75282	75618	75593	73036	75576	75554	75535

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Table B.2. Robustness: Falsification Test

	(1) $\tau-1$	(2) $\tau-2$	(3) $\tau-3$	(4) $\tau-4$	(5) $\tau-5$	(6) $\tau-6$	(7) $\tau-7$	(8) $\tau-8$	(9) $\tau-9$	(10) $\tau-10$
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	1.521**	0.716	-0.640	-1.533**	-0.226	0.473	0.446	0.161	-0.784	-0.981
	(0.707)	(0.777)	(0.637)	(0.711)	(0.663)	(0.567)	(0.695)	(0.642)	(0.863)	(0.760)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector_time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.248	0.327	0.243	0.206	0.295	0.316	0.265	0.282	0.271	0.313
Observations	75358	75663	75334	75648	75638	74617	75618	73528	75615	71264

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental score as described in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Table B.3. Controlling for Social and Governance Scores

	(1)	(2)	(3)	(4)
	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.975***	3.240***	3.073***	3.407***
	(0.867)	(0.812)	(0.872)	(0.832)
MP shock × Soc. score ($\varepsilon_t^m \times g_{i,t-1}$)		0.679		0.753
		(0.564)		(0.608)
MP shock × Gov. score ($\varepsilon_t^m \times g_{i,t-1}$)			0.270	0.384
			(0.684)	(0.716)
Firm FE	Yes	Yes	Yes	Yes
Sector_time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R-squared	0.328	0.328	0.328	0.328
Observations	75687	75687	75679	75679

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score, Soc. score and Gov. score are the unadjusted firm-level environmental scores, social responsibility scores and corporate governance scores constructed from the E, S and G pillars of ESG using a methodology detailed in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Table B.4. SP500 firms only

	(1)	(2)	(3)	(4)
	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$	$\Delta p_{i,t}$
MP shock (ε_t^m)	-16.12***	-16.54***		
	(4.057)	(4.047)		
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)		3.603***	3.514***	2.709***
		(0.879)	(0.866)	(0.747)
Firm FE	Yes	Yes	Yes	Yes
Sector_time FE	No	No	No	Yes
Controls	Yes	Yes	Yes	Yes
R-squared	0.0748	0.0770	0.346	0.397
Observations	31528	31528	31528	31281

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score, Soc. score and Gov. score are the unadjusted firm-level environmental scores, social responsibility scores and corporate governance scores constructed from the E, S and G pillars of ESG using a methodology detailed in Section 2.1. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Table B.5. Baseline Result - Industry Split

	(1) Mining	(2) Construction	(3) Manufacturing	(4) Transport	(5) Wholesale	(6) Retail	(7) FIRE	(8) Services
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	5.341*	-2.900	3.890**	0.925	1.110	-0.334	6.669***	4.428***
	(2.864)	(4.795)	(1.517)	(1.264)	(2.630)	(1.923)	(1.757)	(1.597)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.534	0.497	0.301	0.317	0.382	0.310	0.387	0.299
Observations	3430	845	35757	9938	3342	6237	2953	13021

Notes: The dependent variable is the two-day stock return bracketing an FOMC announcement (in percent). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. Env. score is the unadjusted firm-level environmental scores from MSCI ESG IVA Metrics. Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. ε_t^m is the BRW monetary policy shock (in percent). The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. Columns (1) -(8) estimate the baseline specification in Equation (3) on a per-industry basis. FIRE stands for financial, insurance and real estate. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Table B.6. Event Study - Credit Default Swap Spreads

	(1) ΔCDS	(2) ΔCDS	(3) ΔCDS	(4) ΔCDS
MP shock (ε_t^m)	21.47**	21.42**		
	(9.350)	(9.342)		
MP shock × Env. score ($\varepsilon_t^m \times g_{i,t-1}$)		-7.894***	-7.909***	-6.109**
		(2.793)	(2.789)	(2.459)
Firm FE	Yes	Yes	Yes	Yes
Sector_time FE	No	No	No	Yes
Controls	Yes	Yes	Yes	Yes
R-squared	0.0335	0.0346	0.133	0.165
Observations	19610	19610	19610	19422

