Stockholm School of Economics

Department of Economics

BE 551 Degree Project in Economics

Fall 2023

The impact of firm-level greenness on the transmission of monetary policy shocks to stock market prices in Sweden

Marcus Boman (24981) and Ira Kansara (25515)

December 4, 2023

Abstract

A growing literature has indicated that monetary policy shocks impact the stock prices of brown firms more strongly than the stock prices of green firms. Monetary policy tightening is associated with lower stock prices since it leads to a higher cost of capital and in turn a higher discount rate for the expected stream of cash flows. Therefore, if the stock prices for brown firms drop more, relative to that of green firms, then brown firm's cost of capital is more sensitive to the decisions of central banks. Moreover, recent studies have shown that if the cost of capital for brown firms increases relative to green firms, the former tends to become less environmentally friendly, as they are unable to make the long-term investment to become greener, while the latter's environmental performance is unaffected. Therefore, if the stock prices of brown firms are more sensitive to monetary policy than those of green firms, then the elevated interest rates we currently see around the globe might have a more negative impact on the green transition than previously thought. In light of this, we first investigate the effect of monetary policy shocks on the Swedish stock market. We use high-frequency data to identify the impact of stock prices on policy shocks. We find that an unexpected 1 percentage point increase in Sveriges Riksbank's repo rate translates into a 3.5% decrease in daily stock returns. To examine if there is a heterogeneous impact of monetary policy on the stock prices of green and brown firms, we use a panel data event study methodology. In contrast to previous studies done in a US setting, we find that the environmental performance of a firm does not impact the effect monetary policy shocks have on its stock price.

Keywords: Monetary Policy, Heterogeneity, Sustainable Investing, ESG, Green Transition.

JEL: E52, G12, G14, G30

Supervisor:	Sampreet Goraya
Date submitted:	December 4, 2023
Date examined:	December 20, 2023
Discussant:	Axel Eisner Sjöberg
Examiner:	Johanna Wallenius

Acknowledgments

We would like to express our sincere gratitude to our supervisor Sampreet Goraya, Assistant Professor, and Lars Svensson, Affiliated Professor, for providing invaluable insights and support throughout the writing of this thesis. In addition, we would like to thank Dr. Josefin Kilman and Dr. Stefan Laséen for sharing their monetary policy shock series with us, without which this thesis would not have been possible. Finally, we are grateful to our classmates Pippa Johns and Elsa Rosengren, as well as everyone else who has provided feedback during this writing process.

Table of Contents

1. Introduction

During the symposium on central bank independence held at Sveriges Riksbank earlier this year, Jerome Powell, the chair of the US Federal Reserve (FED), stated that the FED is not and will not function as a "climate policymaker." Powell's statement was a response to the growing suggestion among analysts and commentators that central banks should factor in the risks of climate change when formulating monetary policy (Powell 2023). Recently, there has been substantial interest in understanding how monetary policy influences the green transition. Notably, influential central bankers, such as Isabel Schnabel, a member of the executive board of the European Central Bank (ECB), have underscored the critical role of the cost of credit in determining firms' ability to adopt greener practices, due to substantial upfront transition costs (Schnabel 2023).

Bernanke and Kuttner (2005) emphasize that the primary and immediate impacts of monetary policy interventions are felt in financial markets. Policymakers aim to influence economic behavior by adjusting asset prices and returns to accomplish their ultimate objectives.[1] As the green transition is fundamentally changing how financial markets are beginning to integrate climate transition risks, understanding how the relationship between asset prices and monetary policy is affected becomes essential for comprehending the transmission mechanism of monetary policy. In light of this, this paper empirically investigates two hypotheses. First, how does the stock market in Sweden react to monetary policy shocks? Second, are the stock market prices of brown firms more sensitive to monetary policy shocks than the stock market prices of green firms?

According to the discounted cash flow model, stock prices are equal to the present value of expected future net cash flows. Monetary policy tightening is associated with lower stock prices since it leads to a higher cost of capital and in turn a higher discount rate, for the expected stream of cash flows.[2] If our main hypothesis is true, i.e., monetary policy shocks have a stronger impact on brown firms' stock prices, this would imply that the policy decisions of Sveriges Riksbank might have a more substantial adverse impact on the green transition than previously acknowledged. This is because a lower stock price implies a lower valuation of a company, which in turn implies a higher cost of capital for that firm. Hartzman and Shue (2023) highlight that increasing the cost of capital for brown firms relative to green firms tends to make the former less environmentally friendly, without a simultaneous improvement in the environmental performance of the latter. Given that brown firms are major contributors to carbon emissions and other pollutants, efforts to mitigate their environmental impact have proven to be highly effective in addressing climate change (Hartzman and Shue 2023). Hence, our hypothesis is of primary importance for understanding how monetary policy impacts the green transition. An unexpected tightening of monetary policy might hinder the funding of the green transition by elevating the cost of capital for firms and in turn lowering the stock prices, particularly impacting brown firms since newer projects undertaken by them would face higher costs of capital. This would make it more expensive for brown firms to transition and become greener.

