

Green Transmission: Monetary Policy in the Age of ESG

ALBA PATOZI *

30 May 2023

[\(Click here for the latest version\)](#)

Abstract

How sensitive are green firms to monetary policy? In this paper, I evaluate the implications of firms becoming greener for the transmission of monetary policy on asset prices, credit risk and firm-level investment. In response to a shock to monetary policy, green firms (with high environmental scores) are significantly less impacted than their brown counterparts (with lower environmental scores). This difference in response cannot be attributed to inherent differences in firms' characteristics. Instead, I show that it is driven by investors' preferences for sustainable investing. Using a stylized theoretical framework and a comprehensive empirical analysis, I show how preferences for sustainable investing lower the sensitivity of green capital flows to monetary policy shocks. Consequently, this enhances the resilience of green firms to higher interest rates.

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

JEL Codes: E52, G12, G14, G30

*ap991@cam.ac.uk , Faculty of Economics, University of Cambridge. I am indebted to Tiago Cavalcanti, Giancarlo Corsetti, Vasco Carvalho, Kamiar Mohaddes and Mehrshad Motahari for extensive feedback and valuable discussions. I thank Yannis Dafermos (discussant) for the constructive feedback during the ECONDAT 2023 Conference, where my research was presented. I am also grateful to my colleagues Charles Parry, Zeina Hasna, Lidia Smitkova, Alastair Langtry and Niklas Schmitz for their invaluable support. I also benefited from helpful discussions with Charles Brendon, Chryssi Giannitsarou, Meredith Crowley, Ricardo Reis, Florin Bilbiie, Lin Peng, Hanbaek Lee, Thomas Winberry, Christian Wolf, Constantine Yannelis, Ludwig Straub, Lint Barrage and Robert F. Engle and Maarten de Ridder. I thank the participants at the ECONDAT 2023 Conference and the Cambridge Macroeconomic PhD Workshop for the helpful comments. I gratefully acknowledge the support provided by the Cambridge Endowment for Research in Finance (CERF).

1 Introduction

How sensitive are green firms to monetary policy? This question has gained significant attention in policy discussions for the following reason. Green firms, being responsible for private green investments, hold a pivotal position in expediting the transition towards a Net-Zero Economy. Given that substantial investments in technological advancements and renewable energy are susceptible to fluctuations in the cost of credit, higher interest rates may threaten these firms' efforts to decarbonise.

However, in the context of the current high interest rate environment, Isabel Schnabel from the European Central Bank pointed out that despite the large upfront costs, green firms may not be as vulnerable to higher interest rates as previously expected. Her recent speech at the Symposium for Central Bank Independence suggests only a mild impact of rising borrowing costs on the Net-Zero transition and no evidence of funding shortages on green investments (Schnabel, 2023). In this chapter, I ask: Is this observation true more generally and across time? In other words, are green firms less responsive to monetary policy shocks? And if so, what explains their sensitivity (or lack thereof).

The contributions of this paper are two-fold. First, this is the first paper to characterise how firms' sensitivity to monetary policy shocks depends on their environmental performance. Using stock market, credit risk and investment data from a sample of US publicly listed firms, firm-level environmental performance data, and an exogenous monetary policy shock series, I show that green firms are considerably less sensitive to monetary policy than their brown counterparts. Second, I show that the dampened sensitivity of green firms to monetary policy is not driven by differences in firms' fundamentals. Instead, I develop a stylized theoretical model in which investors derive a non-pecuniary benefit from holding green stocks. I argue that this preference structure gives rise to weaker responses of green firms to monetary policy shocks, and show that the predictions of the model are consistent with the data.

My sample of US publicly listed firms spans the period between 2007 to 2020. To capture the unconventional nature of monetary policy that characterised this period, I use a series

of monetary policy surprises from [Bu et al. \(2021\)](#).¹ I also collect environmental score data at the firm-level from MSCI ESG IVA Ratings, which are available at an annual frequency and span the period between 2007 to 2020.² Following a methodology proposed by [Pástor et al. \(2022\)](#), I extract the environmental performance (E) component from the ESG metrics. In the ESG framework, MSCI considers a firm to be greener if it is more resilient to both long term physical and transitional climate change risks. For example, this includes publishing a carbon sustainability report, limiting emissions of harmful pollutants or chemicals, or seeking to lower its carbon footprint.

At first glance, it is not obvious whether the process of greennification should make green firms more (or less) responsive to monetary policy changes compared to their brown counterparts. On the one hand, I document 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). Existing literature suggests that young firms paying no dividends exhibit the largest and most significant change in capital expenditure following a monetary policy shock ([Cloyne et al., 2018](#)). This is driven by the fact that these firms’ external finance is most exposed to the asset value fluctuations induced by monetary policy shocks. On the other hand, I also show that greener firms tend to be on average less leveraged, more liquid and exhibit larger distance to default compared to brown firms. In a model of heterogeneous firms, which issue long-term debt subject to fixed issuance costs, [Jeenas \(2019\)](#) 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 \(2020\)](#) 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. Given these two opposing forces, it is not clear what the relative sensitivity of green firms to monetary policy shocks should be. Without a clear prediction from theory, I proceed

¹For robustness, I also test my results against a number of other unconventional series such as the ones constructed by [Gürkaynak et al. \(2005\)](#), [Swanson \(2021\)](#) and [Rogers et al. \(2018\)](#).

²MSCI is an ESG score provider, which rates firms according to their environmental performance (E), social responsibility (S) and corporate governance (G).

by addressing this question empirically. Using panel event study regressions, I look at stock price responses around FOMC announcements dates.

I find that an unanticipated monetary policy surprise of 100 basis points leads to an average reduction in stock prices of approximately 15%. However, this effect varies considerably with firm-level greenness. In particular, stock prices of green firms are considerably less responsive to monetary policy surprises: 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%. The heterogeneous results based on firm-level greenness are robust to a battery of tests. Specifically, they are robust to: (i) using alternative interest rate surprises; and (ii) assessing firm-level greenness based on other ESG score metrics, such as Sustainalytics. Additionally, they are relatively symmetric and equally significant across contractionary and expansionary monetary policy episodes and they hold in the ZLB as well as in the post-ZLB period. Further, they are consistent with the relative effects of monetary policy on CDS spreads, whereby green CDS spreads appear less sensitive to monetary policy shocks compared to their brown counterparts. Moreover, they are also consistent with the relative response of investment for green vs. brown firms in the aftermath of a monetary policy shock, with green firms' investment reacting less strongly than that of brown firms.

In order to better understand the underlying drivers of the differential responses of green vs. brown asset prices to monetary policy shocks, I assess whether the observed heterogeneity can be explained by intrinsic differences in firm-level characteristics of green and brown firms. To do this, I double-sort firms by their greenness and other financial characteristics.³ I find that while some of these characteristics are important drivers of monetary policy heterogeneity on their own, they cannot explain the dampened sensitivity of green firms (compared to brown) to monetary policy shocks.

³I augment my baseline specification with an additional double interaction term that controls for the heterogeneous effect that monetary policy may have on leverage, liquidity, age, size, market-to-book ratio, among other things.

To rationalise the unexplained heterogeneity in firms' responses to monetary policy, I look at investors' preferences for sustainable investing. I consider a stylized theoretical framework where investors derive additional utility from their holdings of green assets. My findings reveal that when investors value green assets for non-pecuniary reasons other than risk and return, this creates an imperfect sustainability between green and brown assets. 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 attenuates the impact of changes in interest rates on green asset prices. Consequently, the type of investor that holds green firms plays a crucial role in the response of green asset prices to financial shocks.

Leveraging information from a quarterly panel on mutual funds' stock ownership, I show that green firms held by index funds with ESG mandates exhibit a lower sensitivity to monetary policy shocks compared to their brown counterparts. Furthermore, 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, risk perceptions and policy support for action against climate change is stronger; and (iii) times of heightened climate change concerns.

Additionally, the theoretical framework implies a re-weighting of the fraction of green stocks in investors' portfolios. When environmentally conscious investors demand compensation for modifying their asset holdings in response to shocks, green securities comprise a larger fraction in investors' portfolios thereafter. Using security holdings data from large US institutional investors, I find supporting evidence of a rise in the portfolio green weight in the aftermath of a monetary policy shock.

Lastly, to further explore whether preferences for sustainable investing are a key characteristic of institutional or retail investors, I examine mutual fund flow data. I find that equity index funds with ESG mandates exhibit considerably lower outflows in the aftermath of a monetary policy shock, and this effect is driven by institutional investors.

To summarise, the empirical results are consistent with the predictions of the stylized model. They 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 is related to two different strands of literature. The first focuses on the role of financial frictions for the transmission of monetary policy. The second investigates the effect of climate change on asset prices and financial markets.

The literature on monetary policy transmission 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., 2018](#); [Jeenas, 2019](#); [Ozdagli and Velikov, 2020](#)). However, there has not yet been any work on whether monetary policy affects firms differently conditional on firm-level greenness. Additionally, this literature has typically focused on the response of firm-level quantities, such as investment and employment in the aftermath of a surprise in monetary policy. As these quantities are usually available at a quarterly frequency, assessing the impact of monetary policy on these variables involves aggregating surprises around Federal Open Market Committee (FOMC) announcements to a quarterly level.⁴ Different from these papers, I use panel event study regressions based on high-frequency stock market data. The high-frequency approach is particularly useful for three reasons. First, it is free of aggregation bias.⁵ Second, endogeneity concerns are minimised with high-frequency data.⁶ Third, due to their forward-looking nature, stock prices are likely to reflect future changes in real outcomes such as investment and employment (more quickly than the vari-

⁴Three notable exceptions are [Anderson and Cesa-Bianchi \(2020\)](#), [Gürkaynak et al. \(2019\)](#) and [Lakdawala and Moreland \(2021\)](#).

⁵Lower-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. Additionally, [Gazzani et al. \(2019\)](#) and [Chudik and Georgiadis \(2022\)](#) show that such aggregation results in inconsistent estimates of aggregated impulse responses.

⁶Research shows that at lower frequencies, FOMC decisions may be influenced by stock market movements ([Rigobon and Sack, 2004](#); [D'Amico and Farka, 2011](#)).

ables themselves). The high frequency approach therefore delivers a much cleaner identification ([Anderson and Cesa-Bianchi, 2020](#)).

With respect to the second strand of the financial effects of climate change, [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 ([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, [Baker et al. \(2022\)](#) found that investors are, on average, willing to pay an additional 0.2% annually when investing in a fund with an ESG mandate. 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 alongside several robustness checks and additional results. Section 4 assesses the extent to which the observed heterogeneity is driven by differences in firm characteristics. Section 5 provides theoretical and empirical evidence in support of the investors' preferences for sustainable investing channel. 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; quarterly forecasts on future company earnings from the Institutional Brokers' Estimate System (I/B/E/S) dataset; quarterly county-level natural hazard risk data from the US Federal Emergency Management Agency (FEMA); county-level data on climate change beliefs from the Yale Climate Opinion Survey (YCOS); daily data on news about climate change by [Ardia et al. \(2020\)](#); quarterly institutional ownership data from Thomson Reuters 13F database; monthly capital flows data from the CRSP survivorship-bias free database.

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 a total of 75,931 observations.