Notes: The dependent variable in columns (1) and (2) is the two-day change in CDS spreads bracketing an FOMC announcement (in basis points). The sample covers 102 FOMC announcements between 31 January 2008 and 31 December 2020. ε_t^m is the BRW monetary policy shock (in percent). Control variables are size, profitability, book leverage, market-to-book ratio, short term liabilities, retaining earnings, dividend per share and distance to default. The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the event-level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

B.1 Real Effects of Monetary Policy

The analysis has thus far focused on the short-term reaction of stock market outcomes to monetary policy surprises. The high frequency approach allows for a more credible identification of the impact of monetary policy on firm-level outcomes, as well as a more precise estimation of its effects (Anderson and Cesa-Bianchi, 2024). However, the impact of monetary policy on equity prices and CDS spreads documented so far could simply reflect a temporary adjustment in asset prices. Furthermore, the identified monetary policy surprises could be temporary disruptions to interest rates that do not have long-lasting effects on firm-level outcomes. With this in mind, I extend the daily event-study panel regressions of Section 3.1 to a quarterly frequency and consider the heterogeneous response of real variables to monetary policy.

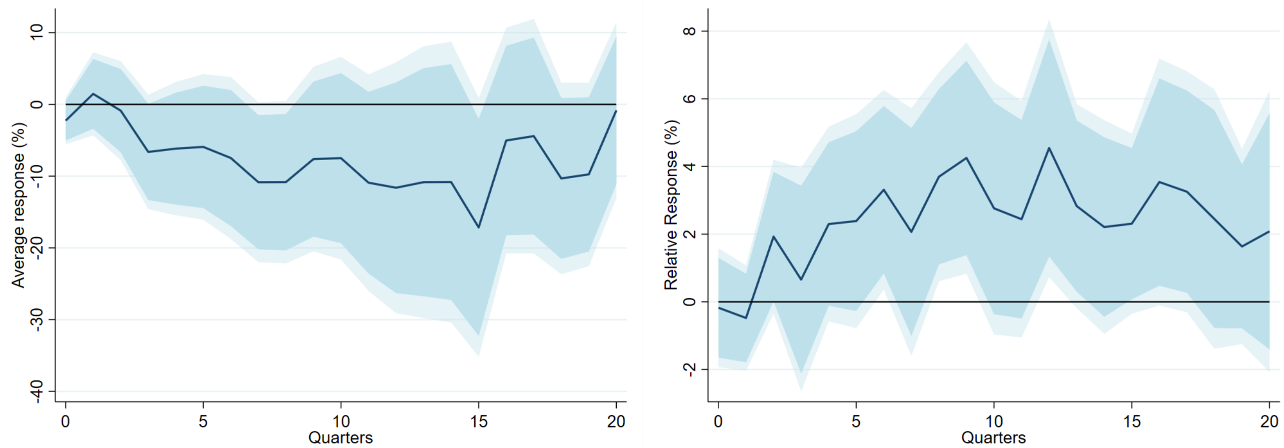
I proceed by collecting quarterly data on firm-level investment from Compustat and aggregating the monetary policy surprises to a quarterly frequency. With this dataset, I use panel local projection methods a la Jordà (2005), to examine whether the investment response to monetary policy depends on firm-level greenness. Specifically, I estimate the following specification:

$$\Delta_h log(k_{i,t}) = \alpha_i^h + \alpha_{s,t}^h + \beta^h(\varepsilon_t^m \times g_{i,t-1}) + \delta^h g_{i,t-1} + \Gamma'^h Z_{i,t-1} + e_{i,t,h} \tag{B.1}$$

where $\Delta_h log(k_{i,t}) \equiv log(k_{i,t+h}) - log(k_{i,t-1})$ denotes the response variable of interest (i.e. the cumulative change in capital stock between quarter t-1 and quarter t+h over varying prediction horizons h = 0,2...10), α_j^h are firm FE, $\alpha_{s,t}^h$ are sector-by-time FE and ε_t^m denotes the Bu et al. (2021) monetary policy surprise aggregated to a quarterly level. $Z_{j,t-1}$ is a vector of (lagged) firm-level controls (size, real sales growth, leverage and distance to default) and g_{jt-1} is firm i's greenness score, computed from MSCI ESG IVA ratings.