2.1 Environmental Performance

I compute stock-level environmental scores based on MSCI ESG IVA (Intangible Value Assessment) Ratings. The MSCI dataset stands out for both the breadth of its coverage and the

depth of its analysis. MSCI ESG IVA rates and analyzes over 5,500 companies, thus covering more firms than any of its competitor ESG rating providers. 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. The availability of the disaggregated scores is exactly what I will explore to construct industry-unadjusted Environmental scores at the firm level as outlined by [Pástor et al. \(2022\)](#).

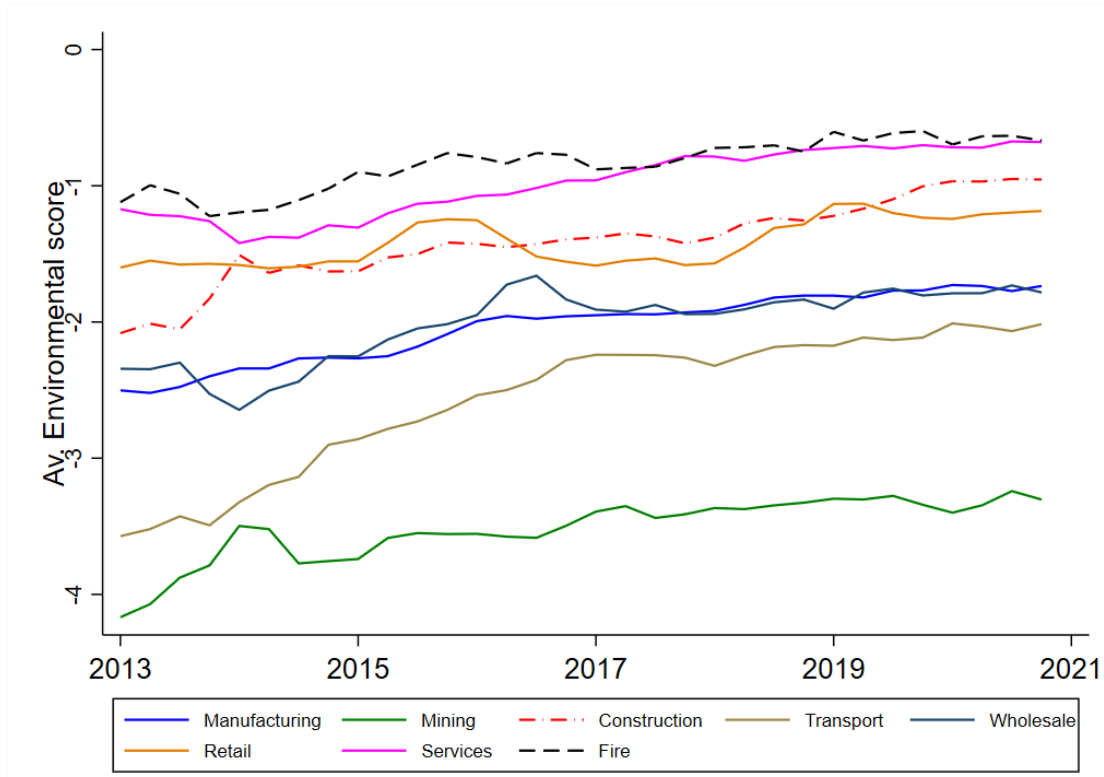
For this analysis, it is important to make use of industry-unadjusted environmental scores, because with industry adjustment, a heavy polluting (brown) firm may be classified as green simply because it pollutes less than its peers in the same industry. MSCI's granular data allows us to compute a measure of firm-level greenness score that characterises that firm irrespective of which industry the firm belongs to. Following [Pástor et al. \(2022\)](#), I start with MSCI variables 'Environmental Pillar Score' (E_score) and 'Environmental Pillar Weight' (E_weight). E_score is a number between 0 and 10, measuring a firm's weighted average score across 13 environmental issues related to climate change, natural resources, pollution and waste and environmental opportunities. The scores are designed to measure a firm's resilience to both physical and transitional long-term climate change risks. 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. To convert the industry-adjusted scores to unadjusted scores, I transform the MSCI (adjusted) environmental scores according to the following equation:

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

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.

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 [Pástor et al. \(2022\)](#).

My sample extends from January 2007 to December 2020, consistent with MSCI ESG data availability. Figure 1 details average firm unadjusted environmental scores over time on a per industry basis.⁷ Two important stylized facts emerge. First, the lowest ranked industries appear to be mining and transport and the highest ranked industries include services, financial, insurance and real estate (Fire).⁸ This pattern is quite reassuring, as it shows that the environmental ranking that emerges after the transformation laid out in equation (1), is in line with

⁷Figure 1 begins in November 2012 because MSCI's coverage increases substantially in October 2012, when MSCI began covering small U.S. stocks.

⁸Table 12 lists the top (bottom) five companies based on firm-level environmental scores for every industry.

what are generally viewed as high (low) polluting industries. The second stylized fact that Figure 1 makes apparent is the upward trend in average firm level-greenness. This upward trend is common across all major industries, thus showing that the composition of firms in the economy has changed in a way that is indicative of a larger proportion of green firms than a decade ago.

To be entirely consistent with [Pástor et al. \(2022\)](#), the environmental score I use in my analysis is:

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

where \bar{G}_t is the value-weighted average of $G_{i,t}$ across all firms i . Since I subtract \bar{G}_t , $\text{Env score}_{i,t}$ measures a company's cross-sectionally demeaned greenness score as in [Pastor et al. \(2021\)](#).⁹ If w_t and Env score_t denote the vectors containing stocks' market weights and $\text{Env score}_{i,t}$ values in period t , then:

$$w_t' \text{Env score}_t = 0, \quad (3)$$

a condition imposed by [Pastor et al. \(2021\)](#)¹⁰.

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.

⁹[Engle et al. \(2020\)](#) argue that cross-sectionally demeaning the ESG scores minimises errors arising from discontinuous breaks in ESG scores due to ESG model changes.

¹⁰I have chosen to perform this additional transformation for an exact comparison to [Pástor et al. \(2022\)](#), but this has no effect on the final results as it gets absorbed by the time fixed effects.

However, while the Kuttner surprise is really effective at capturing the monetary policy stance in the pre-GFC crisis period, it 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., 2019](#)). 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.¹¹

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.¹²

The monetary policy surprise series begins in January 2008, when the (one-year lagged) ESG data becomes available and ends in December 2020. During this time, there were 102 monetary policy surprises with a mean of approximately zero and standard deviation of approximately 5 basis points. 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.

¹¹First 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.

¹²The presence of central bank information effects may lead to instances where a contractionary monetary policy surprise drives asset prices up.

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.

2.3 Investors' Preferences and Environmental Concerns

To assess the degree to which investors with sustainable preferences can explain the dampened sensitivity of green firms to monetary policy, I leverage information from different data sources. For information on institutional and mutual fund stock ownership I use the Securities and Exchange Commission (SEC) Form 13 and the CRSP survivorship-bias-free mutual fund database.

The SEC Form 13 database contains quarterly ownership reports filed by institutions with assets under management of over \$100 million.¹³ Together, these institutions manage approximately 63% of the US market, with the remaining 37% being held by households and non-13F institutions ([Kojen and Yogo, 2015](#)). The Form 13 filings include information about the institutional investor's ownership, such as the number of shares owned, the percentage of ownership, and the class of securities held. My final sample has information on the stock ownership of 6,422 institutional investors and covers the period between January 2008 and December 2019.

The CRSP survivorship-bias-free mutual fund database 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

¹³The 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.

date. My final sample has information on 22,536 mutual funds and covers the period between January 2008 and December 2019.

Following existing literature that examines the link between asset prices and investors' environmental preferences, I account for investors' propensity for sustainable investing by employing three measures of climate concerns.¹⁴ Namely, (i) the National Risk Index from the Federal Emergency Management Agency in the US, (ii) the Media Climate Change Concern Index by [Ardia et al. \(2020\)](#) and (iii) the Yale Climate Change Opinion Survey.

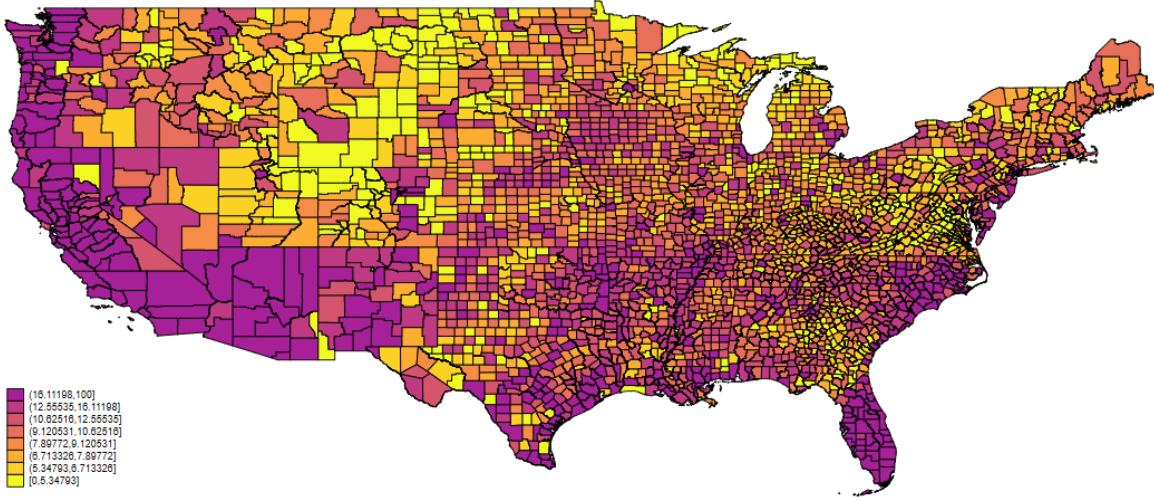
The National Risk Index (NRI) is a composite measure of natural hazard risk at the county level in the US, which combines hazard exposure, frequency and historic loss data for 18 different natural hazards with social vulnerability and community resilience data to calculate a standardized risk value for every U.S. county.¹⁵ The NRI is publicly available and its granularity is quite useful for our analysis as it helps identify those counties which are particularly vulnerable to natural disaster risk. I think of NRI as a proxy 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).

While I acknowledge that not all of the natural disasters encompassed by the National Risk Index are climate change related disasters, I use this measure as a first-pass to controlling for county-level heterogeneities that might be related to climate change. Figure 2 shows considerable variation across counties in their exposure to natural disaster risk.

¹⁴A non-exhaustive list includes [Pástor et al. \(2022\)](#); [Baldauf et al. \(2020\)](#); [Engle et al. \(2020\)](#); [Correa et al. \(2020\)](#).

¹⁵The 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.

Figure 2. National Risk Index



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

The Media Climate Change Concerns (MCCC) Index by [Ardia et al. \(2020\)](#) is a daily index of news about climate change published by major U.S. newspapers and newswires.¹⁶ 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 [Pástor 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. Let $MCCC_t$ denote the daily MCCC index. I define the level of climate concerns at the end of day t as:

$$MCCC_t^{cumulative} = \sum_{\tau=0}^T \rho^{\tau} MCCC_{t-\tau} \quad (4)$$

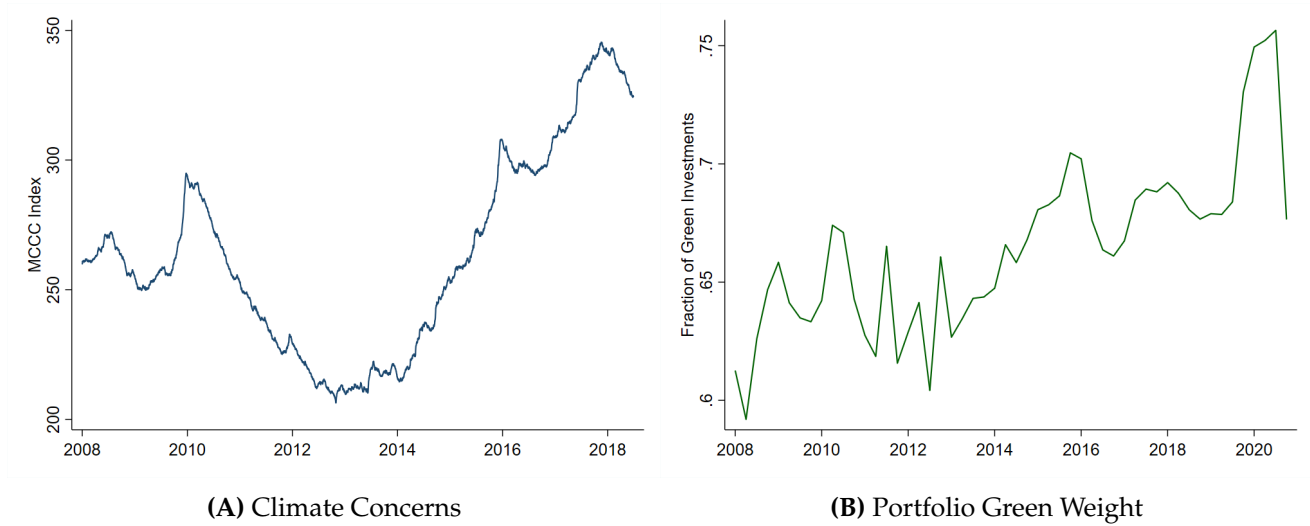
where ρ measures how long climate change news persists in investors' memories. I set the half-life of news stories to one year, which implies $\rho = 0.9981$.¹⁷ T is set to 36 months (1095

¹⁶These include the Los Angeles Times, New York Times, Wall Street Journal, and USA Today, and two major newswires: Associated Press Newswires and Reuters News.

¹⁷I 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 .

days) following [Pástor et al. \(2022\)](#). Panel A of Figure 3 plots the time series of these concerns, which have increased significantly since 2013.

Figure 3. Media Climate Change Concern Index vis-à-vis the Green Portfolio Weight

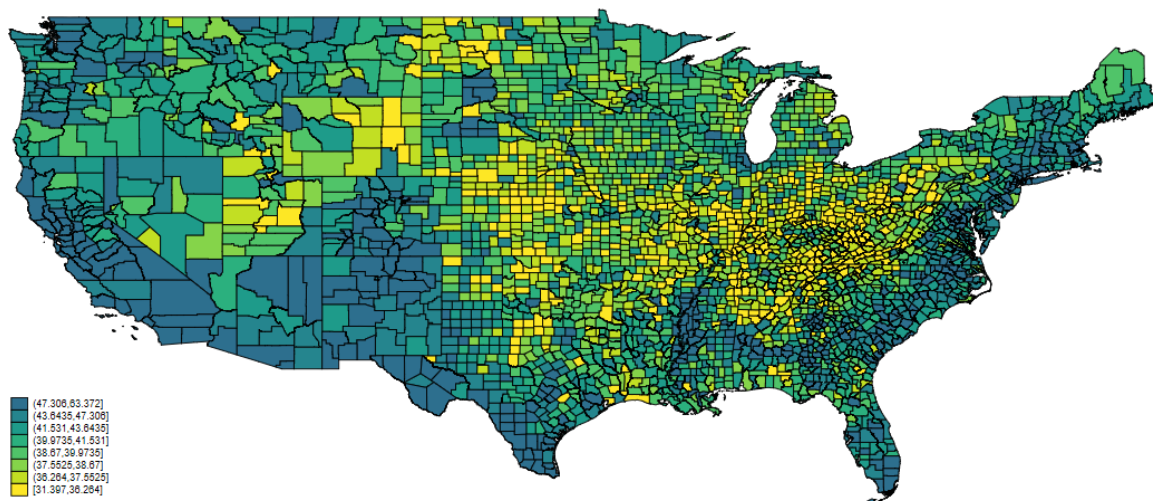


Notes: Panel A depicts the Cumulative Media Climate Change Concerns Index by [Ardia et al. \(2020\)](#), constructed using a distributed lag model as defined in equation (4). Panel B graphs the cross-sectional average of institutional investors' fraction of green security holdings over time, constructed using institutional ownership data from Thomson Reuters 13F database.

Additionally, to assess the degree to which investors' preferences play a role in the transmission of monetary policy, I use institutional ownership data from the Securities and Exchange Commission (SEC) Form 13 Database. I merge the 13F investors' holding data with the security-level greenness scores I constructed in Section 2.1. I then split the sample of securities data into two groups, based on where each security lies in the greenness distribution. Specifically, I define a dummy variable: $g_{i,t}^{high}$, which equals 1 when the greenness score of firm i lies above the median of the greenness score distribution (and zero otherwise). I then compute for every institutional investor j the weight of green securities held in their portfolio at each point in time. In other words, I look at the fraction of total investments by market value that is associated with green securities. Panel B of Figure 3 presents the cross-sectional average of this fraction over time. It shows a clear upward trend in sustainable investing over the past decade, which is consistent with the intensified level of climate change concerns in Panel A.

The Yale Climate Change Opinion Survey (2021) is a public opinion survey that aims to estimate how climate change beliefs, risk perceptions, and policy support vary widely depending on where people live. One of the benefits of using this dataset is its geographic high resolution, which provides us with climate change beliefs' data at the county level. I look at a group of variables.¹⁸ Figure 4 maps the degree to which the respondents of the Yale Climate Opinion Survey (YCOS) believe to be 'personally' affected by climate change.¹⁹

Figure 4. Climate Change Beliefs



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

2.4 Firm-Level 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 data set. 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

¹⁸These variables include whether respondents (i) believe climate change is happening; (ii) are worried about climate change; (iii) support setting strict limits on CO₂ among others. It is worth mentioning that all of these variables are highly correlated with each other.

¹⁹This 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".

comprises of Compustat firms, whose environmental performance is covered by MSCI ESG IVA Ratings and spans the time period from 1 January 2007 to 31 December 2019. This gives a total of 1361 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.

In addition to stock returns, I also collect data on CDS spreads at the firm level. This data comes from IHS Markit and covers 313 firms during the period of 2008 - 2020. The main variables of interest are conventional CDS spreads and the implied probability of default (for the underlying bond). 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.

The standard balance sheet items, explained in detail in Table A.1, come from the Compustat database. In line with previous research on monetary policy transmission and firm heterogeneity, I control for differences in financial constraints across firms (Ottonello and Winberry, 2020; Cloyne et al., 2018; Anderson and Cesa-Bianchi, 2020; Chava and Hsu, 2020). Hence I compute size, book leverage, distance to default and age, which proxy for financial constraints. Size is constructed as the logarithm of total assets and deflated by the implicit price deflator. Book leverage is computed as the ratio of total debts to total assets. Distance to default follows Gilchrist and Zakrajšek (2012). Age represents the period since incorporation of a firm into the CRSP database. Consistent with research on firm balance sheet heterogeneity and monetary policy shocks, I also account for differences in firm profitability, cash holdings (liquidity), market-to-book ratio (growth vs. value stocks), asset maturity, retained earnings, short term and long term debt and dividends per share (Cloyne et al., 2018; Gürkaynak et al., 2019; Ippolito et al., 2018; Lakdawala and Moreland, 2021).

Additionally, following research that suggests that socially responsible firms commit to a higher standard of transparency and provide more financial disclosure, I proceed by computing a measure of financial transparency (Kim et al., 2014). In order to obtain a measure of

financial transparency, 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. \(2022\)](#), under the assumption that more transparent firms have fewer disagreements among financial analysts, I define firm financial transparency as:

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

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

3 Monetary Policy and Green Firms

In this section, I test the joint hypothesis that monetary policy affects green firms differently from their brown counterparts 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 and investment data. Third, I report a battery of robustness tests, where I make use of an alternative measure of firm level greenness and/or alternative measures of monetary policy shocks.

3.1 Empirical Design

I proceed by employing panel event-study regressions based on high-frequency data. The high-frequency approach is particularly useful for my analysis for two reasons. First, it is free of aggregation bias.²⁰ Second, unlike at lower frequencies where FOMC decisions may be influenced by stock market movements, no such endogeneity concerns exist with daily data

²⁰Lower-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. Additionally, [Gazzani et al. \(2019\)](#) and [Chudik and Georgiadis \(2022\)](#) show that such aggregation results in inconsistent estimates of aggregated impulse responses.

(Rigobon and Sack, 2004; D’Amico and Farka, 2011). The model I estimate is:

$$\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \Gamma' Z_{i,t-1} + e_{i,t} \quad (6)$$

where i indexes firm, s indexes major economic sectors and t indexes the FOMC announcements. $\Delta p_{i,t}$ denotes the percentage change in the stock price of firm i at time t (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. \(2019\)](#) 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 (6) 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_{st} 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 standard errors at the time level to account for correlation of error terms within an FOMC event.²¹

²¹Results 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.

3.2 Results

Table 2 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. Overall, I find strong and robust evidence that an increase in environmental performance dampens the effect that monetary policy has on stock prices.

Table 2. 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*** (3.999)	-16.31*** (4.013)		
MP shock \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)		3.091*** (1.069)	3.500*** (0.946)	2.975*** (0.867)
Env. score ($g_{i,t-1}$)		-0.0427 (0.0637)	-0.0123 (0.0457)	0.0109 (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 2019. 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 $p < 0.1$).

One concern is that the results in Table 2 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 than their brown counterparts.²² 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 3 show that the differential response of green firms compared to their brown counterparts is not just a transitional adjustment in prices, but this effect is rather persistent for up to 10 days after the FOMC announcement.

Table 4 presents the regression results without imposing linearity in the interaction of monetary policy and firms' environmental performance. Here I estimate equation (6) 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. \(2018\)](#) 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 4. Quintile 1 refers to firms whose environmental 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 4 make it clear that stock prices of green firms are considerably less responsive to monetary policy surprises: following a 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%.

²²Table 11 provides summary statistics on the differences in financial characteristics between green and brown firms.

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 5 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 of contractionary monetary policy innovations.²³

²³Results are quantitatively and qualitatively unchanged when considering a value-weighted Green-minus-Brown portfolio.

Table 3. Cumulative Returns

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	$\Delta_0 p_{i,t}$	$\Delta_1 p_{i,t}$	$\Delta_2 p_{i,t}$	$\Delta_3 p_{i,t}$	$\Delta_4 p_{i,t}$	$\Delta_5 p_{i,t}$	$\Delta_6 p_{i,t}$	$\Delta_7 p_{i,t}$	$\Delta_8 p_{i,t}$	$\Delta_9 p_{i,t}$	$\Delta_{10} p_{i,t}$
MP shock \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	1.926*** (0.581)	2.975*** (0.867)	1.993** (0.891)	1.603 (1.070)	1.474 (1.052)	1.641 (1.049)	1.940* (1.124)	2.029 (1.410)	2.244* (1.278)	1.968 (1.327)	1.857 (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 4. 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*** (4.409)	-19.44*** (4.598)	-16.25*** (4.097)	-13.98*** (3.851)	-11.17*** (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 $p < 0.1$).