Before presenting the relative response of green firms' investment to monetary policy, it is useful to report the average effect for the sample of firms in my analysis. This serves the purpose of providing a benchmark against which to compare the relative response. With this

Figure B.1. Impulse Response Function of Investment



(A) Average Effect

(B) Interaction Effect

Notes: In line with local projection methods, each horizon is estimated separately. The dependent variable is $\Delta logk_{i,t+h}$, over the horizons considered. The independent variable in Panel (A) is ε_t^m. The independent variable in Panel (B) is $\varepsilon_t^m \times g_{i,t-1}$. The light and dark blue shaded areas denote the 90% and 95% confidence intervals, respectively. The standard errors clustered at the time level.

in mind, Panel (A) estimates a version of the specification in (B.1) without the sector-time fixed effects and shows that the average firm reduces investment by around 10% in response to a contractionary monetary policy surprise of 100 basis points.

Panel (B) in Figure B.1 graphs the marginal impulse response for investment when increasing firm-level greenness by one standard deviation, as captured by the coefficient β^h. Environmentally responsible firms react less strongly to a tightening in monetary policy: increasing firm-level greenness by one standard deviation dampens the response in investment by around 4 percentage points, with a peak effect reached approximately 3 years after the monetary policy shock. The dampened sensitivity of green firms' investment to monetary policy is in line with the previous results. First, as shown in Section 3.2, higher interest rates increase the costs of borrowing for green firms to a lesser degree than for brown firms, thereby making it more expensive for brown firms to invest and expand their operations. Additionally, as we saw in Section 3.2, higher interest rates lead to a weaker reduction in green firms' asset prices (compared to brown). This suggests that the decline in market value for green companies, relative to the replacement cost of their assets, might be relatively less severe.

Consequently, this would cause relatively lower responsiveness of green firms' investments to a contractionary monetary policy shock.

To summarise, the results in this Section show that the heterogeneous responses uncovered with the high frequency event study regressions also hold at business cycle frequency, with green firms responding less strongly to monetary policy compared to their brown counterparts.

C A Simple 2-period Model with Green Preferences

Time is discrete and there are only two periods. There is no aggregate or idiosyncratic uncertainty. The household can invest in three riskless assets, namely bonds, green securities and brown securities, $b_1, s_{G,1}, s_{B,1}$ respectively. One unit of bonds purchased in period one, returns with certainty (1+r) units of the consumption good in period two. One unit of green (brown) stocks purchased in period one at a price $q_{G,1}$ $(q_{B,1})$, returns with certainty a payoff π_G (π_B) in period two. The household is endowed with income equivalent to y in period one and makes portfolio decisions in period one, subject to a budget constraint. In addition, I assume investors exhibit a preference for sustainable investing. In other words, investors derive a utility of $f(s_{G,1})$ from their holdings of green securities. The household/investor then maximizes the following utility function:

$$\max_{c_t, b_1, s_G s_B} E_1 \Big(\sum_{t=1}^{2} \beta^{t-1} \big(u(c_t) + f(s_{G,1})\big)\Big), \quad \text{subject to,}$$

$$c_1 + b_1 + q_{G,1} s_{G,1} + q_{B,1} s_{B,1} \leq y \quad \text{in period one} \tag{C.1}$$

$$c_2 \leq (1+r) b_1 + \pi_G s_{G,1} + \pi_B s_{B,1} \quad \text{in period two.} \tag{C.2}$$

The internal solution of the utility maximisation problem yields the following no-arbitrage conditions:

$$q_{B,1} = \frac{\pi_B}{1+r}; \quad q_{G,1} = \frac{\pi_G}{1+r} + \frac{(1+\beta) f'(s_{G,1})}{u'(c_1)} \tag{C.3}$$