Table 5. 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*** (3.466)	-14.61*** (3.751)	-11.02*** (3.592)	-8.725** (3.450)	-5.965* (3.155)	9.906*** (1.977)
mktrf	0.612*** (0.193)	0.786*** (0.184)	0.868*** (0.198)	0.863*** (0.210)	0.818*** (0.181)	0.206* (0.112)
smb	0.930** (0.454)	0.887* (0.455)	0.755* (0.408)	0.638 (0.414)	0.462 (0.337)	-0.469** (0.181)
hml	0.307 (0.484)	0.193 (0.494)	0.0827 (0.462)	0.128 (0.481)	-0.0494 (0.427)	-0.356*** (0.131)
rmw	0.426 (0.554)	0.602 (0.554)	0.782 (0.564)	0.723 (0.584)	0.611 (0.489)	0.184 (0.262)
cma	0.976 (0.685)	1.088 (0.767)	0.962 (0.710)	0.666 (0.702)	0.286 (0.628)	-0.689* (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 $p < 0.1$).

3.3 Robustness of the Baseline Results

Alternative interest rate surprises. The first set of additional results contains a number of robustness checks of the baseline result reported in Table 2. Table 6 shows that the heterogeneity identified in the baseline results is robust to using alternative interest rate surprises. Columns (2) to (6) of Table 6 report the coefficient estimates from specification (6), 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.

Table 6. 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 \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.209*** (0.506)	3.272** (1.317)	0.824*** (0.278)	2.565* (1.392)	0.867** (0.352)	2.395*** (0.898)	2.776*** (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. The second set of results contains robustness checks regarding the firm-level greenness measure by investigating other metrics of environmental performance. Table 7 reports the results obtained from running specification (6) 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 Pástor

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.²⁴ The interaction coefficient (measuring the relative responsiveness of low polluting firms relative to high polluting firms) is still positive and significant.

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 7 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 A.4 in the Appendix shows that the heterogeneous impact of monetary policy on firm-level returns is only the case for firms with high environmental scores, but does not arise in the case of firms with higher social responsibility or corporate governance scores. These results lend additional support to the idea that firm-level environmental performance plays a significant role in the transmission of monetary policy.

²⁴Here I have applied the same greenness score construction methodology that was proposed by Pástor 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.

Additional analysis of the data. The third set of results includes some additional analysis of the data. First, Columns (2) and (3) in Table 8 show that the heterogeneous response of green vs. brown firms to monetary policy shocks is relatively symmetric across episodes of expansionary and contractionary monetary policy shocks.²⁵ 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.

Table 7. 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 \times Env. score ($\epsilon_t^m \times g_{i,t-1}$)	2.975*** (0.867)	2.726*** (0.779)	2.960*** (1.026)	0.832* (0.440)	1.092** (0.548)	1.692*** (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 $p < 0.1$).

²⁵Removing 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%.

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 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.²⁶

Second, Table 9 performs a falsification test in line with [Gürkaynak et al. \(2019\)](#), 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.

Table 8. Robustness: Additional analysis of the data

	(1) Baseline	(2) Contractionary	(3) Expansionary	(4) Post- GFC	(5) ZLB	(6) Post ZLB
MP shock \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.975*** (0.867)	2.778* (1.539)	- 4.615* (2.375)	2.566*** (0.899)	1.555** (0.681)	4.846** (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 $p < 0.1$).

²⁶Removing 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.

Table 9. Robustness: Falsification Test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$\tau - 1$	$\tau - 2$	$\tau - 3$	$\tau - 4$	$\tau - 5$	$\tau - 6$	$\tau - 7$	$\tau - 8$	$\tau - 9$	$\tau - 10$
MP shock \times Env. score ($\epsilon_t^m \times g_{i,t-1}$)	1.521** (0.707)	0.716 (0.777)	-0.640 (0.637)	-1.533** (0.711)	-0.226 (0.663)	0.473 (0.567)	0.446 (0.695)	0.161 (0.642)	-0.784 (0.863)	-0.981 (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 $p < 0.1$).

3.4 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. I consider the following event study specification:

$$\Delta CDS_{i,t} = \alpha_i + \beta_1(g_{i,t-1}^{high} \times \epsilon_t^m) + \beta_2(g_{i,t-1}^{low} \times \epsilon_t^m) + \delta_1 g_{i,t-1}^{high} + \delta_2 g_{i,t-1}^{low} + \Phi' Z_{i,t-1} + e_{i,t} \quad (7)$$

where $\Delta CDS_{i,t}$ denotes the change in the CDS spread of firm i at time t (difference of the CDS spread the day before and the day after an FOMC announcement, in basis points), ϵ_t^m is a monetary policy shock. $g_{i,t-1}^{high}$ and $g_{i,t-1}^{low}$ are two dummy variables. Specifically, $g_{i,t-1}^{high}$ equals 1 when the environmental score of firm i lies above the median of the greenness distribution in the year proceeding the monetary policy surprise (and zero otherwise), and $g_{i,t-1}^{low}$ equals 1 when the environmental score of firm i lies below the median of the greenness distribution (and zero otherwise). $Z_{i,t-1}$ is a vector of controls that include size, profitability, book lever-

age, 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 column (2) of Table 10. They show that CDS spreads rise in response to contractionary monetary policy shocks. This is because an interest rate rise reduces a firm's net present value, which increases its likelihood of default. However, the response of CDS spreads for green firms is smaller compared to the response in CDS spreads for their brown counterparts. In particular, a monetary policy surprise of 100 basis points increases CDS spreads by around 16 basis points in the case of green firms and 27 basis points in the case of brown firms. Analogously, column (4) shows that in the aftermath of a monetary policy surprise of 100 basis points the implied probability of default for green firms increases to a lesser extent than for brown firms.

Table 10. 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** (9.350)		1.692** (0.734)	
MP shock \times Green ($\varepsilon_t^m \times g_{i,t-1}^{high}$)		16.21* (8.716)		1.403* (0.721)
MP shock \times Brown ($\varepsilon_t^m \times g_{i,t-1}^{low}$)		26.62** (10.39)		1.982** (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 (3) and (4) 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 $p < 0.1$).

3.5 Real Effects of Monetary Policy

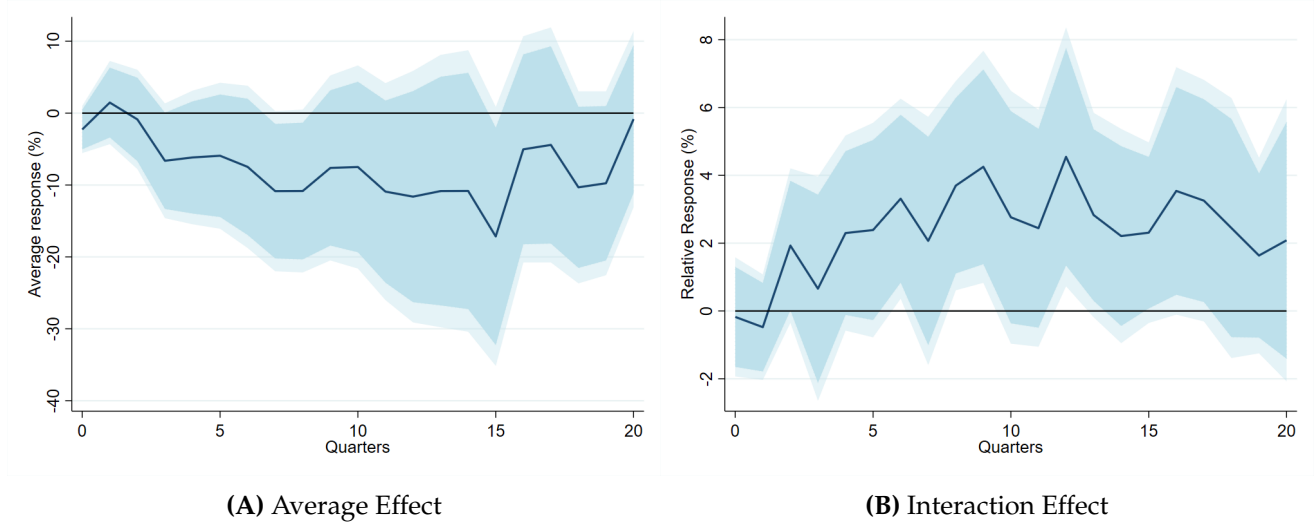
So far, I have only focused on the short-term reaction of stock market outcomes to monetary policy surprises. This is because the high frequency approach allows for a more credible identification of the impact of monetary policy on firm-level outcomes, as well as a more precise estimation of its effects ([Anderson and Cesa-Bianchi, 2020](#)). However, the impact of monetary policy on equity prices and CDS spreads documented so far could be reflecting a temporary adjustment in asset prices. It could also be that the identified monetary policy surprises are 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.

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:

$$\Delta_h \log k_{i,t} = \alpha_i^h + \alpha_{s,t}^h + \beta^h (\varepsilon_t^m \times g_{i,t-1}) + \delta^h g_{i,t-1} + \Gamma'^h Z_{i,t-1} + e_{i,t,h} \quad (8)$$

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 $h = 0, 2, \dots, 10$), α_j^h are firm FE, $\alpha_{s,t}^h$ are sector-by-time FE, ε_t^m and 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.

Figure 5. Impulse Response Function of Investment



Notes: In line with local projection methods, each horizon is estimated separately. The dependent variable is $\Delta \log k_{i,t+h}$, 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 blue shaded areas denote the 95% and 90% confidence intervals around point estimates constructed with standard errors clustered at the time level.

Panel (B) in Figure 5 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. Panel (A) estimates a dynamic version of the specification in (8) 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 1 percentage point.

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.

4 Characteristics of Green and Brown Firms

In this section, I test the hypothesis that monetary policy affects green firms differently from their brown counterparts because of intrinsic differences in firm-level financial characteristics. Table 11 provides the summary statistics for different financial variables conditional on firm level greenness. Green (brown) firms are thought to be those whose environmental score falls in the top (bottom) quintile of the firm level greenness distribution. Table 11 shows that green firms are on average smaller, younger, less leveraged, more liquid and less riskier than their brown counterparts. Existing literature looks at how these firm characteristics may amplify or dampen the investment channel of monetary policy.

For instance, [Cloyne et al. \(2018\)](#) provides evidence 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 mostly exposed to the asset value fluctuations induced by monetary policy shocks. [Jeenas \(2019\)](#), on the other hand, assesses the role of firms' liquidity management in the transmission of monetary policy.

In a model of heterogeneous firms, which issue long-term debt subject to fixed issuance costs, [Jeenas \(2019\)](#) argues that a firm's liquid assets are a good predictor of lower future likelihood of debt issuance and insensitivity to borrowing rates. Thus, in response to a contractionary monetary policy shock, firms with more liquid assets reduce investment less relative to others. Additionally, [Ottonello and Winberry \(2020\)](#) find that investment of firms with low default risk and debt burdens, as measured by firm's leverage and 'distance to default' are the most responsive to monetary policy shocks. This is because these firms face a flatter marginal cost curve for financing investment.

To investigate whether the differential sensitivity of green firms to monetary policy surprises is the result of any of the firm characteristics outlined above, I augment equation (6) with an additional term:

$$\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \gamma(\varepsilon_t^m \times c_{i,t-1}) + \Gamma' Z_{i,t-1} + e_{i,t} \quad (9)$$

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 11. 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 12 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 12 reports the results from specification (9), i.e. the specification including sector-time fixed effects, firm-level controls and a single interaction based on firm-level greenness score. Columns (2) to (9) report the results from specification (9), 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.²⁷

Results in Table 12 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 the effect of other firm-level characteristics. 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. (2018), results in column (4) show that younger firms are less responsive to monetary policy shocks. Similar to Anderson and Cesa-Bianchi (2020), but in contrast to Ottonello and Winberry (2020), I find that distance to default dampens a firm's sensitivity to monetary policy shocks.

²⁷See Appendix A for a detailed description on how these variables were computed.

Following research that suggests that socially responsible firms commit to a higher standard of transparency and provide more financial disclosure, I also investigate whether the differential response to monetary policy shocks is driven by differences in valuation uncertainty across green versus brown firms. Column (9) of Table 12 presents the results from the inclusion of the double interaction term, $\varepsilon_t^m \times 1/\text{std.}(\text{EPS})$.²⁸ The coefficients before this terms in column (9) suggest 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. In addition to the double interaction terms shown in Table 12, I have also double sorted firms according to their firm-level greenness, cyclicalities (defined as correlation of sales growth with GDP growth), long term debt ratio and retained-earnings. The baseline result remains largely unchanged, suggesting that the heterogeneous effect of monetary policy conditional on firm-level greenness is not explained by intrinsic differences in financial characteristics between green and brown firms.

²⁸Section 2 describes how previous research has used this variable as a proxy for firm financial transparency.

Table 11. 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. performance	-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 $p < 0.1$.

Table 12. 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 \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.975*** (0.867)	2.972*** (0.868)	2.864*** (0.861)	3.152*** (0.872)	2.567*** (0.806)	2.980*** (0.819)	2.877*** (0.851)	2.977*** (0.866)	3.051*** (0.935)	3.002*** (0.868)	2.797*** (0.746)	2.692*** (0.771)
MP shock \times Leverage ($\varepsilon_t^m \times c_{i,t-1}$)		-2.670 (5.035)										0.735 (4.819)
MP shock \times Size ($\varepsilon_t^m \times c_{i,t-1}$)			1.433 (0.894)									0.705 (0.736)
MP shock \times Age ($\varepsilon_t^m \times c_{i,t-1}$)				1.698*** (0.603)								1.009** (0.419)
MP shock \times D2default ($\varepsilon_t^m \times c_{i,t-1}$)					3.593*** (1.208)							3.185*** (0.913)
MP shock \times Liquidity ($\varepsilon_t^m \times c_{i,t-1}$)						-0.0356 (0.783)						0.159 (0.553)
MP shock \times Profitability ($\varepsilon_t^m \times c_{i,t-1}$)							3.774** (1.796)					1.112 (1.604)
MP shock \times Short-term debt ($\varepsilon_t^m \times c_{i,t-1}$)								0.980 (0.630)				1.717** (0.662)
MP shock \times Transparency ($\varepsilon_t^m \times c_{i,t-1}$)									1.880*** (0.561)			1.315** (0.506)
MP shock \times Dividends ($\varepsilon_t^m \times c_{i,t-1}$)										1.789 (1.150)		-0.168 (0.664)
MP shock \times Market-to-Book ($\varepsilon_t^m \times c_{i,t-1}$)											1.667 (1.872)	0.0121 (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 2019. 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, asset maturity, 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 $p < 0.1$.

5 Investors' Green Preferences

In this section, I assess whether the dampened sensitivity of green firms to monetary policy shocks can be explained by developments in investors' preferences for sustainable investing. 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 require compensation for changing their asset holdings in response to shocks.

Accounting for investors' preferences for sustainable investing in a simple stylized model can help justify the differential response of green vs. brown equity prices to monetary policy shocks. Section 5.1 illustrates how incorporating green preferences in investors' utility function can have three important implications: (i) the semi-elasticity of equity prices to interest rates is lower for green firms compared to their brown counterparts; (ii) the differential response of green-vs-brown firms to interest rates gets 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.

5.1 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 y in period one and receives no income in period two. The household 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:

$$\max_{c_t, b_1, s_{G,1}, s_{B,1}} E_1 \left(\sum_{t=1}^2 \beta^{t-1} (u(c_t) + f(s_{G,1})) \right), \text{ subject to,}$$

$$c_1 + b_1 + q_{G,1}s_{G,1} + q_{B,1}s_{B,1} \leq y \text{ in period one,} \quad (10)$$

$$c_2 \leq (1+r)b_1 + \pi_G s_{G,1} + \pi_B s_{B,1} \text{ in period two.} \quad (11)$$

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

$$q_{B,1} = \frac{\pi_B}{1+r}; \quad q_{G,1} = \frac{\pi_G}{1+r} + \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \quad (12)$$

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:

$$q_{B,1}^* = \frac{\pi_B}{1+r}, \quad q_{G,1}^* = \frac{\pi_G}{1+r} + \frac{\alpha}{1+\alpha} y \quad (13)$$

These expressions show that investors do not value green stocks purely for their pecuniary benefit (i.e. the discounted present value of future payoff), but also because they derive an additional utility from their holdings of green assets. In contrast to green securities, brown

assets are only valued for their pecuniary benefit (i.e. price of brown securities is equivalent to the discounted present value of their future payoffs).

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 (13), I provide the theoretical analogue to my empirical specification in Section 3.1. In line with the empirical design, I next differentiate these log expressions with respect to the real interest rate (which proxies for the unanticipated monetary policy shock in Section 3.1). This derivation allows us to compare the semi-elasticity of green-vs-brown asset prices with respect to real interest rates.

5.2 Theoretical Predictions

PROPOSITION 1: *Green security prices have a lower semi-elasticity with respect to monetary policy shocks, given $\alpha > 0$.*²⁹

$$\left| \frac{d \ln(q_{G,1}^*)}{dr} \right| < \left| \frac{d \ln(q_{B,1}^*)}{dr} \right| \quad (14)$$

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, this then leads to an attenuated effect on the semi-elasticity of green stocks with respect to interest rates.

²⁹ $\left| \frac{d \ln(q_{B,1})}{dr} \right| = \frac{1}{1+r}$; $\left| \frac{d \ln(q_{G,1})}{dr} \right| = \frac{1}{1+r} - \frac{(q_{G,1}^* - q_{B,1}^*)}{q_{G,1}^*} \frac{1}{1+r}$, assuming $\pi_B = \pi_G$. The differential response in the semi-elasticities of green-vs-brown stocks is: $\left(\left| \frac{d \ln(q_{G,1})}{dr} \right| - \left| \frac{d \ln(q_{B,1})}{dr} \right| \right) = -\frac{\frac{\alpha}{1+\alpha} y}{\frac{\pi_G}{1+r} + \frac{\alpha}{1+\alpha} y} \frac{1}{1+r} < 0$

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 (i.e. as the interest rate increases, investors substitute away from equities and towards bonds). The non-pecuniary force, which is only present in the case of green stocks, dampens the first force because investors derive an additional utility from holding green assets.

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

$$\frac{d\left(\left|\frac{d\ln(q_{G,1}^*)}{dr}\right| - \left|\frac{d\ln(q_{B,1}^*)}{dr}\right|\right)}{d\alpha} < 0 \quad (15)$$

Corollary 1 is the result of differentiating the difference in the semi-elasticities of green vs. brown asset prices in equation (14) with respect to the sustainable preference parameter α . Equation (15) 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.

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. $s_{G,1}^* = s_{B,1}^* = 1$).

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

$$\frac{d\ln(w_{G,1})}{dr} > 0 \quad (16)$$

An implication of Proposition 1 is that the relative weight of green stocks compared to their brown counterparts increases in the aftermath of a monetary policy shock. This is because a contractionary monetary policy shock depresses the valuation of green stocks to a lesser extent than that of brown stocks. Therefore, in relative terms the (log) prices of green securities

react less to monetary policy shocks than (log) prices of brown securities. This has the effect of increasing the share of investors' portfolio that consists of green securities.

6 Empirical Evidence: The Impact of Preferences for Sustainable Investing

This section provides an empirical analysis on whether the dampened sensitivity of green firms to monetary policy is the result of investors preferences for sustainable investing. Results confirm the theoretical predictions outlined in the previous section, highlighting the role of institutional ownership in the transmission of shocks in financial markets.

6.1 Evidence from Index Funds with ESG Mandates

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. Typically, index funds with ESG mandates construct their portfolios by selecting investments that meet their specific ESG criteria. As such, they form a perfect 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 \(2021\)](#).³⁰ 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.³¹ 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.

³⁰The considered keywords are: Environment, social, governance, green, sustainable, responsible, SRI, ESG, climate, clean, carbon, impact, fair, gender, solar, renewable, ethical, thematic, and conscious.

³¹My dataset consists of 3,156 index funds, which are managed by 228 distinct companies. Among these funds, 121 of them incorporate an ESG keyword in their name, and they are managed by 37 investment companies.

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

$$\text{ESG fund fraction}_{i,t} = \sum_{m \in \Omega(i)} \tilde{w}_{i,m,t} \times \text{ESG}_{m,t} \quad (17)$$

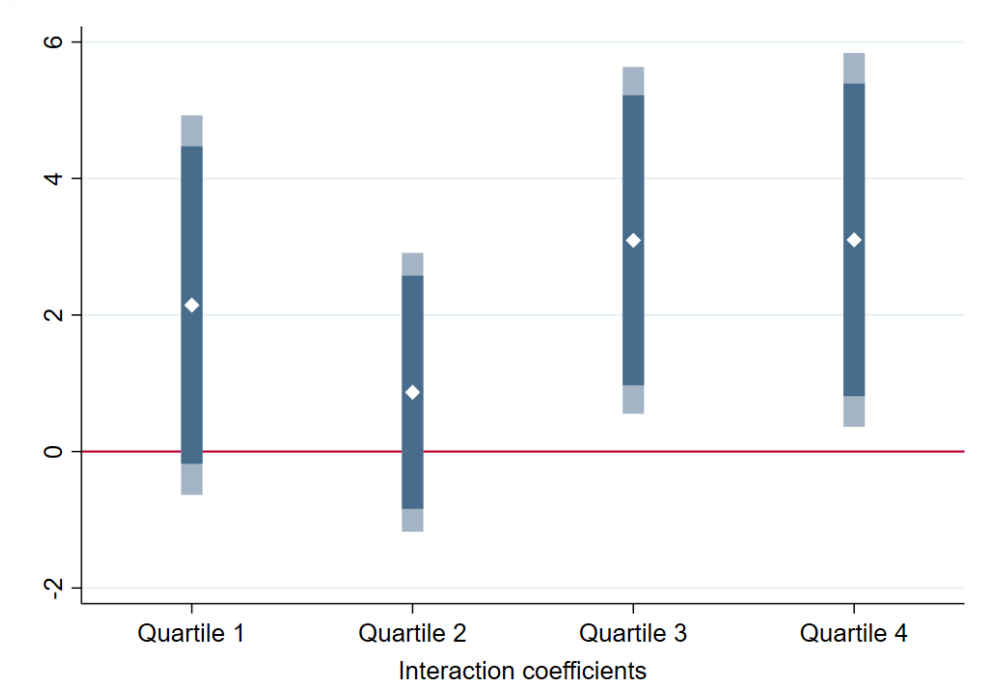
where $\Omega(i)$ denotes the set of index funds that hold firm i in their portfolio and $\text{ESG}_{m,t}$ is an indicator that takes a value of one for index funds with an ESG mandate and zero otherwise.