As a theoretical analogue to the empirical specification laid out in Section 3.1, I proceed by computing the semi-elasticity of these asset prices with respect to the risk-free interest rate. In this set-up, the risk-free rate can be thought of as a proxy for the unanticipated shock to the policy rate in Section 3.1:

$$\frac{dln(q_{B,1})}{dr} = -\frac{1}{1+r} \tag{C.4}$$

$$\frac{dln(q_{G,1})}{dr} = -\frac{1}{1+r} + \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \frac{\left[1-(1+r)\frac{u''(c_1)}{u'(c_1)}\frac{\partial c_1}{\partial r} + (1+r)f''(s_{G,1})\frac{\partial s_{G,1}}{\partial r}\right]}{(1+r)q_G} \tag{C.5}$$

Assuming in a tight window around a monetary policy announcement the equilibrium supply of both green and brown assets is fixed, and therefore insensitive to interest rates, I can equate $\frac{\partial s_{G,1}}{\partial r}$ to 0. Under this assumption equation (C.5) can be re-written as:

$$\frac{dln(q_{G,1})}{dr} = -\frac{1}{1+r} + \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \frac{\left[1-(1+r)\frac{u''(c_1)}{u'(c_1)}\frac{\partial c_1}{\partial r}\right]}{(1+r)q_G} \tag{C.6}$$

Assuming for simplicity $\pi_G = \pi_B$, and recognizing that $\frac{dln(q_{G,1})}{dc_1} = -\frac{1}{q_G}\frac{(1+\beta)f'(s_{G,1})}{u'(c1)}\frac{u''(c_1)}{u'(c_1)}$, I can simplify equation (C.5) further:

$$\frac{dln(q_{G,1})}{dr} = \underbrace{-\frac{1}{1+r}}_{\text{Pecuniary effect}} + \underbrace{\frac{(q_{G,1}-q_{B,1})}{(1+r)q_{G,1}}}_{\text{Green preferences effect}} + \underbrace{\frac{dln(q_{G,1})}{dc_1}\frac{\partial c_1}{\partial r}}_{\text{Wealth effect}} \tag{C.7}$$

Equation (C.7) shows that the effect of an increase in interest rates on green asset prices is a composite of three forces. The 'pecuniary' force that is common across both green and brown assets, results in a reduction of both of these asset prices (i.e. as the interest rate increases, investors substitute away from equities and towards bonds). The 'green preferences' force, which is only present in the case of green stocks, attenuates the first force because investors derive an additional utility from holding green assets. The third force, which I call the 'wealth effect', captures the idea that investors' propensity to hold green assets is proportional to their wealth in period one. While the pecuniary force is always negative and the green preferences force is always positive, the sign and magnitude of the wealth effect will vary depending on $\frac{\partial c_1}{\partial r}$ (i.e. the interplay between income and substitution effects).

Case 1: Green security prices have a lower semi-elasticity with respect to monetary policy shocks compared to their brown counterparts if higher interest rates have a net zero effect on period 1 consumption (i.e. $\frac{\partial c_1}{\partial r} = 0$).

$$\Big(|\frac{dln(q_{G,1})}{dr}| - |\frac{dln(q_{B,1})}{dr}|\Big) = -\frac{(q_{G,1} - q_{B,1})}{(1+r)q_{G,1}} < 0 \tag{C.8}$$

Case 2: Green security prices have a lower semi-elasticity with respect to monetary policy shocks compared to their brown counterparts if higher interest rates have a net positive effect on period 1 consumption (i.e. $\frac{\partial c_1}{\partial r} > 0$).

$$\Big(|\frac{dln(q_{G,1})}{dr}| - |\frac{dln(q_{B,1})}{dr}|\Big) = -\frac{(q_{G,1} - q_{B,1})}{(1+r)q_{G,1}} - \frac{dln(q_{G,1})}{dc_1}\frac{\partial c_1}{\partial r} < 0 \tag{C.9}$$

Case 3: Green security prices have a lower semi-elasticity with respect to monetary policy shocks compared to their brown counterparts if $\frac{\partial c_1}{\partial r} < 0$ and the following condition holds:

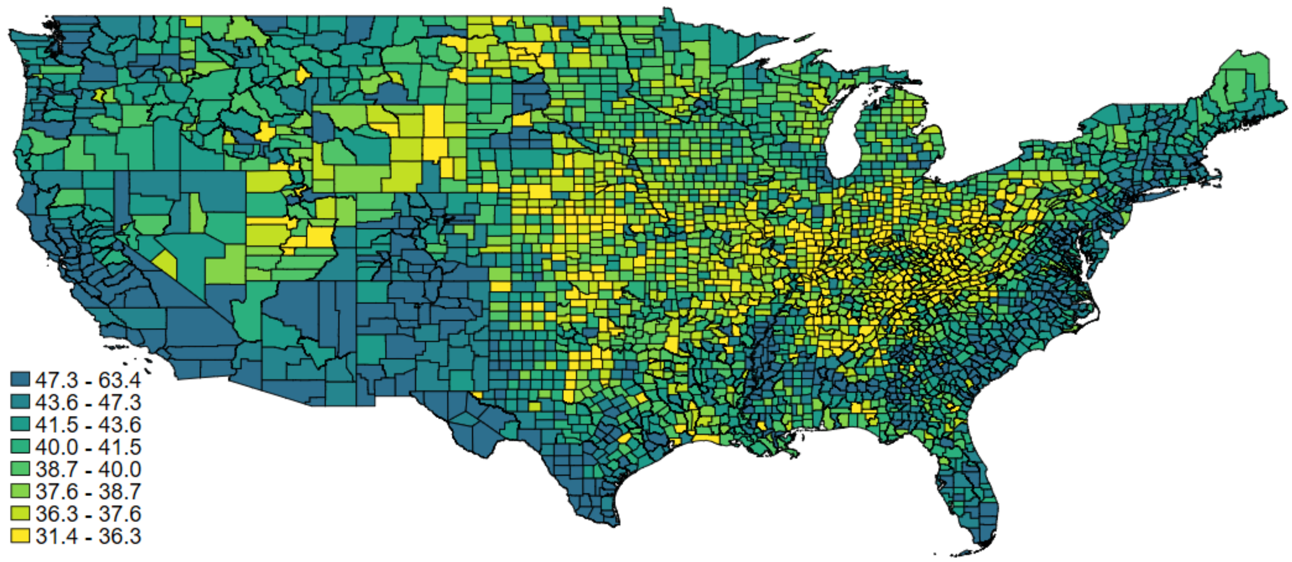
$$\frac{(q_{G,1} - q_{B,1})}{(1+r)q_{G,1}} > -\frac{dln(q_{G,1})}{dc_1}\frac{\partial c_1}{\partial r} \tag{C.10}$$

When the substitution effect dominates the income effect, an increase in interest rates results in a net-negative effect on period-1 consumption. This effect is captured by the term $\frac{\partial c_1}{\partial r} < 0$ in equation (C.10). Because investors' propensity to hold green assets is proportional to their wealth in period 1, this puts downward pressure on the demand for holding green securities. The magnitude of the wealth effect is captured by the product $\frac{dln(q_{G,1})}{dc_1}\frac{\partial c_1}{\partial r}$. When the 'green preferences' effect dominates the 'wealth' effect, I can show that green asset prices are less sensitive to monetary policy shocks compared to their brown counterparts.

Case 4: Green security prices have a higher semi-elasticity with respect to interest rates compared to brown security prices, if and only if $\frac{\partial c_1}{\partial r} < 0$ and the wealth effect dominates the green preferences effect.