As a last step, I split the distribution of firms into four different bins based on the fraction of the firm held by ESG mandated funds (i.e. $\text{ESG fund fraction}_{i,t}$ in equation (17)). 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 before the monetary policy shock. Quartile 1 refers to securities that a quarter before the monetary policy shock were held by investors with a preference for browner firms. Quartile 4 refers to securities that a quarter before the monetary policy shock were held predominantly in ESG-mandated funds. I proceed by estimating the baseline specification in equation (6) for the four different bins of investor types.

Figure 6 plots the beta coefficients before the interaction term of firm-level greenness with monetary policy shocks for four different bins of the ESG fund fraction distribution. Greener firms are less sensitive to monetary policy when they are held by investors with ESG mandates. 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 is only observed for firms held by environmentally conscious investors (Quartiles 4 and 5). In a similar vein, Appendix C.1 looks at a larger group of institutional investors and confirms that the differential sensitivity of green firms to monetary

policy can be explained by the type of institutional investor who holds the firm.³² To summarise, these results confirm the theoretical predictions implied by Proposition 1 in Section 5.1. They show that the differential response of green firms (compared to brown) to monetary policy can be explained by investors' preferences for sustainable investing.

Figure 6. 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 index funds with ESG mandates. Quartile 1 refers to securities that are held by investors with 'brown' preferences, as of a quarter before the monetary policy shock. Quartile 5 refers to securities that were held by 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.

6.2 Evidence from Green Portfolio Weights of Institutional Investors

Next, I look at how the green weight in institutional investors' portfolio changes in the aftermath of monetary policy. One of the predictions of the stylized theoretical framework

³² Appendix C.1 runs a similar exercise to the one shown in Figure 6 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.

in Section 5.2 is that this weight must increase 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 monetary policy shocks. To assess the empirical validity of this prediction, here I utilise data from institutional stock ownerships and employ the following specification:

$$\Delta_h w_{j,t}^G = \alpha_j^h + \beta^h \epsilon_t^m + \delta t + e_{j,t+h} \quad (18)$$

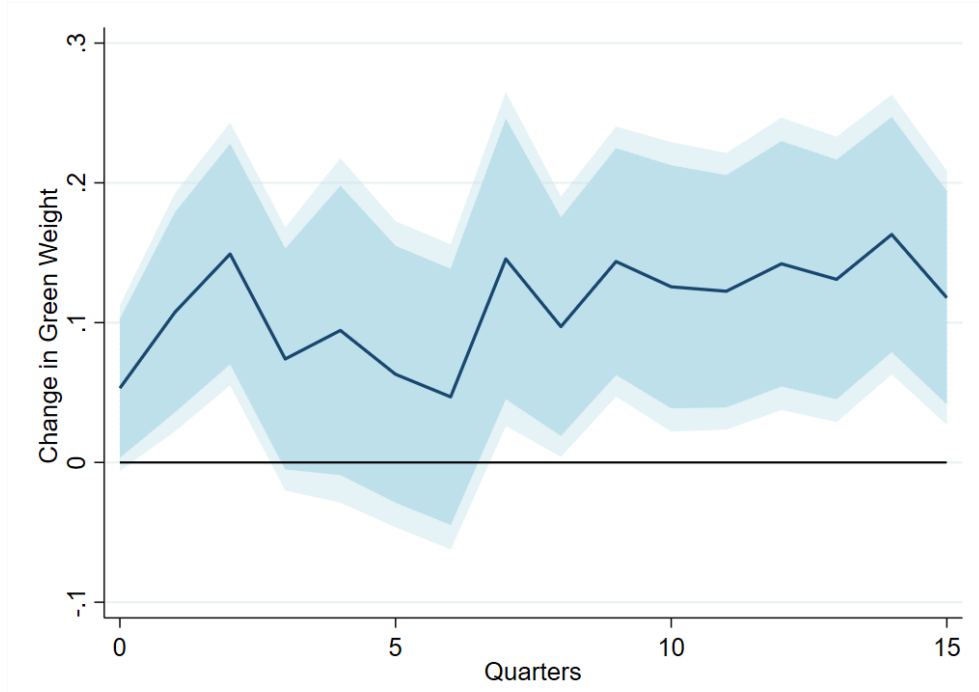
where $\Delta_h w_{j,t} \equiv \text{Green weight}_{j,t+h} - \text{Green weight}_{j,t-1}$. $\text{Green weight}_{j,t}$ denotes the proportion of securities held by institutional investor j with a greenness score above the median of the environmental score distribution.³³ ϵ_t^m is the monetary policy surprise by Bu et al. (2021), t is a linear time trend, α_j^h is a fixed effect that captures time-invariant characteristics at the institutional investors' level and h denotes the estimation horizon, with $h = 0, 1, 2, \dots, H$. The coefficient of interest β^h measures the change in the green portfolio weight held by an average institutional investor in response to a monetary policy surprise of 100 basis points. The resulting impulse response captured by coefficient β^h is reported in Figure 7.

Figure 7 shows that in the face of contractionary monetary policy surprises, institutional investors respond by increasing the fraction of green assets held in their portfolio by 6 percentage points. This response is statistically significant on impact, pointing to a sizeable portfolio rebalancing effect. Similarly, Appendix 10 shows that this effect is quantitatively and qualitatively very similar when considering different types of institutional investors.

To summarise, these results confirm the theoretical predictions implied by Corollary 2 detailed in Section 5.1. They show that the differential sensitivity of green firms (compared to brown) to monetary policy is driven by investors' preferences for sustainable investing.

³³Here, a security is considered 'green' if its environmental performance score falls above the median of the environmental score distribution in the *previous* year.

Figure 7. Impulse Response Function of Green Portfolio Weight



Notes: In line with local projection methods, each horizon is estimated separately. The blue solid line represents the $\{\beta^h\}_{h=0}^{20}$ estimates in percent. The dependent variable is $\Delta_h \log(\text{Green weight}_{j,t})$, over the horizons considered. The independent variable is ε_t^m . The light and dark blue shaded areas denote the 90% and 95% confidence intervals around point estimates constructed with standard errors clustered at the time level.

6.3 Geographical and Temporal Variation in Preferences for Sustainable Investing

In this subsection, I run a series of triple interaction terms to test whether the differential response of green asset prices (compared to brown) gets amplified in states of the world with stronger preferences for sustainable investing. That is, I augment the baseline specification (6) with a triple interaction term:

$$\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\varepsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \gamma(\varepsilon_t^m \times g_{i,t-1} \times s_{i,t-1}) + \Gamma' Z_{i,t-1} + e_{i,t} \quad (19)$$

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

monetary surprises and firm-level greenness. To construct $s_{i,t}$, I combine information from firm i 's mutual funds investors' holdings from CRSP with climate change concerns measures at the county level. I restrict my attention to those 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 , $s_{i,t}$ is then given by:

$$s_{i,t} = \sum_{j \in \Gamma(i)} \tilde{w}_{i,j,t} \times \text{Investor Sustainable Preference}_j \quad (20)$$

where $\Gamma(i)$ denotes the set of index fund investors that hold firm i in their portfolio and the $\text{Investor Sustainable Preference}_j$ 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.³⁴ Variable $s_{i,t}$ therefore represents a weighted average of investors' green preferences at the firm level.

First, I consider the the natural risk index (NRI), which measures exposure to natural disaster risk based on the county where mutual fund j is located at.³⁵ The coefficient before the triple interaction term, MP shock \times Env. Score \times NRI in column (2) of Table 13 indicates that 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

³⁴Previous 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.

³⁵See Section 2.3 for more detail on this variable.

that are highly vulnerable to natural disasters, the significance of this triple interaction term is indicative of an investor 'green' preference channel.

However, not all natural disasters are the result of climate change.³⁶ Hence the national risk index may not necessarily be capturing climate change concerns. To address this concern, I consider another set of measures, which proxy for climate change beliefs, risk perceptions, and policy support in all the different counties where firm *i*'s index fund investors are located at.³⁷ Column (2) - (6) in Table 13 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, (ii) support regulating CO₂ 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.³⁸ 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. 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. Coefficient before MP shock \times Env. score \times MCCC thus serves as evidence that sustainable investing preferences can have a significant impact on the transmission of monetary policy. Additionally, since preferences for sustainability have increased significantly following the Paris Agreement, column (8) performs a diff-in-diff analysis. In particular, it considers whether the dampened sensitivity of green firms is stronger in the period following the 2015 Paris Agreement. Results in column (8) show that this is indeed the case.

³⁶For example earthquakes, volcano eruptions, tsunamis and dry mass movements are geophysical events that are not related to climate change.

³⁷See Section 2.3 for more detail on these variables.

³⁸I use the Cumulative Media Climate Change Concerns variable defined in Section 2.3, detrended linearly.

Table 13. 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 \times Env. score	2.975*** (0.867)	2.817*** (0.853)	2.672*** (0.850)	2.806*** (0.847)	2.691*** (0.853)	2.861*** (0.868)	3.538*** (0.924)	1.987*** (0.691)
MP shock \times Env. score \times NRI		1.548** (0.704)						
MP shock \times Env. score \times Happening			1.172* (0.613)					
MP shock \times Env. score \times Worried				1.676** (0.748)				
MP shock \times Env. score \times Personal					1.492** (0.658)			
MP shock \times Env. score \times CO ₂ Limits						1.753** (0.744)		
MP shock \times Env. score \times MCCC							1.890** (0.778)	
MP shock \times Env. score \times 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, asset maturity, 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 control 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 $p < 0.1$.

6.4 Evidence from Mutual Fund Flows

In this subsection, I explore the impact of US monetary policy shocks on investors' allocation decisions with respect to mutual funds. Specifically, I investigate whether there are heterogeneities in the funding behaviour of mutual funds with and without Environmental, Social, and Governance (ESG) mandates. Leveraging information from the CRSP survivorship-bias-free mutual fund database, 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:

$$Flows_{m,t} = \frac{A_{m,t} - A_{m,t-1}(1 + r_{m,t})}{A_{m,t-1}} \quad (21)$$

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 .³⁹

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 5.2, I expect investors to rebalance their portfolios differently when they invest in ESG-mandated funds. To test this conjecture, I estimate the relative effect of monetary policy shocks on mutual fund flows for funds with ESG mandates. Specifically, I estimate the following panel regression:

$$Flows_{m,t+1} = \alpha_c + \alpha_{s,t} + \beta(\varepsilon_t^m \times ESG_{m,t-1}) + \delta ESG_{m,t-1} + \Gamma' Z_{m,t-1} + e_{m,t} \quad (22)$$

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 mandate 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 14 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 outlined in (22) 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

³⁹Note that equation (21) accounts for the fund's returns within the month, ensuring that $Flows_{m,t}$ accurately represents the net investments received by (or withdrawn from) the fund in that month.