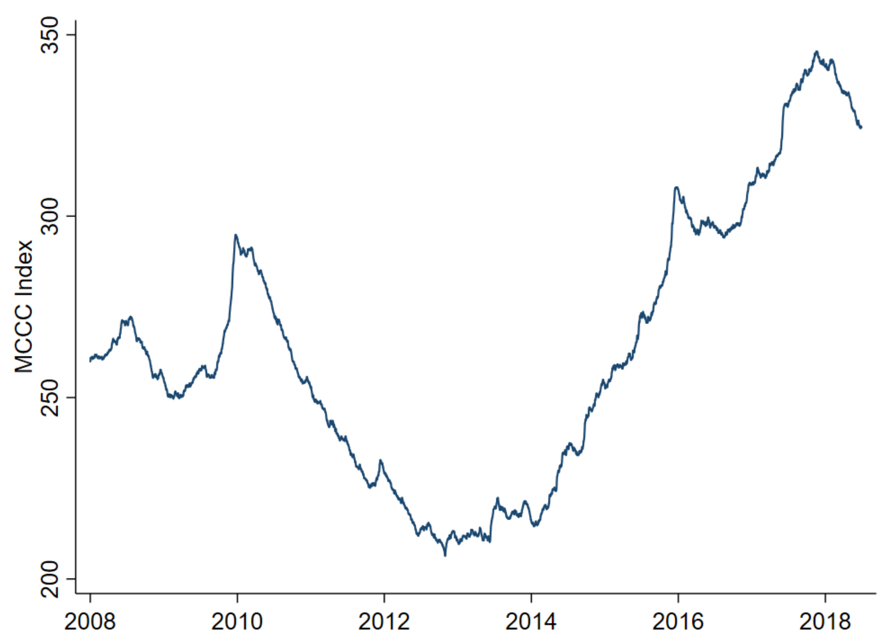
C.1 Proxies for climate change awareness

Figure C.1. Climate Change Beliefs



Notes: Map of Climate Change Beliefs at county level provided by the Yale Climate Opinion Survey (2021), following Howe et al. (2015).

Figure C.2. Cumulative Media Climate Change Concern Index



Notes: The Cumulative Media Climate Change Concerns Index by Ardia et al. (2023) is constructed using a distributed lag model as defined in equation (15).

C.2 Evidence from Institutional Investors

In this subsection I leverage information from institutional investors' portfolio holdings to uncover whether the dampened sensitivity of greener firms to monetary policy is related to investors' preferences for sustainable investing. The institutional holdings data is obtained from Securities and Exchange Commission Form 13F and includes quarterly security holdings of institutions with assets under management of over $100 million dating back to 1980.[42] Together, these institutions manage approximately 63% of the US market, with the remaining 37% being held by households and non-13F institutions (Koijen and Yogo, 2019). I use this rich dataset to address the following two questions: (i) What type of investors are responsible for the dampened sensitivity of greener firms to monetary policy?; (ii) How does the green weight in institutional investors' portfolios change in the aftermath of monetary policy?

[42]The 13F institutions include banks, insurance companies, investment advisors (including hedge funds), mutual funds, pension funds, and other institutions such as endowments, foundations, and nonfinancial corporations.

To address the first questions, I first classify investors into types based on the environmental performance score of their security holdings. Specifically, let $w_{j,i,t}$ denote institutional investor j's holdings share of security i at time t and $g_{i,t}$ denote firm i's environmental performance score at time t as defined in Section 2.1. The overall greenness score for each fund j at time t is computed as:

$$\text{Investor Greenness}_{j,t} = \sum_{i \in \Theta(j)} w_{j,i,t} \times g_{i,t} \tag{C.11}$$

where $\Theta(j)$ denotes the set of securities held by fund j.