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.⁴⁰ 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 15 shows that the response of equity fund flows to monetary policy is heterogeneous across types of funds. In particular equity funds with ESG mandates appear to be considerably less sensitive to monetary policy compared to their non-ESG counterparts. This is especially true for index equity funds, where ESG mandates may be a more salient feature compared to actively managed funds.⁴¹ In particular, within the same Lipper investment objective, investment flows in index funds with ESG mandates are about 7.56 percentage points less sensitive to a 100 basis point surprise increase in the federal fund 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 positions in the face of contractionary monetary policy shocks. This could be because institutional investors such as pension funds, endowments and insurance companies may be more likely to incorporate ESG considerations into their investment strategies due to regulatory require-

⁴⁰This 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.

⁴¹Index funds generally follow a passive investment strategy, which means they track a benchmark index. As such, the fund manager's 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.

ments, 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 index funds with ESG mandates has a positive effect on the constituent ESG securities within the index. In other words, when index fund withdrawals are limited, index funds are not compelled to unwind their positions in order to meet their shareholder demand, thereby bolstering the performance of ESG securities in the index.

Table 14. 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*** (0.00267)	-0.0354*** (0.00412)	-0.0266*** (0.00346)	-0.0228** (0.00922)	-0.0442*** (0.00929)	0.0355 (0.0244)	-0.0170 (0.0130)	-0.0259 (0.0302)	-0.0104 (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 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 15. 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 (0.0190)	0.0559* (0.0288)	-0.0252 (0.0251)	0.0756** (0.0372)	0.122** (0.0489)	-0.0424 (0.0633)	0.103 (0.234)	0.152 (0.533)	0.106 (0.242)
ESG mandate	0.00624*** (0.00158)	0.00455** (0.00216)	0.00720*** (0.00235)	0.00739* (0.00381)	0.00557 (0.00404)	0.00406 (0.00905)	0.0197 (0.0137)	0.0400* (0.0218)	0.00243 (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 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 mandates. 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 $p < 0.1$).

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 price, credit risk and investment 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.

These results have important implications for the transmission of monetary policy during the Net-Zero transition: monetary policy may be less powerful in a world where the share of greener firms in the economy increases, or when preferences for sustainable investing amplify.

An important task for future work is to study how monetary policy should be carried out in light of the green transition.

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.

References

- 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,” *Bank of England Working Paper*, 2020.
- Ardia, David, Keven Bluteau, Kris Boudt, and Koen Inghelbrecht**, “Climate change concerns and the performance of green versus brown stocks,” *National Bank of Belgium, Working Paper Research*, 2020, (395).
- Baker, Malcolm, Mark L Egan, and Suproteem K Sarkar**, “How Do Investors Value ESG?,” *National Bureau of Economic Research Working Paper*, 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.
- 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,” *Working Paper*, 2022.
- Chava, Sudheer and Alex Hsu**, “Financial constraints, monetary policy shocks, and the cross-section of equity returns,” *The Review of Financial Studies*, 2020, 33 (9), 4367–4402.
- Chudik, Alexander and Georgios Georgiadis**, “Estimation of impulse response functions when shocks are observed at a higher frequency than outcome variables,” *Journal of Business & Economic Statistics*, 2022, 40 (3), 965–979.
- Cloyne, James, Clodomiro Ferreira, Maren Froemel, and Paolo Surico**, “Monetary policy, corporate finance and investment,” Technical Report, National Bureau of Economic Research 2018.

- Correa, Ricardo, Ai He, Christoph Herpfer, and Ugur Lel**, "The rising tide lifts some interest rates: Climate change, natural disasters and loan pricing," *Natural Disasters and Loan Pricing* (October 13, 2020), 2020.
- 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 Stroebe**, "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.
- Gazzani, Andrea Giovanni, Alejandro Vicondoa et al.**, "Proxy-SVAR as a bridge for identification with higher frequency data," in "2019 Meeting Papers," Vol. 855 Society for Economic Dynamics 2019.
- Gilchrist, Simon and Egon Zakrajšek**, "Credit spreads and business cycle fluctuations," *American Economic Review*, 2012, 102 (4), 1692–1720.
- Gürkaynak, Refet, HATİCE GÖKÇE Karasoy-Can, and Sang Seok Lee**, "Stock market's assessment of monetary policy transmission: The cash flow effect," *The Journal of Finance*, 2019.
- 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.
- 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.

- Ippolito, Filippo, Ali K Ozdagli, and Ander Perez-Orive**, “The transmission of monetary policy through bank lending: The floating rate channel,” *Journal of Monetary Economics*, 2018, 95, 49–71.
- 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,” *Work*, 2019, 5.
- 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**, *An equilibrium model of institutional demand and asset prices*, National Bureau of Economic Research, 2015.
- 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.
- Lakdawala, Aeimit and Timothy Moreland**, “Monetary policy and firm heterogeneity: The role of leverage since the financial crisis,” *Available at SSRN 3405420*, 2021.
- Miranda-Agrippino, Silvia**, “Unsurprising shocks: information, premia, and the monetary transmission,” *Bank of England Working Paper*, 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.
- Pástor, L’uboš, Robert F Stambaugh, and Lucian A Taylor**, “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*, 2021, (21-71).
- 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.

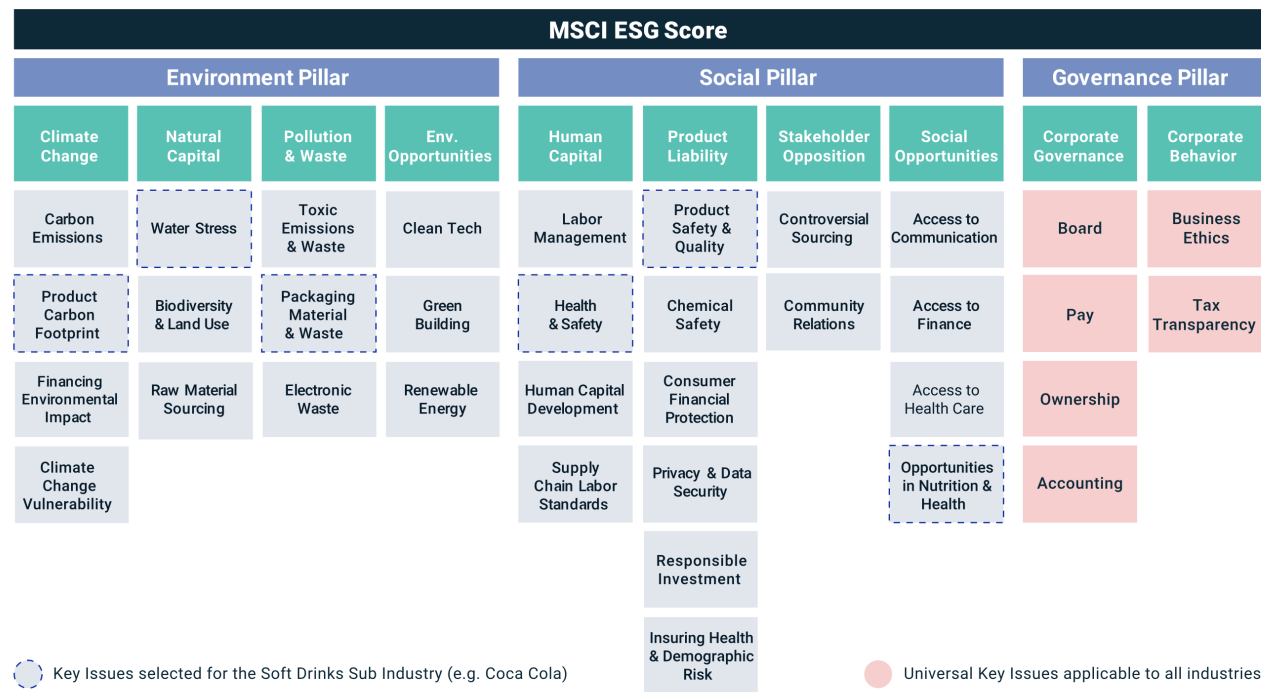
A Appendix

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 Pástor 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)
NRI score	The US National Risk Index from the Federal Emergency Management Agency (FEMA), which measures natural hazard risk at the county level.
MCCC	Media Climate Change Concerns Index by Ardia et al. (2020)
Personal	Percentage of residents at the county level in the US who answered "Yes" to the Yale Climate Opinion Survey question: "Do you think that global warming is having a personal effect on you?"

A.1 The ‘E’ in ESG

Figure 8. 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, a renowned leader in ESG (Environmental, Social, and Governance) research and ratings, employs a robust and comprehensive framework to assess a company’s 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 8 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 environmental concerns compared to its industry peers.

B Additional Results

Table A.2. 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 \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	2.975*** (0.867)	3.240*** (0.812)	3.073*** (0.872)	3.407*** (0.832)
MP shock \times Soc. score ($\varepsilon_t^m \times g_{i,t-1}$)		0.679 (0.564)		0.753 (0.608)
MP shock \times Gov. score ($\varepsilon_t^m \times g_{i,t-1}$)			0.270 (0.684)	0.384 (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 2019. 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 A.3. 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*** (4.057)	-16.54*** (4.047)		
MP shock \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)		3.603*** (0.879)	3.514*** (0.866)	2.709*** (0.747)
Env. score ($g_{i,t-1}$)		0.0230 (0.0609)	-0.0183 (0.0498)	0.0129 (0.0375)
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 2019. 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 $p < 0.05$, * for $p < 0.1$).

Table A.4. Baseline Result - Industry Split

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mining	Construction	Manufacturing	Transport	Wholesale	Retail	FIRE	Services
MP shock \times Env. score ($\varepsilon_t^m \times g_{i,t-1}$)	5.341* (2.864)	-2.900 (4.795)	3.890** (1.517)	0.925 (1.264)	1.110 (2.630)	-0.334 (1.923)	6.669*** (1.757)	4.428*** (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 2019. 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 6 on a per-industry basis. FIRE stands for financial, insurance and real estate. The asterisks denote statistical significance (** for $p < 0.05$, * for $p < 0.1$).