I then use these investor greenness scores to proxy for the type of investor that is likely to hold firm i at time t. In other words, I compute an investor-based environmental performance score for each firm i as a weighted average of its investors' revealed preferences. Specifically, let $\tilde{w}_{i,j,t}$ denote the fraction of total investments in firm i that are made by institutional investor j at time t. The investor-based greenness score for every firm i at time t is given by:

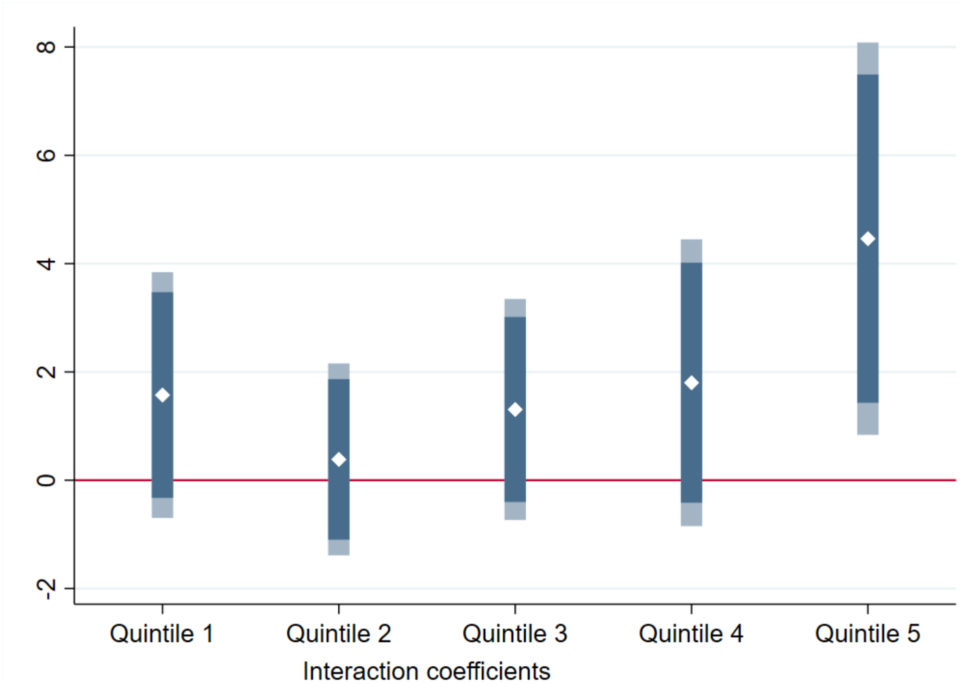
$$\text{Investor-based Greenness}_{i,t} = \sum_{j \in \Gamma(i)} \tilde{w}_{i,j,t} \times \text{Investor Greenness}_{j,t} \tag{C.12}$$

where $\Gamma(i)$ denotes the set of institutional investors that hold firm i in their portfolio.

As a last step, I split the distribution of firms into five different bins based on the revealed green preferences of their investors (i.e. the Investor-based Greenness$_{i,t}$). This allows me to assess how investors' preferences affect the sensitivity of green asset prices to monetary policy. To minimise endogeneity concerns, I look at the Investor-based Greenness scores as of a year before the monetary policy shock. Quintile 1 refers to securities that a year before the monetary policy shock were held by investors with a preference for browner firms. Quintile 5 refers to securities that a year before the monetary policy shock were held by environmentally conscious investors. I proceed by estimating the baseline specification in equation (3) for the five different bins of investor types.

Figure C.3 plots the beta coefficients before the interaction term of firm-level greenness with monetary policy for 5 different bins of the investor greenness distribution. Greener

Figure C.3. Investors' Preferences Channel



Notes: This graph plots the beta coefficients from the following specification: $\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \Gamma' Z_{i,t-1} + e_{i,t}$, for the five different quintiles of the Investor-based greenness distribution. Quintile 1 refers to securities that are held by investors with 'brown' preferences, as of a year before the monetary policy shock. Quintile 5 refers to securities that were held by investors with 'green' preferences, as of a year before the monetary policy shock. White diamonds denote the point estimates. The light and dark blue shaded columns denotes the 90% and 95% confidence intervals, respectively. Standard errors are clustered at the time level.

firms are even less sensitive to monetary policy when they are being held by investors with a preference for sustainable investing. Crucially, the beta coefficients for firms being held by 'brown' investors (Quintiles 1 and 2) are not statistically different from zero. Conversely, the dampened sensitivity of greener firms to monetary is only observed for firms held by environmentally conscious investors (Quintiles 4 and 5). To summarise, these results confirm the theoretical predictions implied by Proposition 1 in Section 4.1. They show that the differential response of green firms (compared to brown) to monetary policy can be explained by investors' preferences for sustainable investing.