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:

$$\max_{c_1, b_1, s_{G,1}, s_{B,1}} E_1 \left(\sum_{t=1}^2 \beta^{t-1} (u(c_t) + f(s_{G,1})) \right), \text{ subject to,} \\ c_1 + b_1 + q_{G,1}s_{G,1} + q_{B,1}s_{B,1} \leq y \text{ in period one} \quad (23)$$

$$c_2 \leq (1+r)b_1 + \pi_G s_{G,1} + \pi_B s_{B,1} \text{ in period two.} \quad (24)$$

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

$$q_{B,1} = \frac{\pi_B}{1+r}; \quad q_{G,1} = \frac{\pi_G}{1+r} + \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \quad (25)$$

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:

$$\frac{d \ln(q_{B,1})}{dr} = -\frac{1}{1+r} \quad (26)$$

$$\frac{d\ln(q_{G,1})}{dr} = -\frac{1}{1+r} + \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \frac{\left[1 - (1+r)\frac{u''(c_1)}{u'(c_1)}\frac{\partial c_1}{\partial r} + (1+r)f''(s_{G,1})\frac{\partial s_{G,1}}{\partial r}\right]}{(1+r)q_G} \quad (27)$$

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 (27) can be re-written as:

$$\frac{d\ln(q_{G,1})}{dr} = -\frac{1}{1+r} + \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \frac{\left[1 - (1+r)\frac{u''(c_1)}{u'(c_1)}\frac{\partial c_1}{\partial r}\right]}{(1+r)q_G} \quad (28)$$

Assuming for simplicity $\pi_G = \pi_B$, and recognizing that $\frac{d\ln(q_{G,1})}{dc_1} = -\frac{1}{q_G} \frac{(1+\beta)f'(s_{G,1})}{u'(c_1)} \frac{u''(c_1)}{u'(c_1)}$, I can simplify equation (27) further:

$$\frac{d\ln(q_{G,1})}{dr} = \underbrace{-\frac{1}{1+r}}_{\text{Pecuniary effect}} + \underbrace{\frac{(q_{G,1} - q_{B,1})}{(1+r)q_{G,1}}}_{\text{Green preferences effect}} + \underbrace{\frac{d\ln(q_{G,1})}{dc_1} \frac{\partial c_1}{\partial r}}_{\text{Wealth effect}} \quad (29)$$

Equation (29) 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. $\frac{\partial c_1}{\partial r} = 0$).

$$\left(\left| \frac{d \ln(q_{G,1})}{dr} \right| - \left| \frac{d \ln(q_{B,1})}{dr} \right| \right) = - \frac{(q_{G,1} - q_{B,1})}{(1+r)q_{G,1}} < 0 \quad (30)$$

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. $\frac{\partial c_1}{\partial r} > 0$).

$$\left(\left| \frac{d \ln(q_{G,1})}{dr} \right| - \left| \frac{d \ln(q_{B,1})}{dr} \right| \right) = - \frac{(q_{G,1} - q_{B,1})}{(1+r)q_{G,1}} - \frac{d \ln(q_{G,1})}{dc_1} \frac{\partial c_1}{\partial r} < 0 \quad (31)$$

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:

$$\frac{(q_{G,1} - q_{B,1})}{(1+r)q_{G,1}} > - \frac{d \ln(q_{G,1})}{dc_1} \frac{\partial c_1}{\partial r} \quad (32)$$

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 (32). 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 $\frac{d \ln(q_{G,1})}{dc_1} \frac{\partial c_1}{\partial r}$. 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 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 (Kojen and Yogo, 2015). 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?

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:

$$\text{Investor Greenness}_{j,t} = \sum_{i \in \Theta(j)} w_{j,i,t} \times g_{i,t} \quad (33)$$

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:

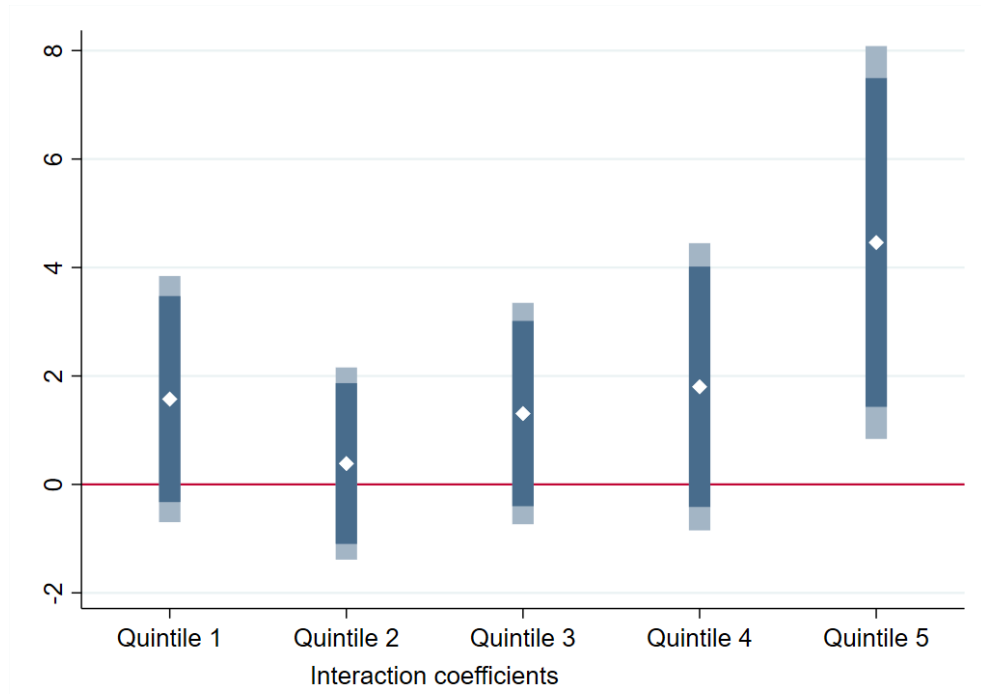
$$\text{Investor-based Greenness}_{i,t} = \sum_{j \in \Gamma(i)} \tilde{w}_{i,j,t} \times \text{Investor Greenness}_{j,t} \quad (34)$$

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

⁴²The 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.

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 (6) for the five different bins of investor types.

Figure 9. Investors' Preferences Channel



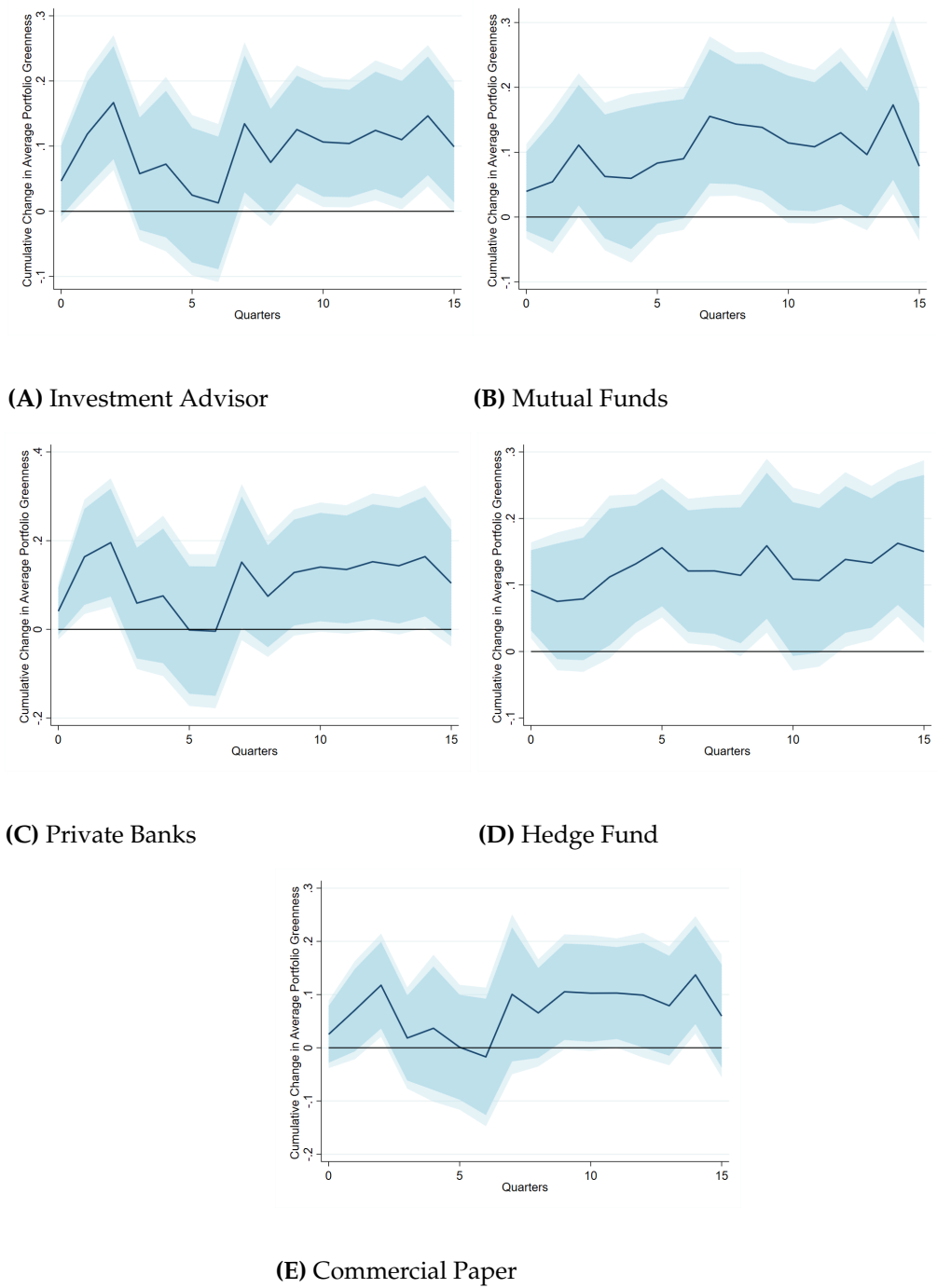
Notes: This graph plots the beta coefficients from the following specification: $\Delta p_{i,t} = \alpha_i + \alpha_{st} + \beta(\epsilon_t^m \times g_{i,t-1}) + \delta g_{i,t-1} + \Gamma' Z_{i,t-1} + e_{i,t}$, for the five different quintiles of the Investor-based greenness distribution. Quintile 1 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.

Figure 9 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 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 5.1. 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.2 Green Portfolio Weight

Figure 10. Impulse Response Functions by Investor Type



Notes: In line with local projection methods, each horizon is estimated separately. The blue solid line represents the $\{\beta^h\}_{h=0}^{20}$ estimates in percent. The dependent variable is $\Delta_h \log(\text{Green weight}_{i,t})$, over the horizons considered. The independent variable is ε_t^m . The light and dark blue shaded areas denote the 90% and 95% confidence intervals constructed with standard errors clustered at the time level.

C.3 Evidence from Mutual Fund Flows

Table A.5. 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 Happening	-0.00130 (0.00255)	0.000719 (0.00407)	-0.00373 (0.00317)	0.0201** (0.00871)	0.0249** (0.0101)	0.00362 (0.0172)	0.00885 (0.0168)	-0.00252 (0.0380)	0.0155 (0.0174)
Happening	0.00154** (0.000739)	-0.00108 (0.000912)	0.00219** (0.00104)	0.00231 (0.00197)	-0.00291** (0.00146)	0.0163*** (0.00558)	-0.00336 (0.00698)	-0.0000547 (0.00860)	-0.00806 (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 mandates. 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 A.6. 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 \times Worried	-0.00101 (0.00248)	0.00309 (0.00392)	-0.00527* (0.00309)	0.0256*** (0.00848)	0.0310*** (0.00952)	0.00268 (0.0189)	-0.00853 (0.0153)	-0.0363 (0.0364)	0.00804 (0.0152)
Worried	0.00121* (0.000718)	-0.000140 (0.000894)	0.000632 (0.00104)	0.000598 (0.00183)	-0.00353** (0.00145)	0.0182*** (0.00643)	-0.00577 (0.00675)	-0.00207 (0.00922)	-0.00994 (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 mandates. 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 $p < 0.1$).