C.3 Evidence from Mutual Fund Flows

Table C.1. Mutual Fund Flows - Marginal Response

	Equity			Index (equity)			Bond		
	(1) All	(2) Inst.	(3) Retail	(4) All	(5) Inst.	(6) Retail	(7) All	(8) Inst.	(9) Retail
MP shock × Happening	-0.00130	0.000719	-0.00373	0.0201**	0.0249**	0.00362	0.00885	-0.00252	0.0155
	(0.00255)	(0.00407)	(0.00317)	(0.00871)	(0.0101)	(0.0172)	(0.0168)	(0.0380)	(0.0174)
Happening	0.00154**	-0.00108	0.00219**	0.00231	-0.00291**	0.0163***	-0.00336	-0.0000547	-0.00806
	(0.000739)	(0.000912)	(0.00104)	(0.00197)	(0.00146)	(0.00558)	(0.00698)	(0.00860)	(0.0134)
Mgmt Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lipper_time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0817	0.0868	0.104	0.162	0.164	0.249	0.143	0.185	0.197
Observations	1063255	552034	509031	146041	115242	29653	31187	10518	20480

Notes: The dependent variable is mutual fund net flows as a fraction of mutual fund's assets under management. MP shock $\times$ ESG is an interaction of the BRW monetary policy shock (in percent) with an ESG indicator that takes the value of 1 for mutual funds with ESG labels. Control variables are fund return, fund return volatility, fund size, fund age, fund's expense ratio and an interaction term of monetary policy and fund's return volatility. All control variables are lagged by a month. Mgmt Firm FE are fixed effects at the level of the firm that managed the mutual fund. Lipper_time FE are fixed effects at the level of the investment strategy of the mutual fund by time. The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the mutual fund level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).

Table C.2. Mutual Fund Flows - Marginal Response

	Equity			Index (equity)			Bond		
	(1) All	(2) Inst.	(3) Retail	(4) All	(5) Inst.	(6) Retail	(7) All	(8) Inst.	(9) Retail
MP × Worried	-0.00101	0.00309	-0.00527*	0.0256***	0.0310***	0.00268	-0.00853	-0.0363	0.00804
	(0.00248)	(0.00392)	(0.00309)	(0.00848)	(0.00952)	(0.0189)	(0.0153)	(0.0364)	(0.0152)
Worried	0.00121*	-0.000140	0.000632	0.000598	-0.00353**	0.0182***	-0.00577	-0.00207	-0.00994
	(0.000718)	(0.000894)	(0.00104)	(0.00183)	(0.00145)	(0.00643)	(0.00675)	(0.00922)	(0.0108)
Mgmt Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lipper_time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0817	0.0868	0.104	0.162	0.164	0.249	0.143	0.185	0.197
Observations	1063255	552034	509031	146041	115242	29653	31187	10518	20480

Notes: The dependent variable is mutual fund net flows as a fraction of mutual fund's assets under management. MP shock $\times$ ESG is an interaction of the BRW monetary policy shock (in percent) with an ESG indicator that takes the value of 1 for mutual funds with ESG labels. Control variables are fund return, fund return volatility, fund size, fund age, fund's expense ratio and an interaction term of monetary policy and fund's return volatility. All control variables are lagged by a month. Mgmt Firm FE are fixed effects at the level of the firm that managed the mutual fund. Lipper_time FE are fixed effects at the level of the investment strategy of the mutual fund by time. The regression coefficients of controls variables are not shown here for brevity. The numbers in parenthesis are standard errors, which are clustered at the mutual fund level. The asterisks denote statistical significance (*** for p < 0.01, ** for p < 0.05, * for p < 0.1).