To test our hypothesis, we begin by investigating how the stock market in Sweden reacts to monetary policy. If monetary neutrality holds, asset prices will be independent of policy changes in the long run.[3]

---

[1] Through its effect on the stock market, monetary policy influences consumption spending (wealth effect channel) and investment spending (balance sheet channel), which is linked to the real economy.
[2] A restrictive monetary environment is not commonly viewed as good news as these periods are usually associated with high interest rates, more expensive capital and decrease in economic activity.
[3] The concept of monetary neutrality posits that changes in the money supply impacts nominal variables but not real variables.

However, in the short run, policy changes might influence asset prices. Exploration of the causal effect of monetary policy on the stock market entails the following challenges:

(1) Separation of anticipated and unanticipated parts of policy changes (Bernanke and Kuttner, 2005)
(2) Separation of policy changes from other economic or financial information in the market (Nakamura and Steinsson, 2018)
(3) Separation of central banks information shocks from policy change shocks (Jarociński and Karadi, 2020).

Jarociński and Karadi (2020), Gertler and Karadi (2015), and Nakamura and Steinsson (2018) highlight that central bank announcements provide an opportunity to isolate the unexpected (exogenous) component of monetary policy change for causal inference. Since the *expected* change in monetary policy is already priced in by the market before the central bank's policy announcement, markets are expected to respond to the *unanticipated* policy changes during the announcements. Hence, we use a high-frequency monetary policy shock series developed by Laśeen (2020) to disentangle the expected policy actions from the unexpected policy actions. A detailed explanation of the shock series is provided in section 3. Furthermore, using the high-frequency approach, we make the identifying assumption that focusing on a narrow window around central bank announcements ensures that any market movements are solely due to the unexpected part of announcements, and not due to other economic or financial variables. However, as Jarociński and Karadi (2020) highlight, monetary policy announcements reveal information both about policy updates as well as the central bank's assessment of the economic outlook. Hence, investors respond both to the central bank's information about the current and future expected economic environment and unexpected changes in policy rates. Therefore, disregarding these information shocks can bias the monetary policy shock estimate.

Considering these challenges, we use the shock series prepared by Laśeen (2020) which already accounts for most of the aforementioned issues, except information shocks. To reduce the bias of our policy shock estimate, we chose 2010-2018 as our main sample period, as this period is characterized by negligible information shocks in central bank announcements. Our results suggest that a surprise increase of the Riksbank repo rate of 1 percentage point translates into a -3.4% decrease in stock prices. This effect is significant at the 1% level. We see these results as monetary policy significantly influences equity returns by adjusting the cost of capital, and in turn the discount rate, as well as shaping expectations of future economic activity. Tightening monetary policy tends to correlate with lower stock prices due to an elevated discount rate for expected cash flow. Conversely, an accommodative monetary environment is generally seen as positive, associated with low interest rates, heightened economic activity, and more affordable capital (Ioannidis and Kontonikas, 2006). Our results are broadly consistent with the strand of literature that has explored the impact of monetary policy on the stock market. For instance, Bernanke and Kuttner (2005) find that an unexpected 25 basis point cut would typically lead to an increase in stock prices of order of one percent.

With the effects of monetary policy on the Swedish stock market clear, we move on to evaluate our main hypothesis: that the stock prices of brown firms are more sensitive to monetary policy shocks than the stock prices of green firms. To empirically explore this question, we adopt an event study panel regression methodology inspired by Patozi (2023) and Döttling and Lam (2023). To capture the exogenous variation in monetary policy, we use the high-frequency shock series developed by Laséen (2020) which covers the period 2003-2018. Our dataset of Swedish publicly listed firms covers the same years. To measure how green or brown our firms are, we use the MSCI ESG Ratings Time Series to extract the ESG (environmental, social, and governance) performance scores for our firms. As we are specifically interested in the environmental performance of our firms, we follow the methodology developed by Pástor et al. (2022) to isolate the environmental part of the ESG rating. This gives us one of the most holistic measures of firm-level greenness possible, as the environmental metric of the MSCI ESG rating considers a firm to be greener if it is resilient to both physical and transitional climate risks. The MSCI ESG ratings also offer the advantage of being the largest providers of ESG scores in the world, with over 1700 organizations, including pension funds, asset managers, consultants, advisers, banks, and insurers regularly using the MSCI's ESG rating to assess the sustainability of firms (Pastor et al 2022). This rating has in numerous studies been shown to have a major impact on the stock market prices, and by extension the cost of capital, for public companies, which makes them a useful measure of firm-level greenness to a study like ours (Patozi 2023, Döttling and Lam 2023, Heinkel et al. 2001, Pastor et. al. 2022).

Intuitively, a tightening of monetary policy has the potential of making it more costly for companies to invest in transitioning their activities toward becoming more climate-friendly. This is because higher interest rates lead to a higher cost of capital, which makes it harder to finance the capital-intensive process of making assets and operations greener. Firms that are not able to transition in time face several key risks, such as climate-related technology risks, regulatory risks, reputation risks, etc. (Döttling and Lam 2023). If monetary policy indeed does slow down the transition for brown firms to become greener due to the higher cost of capital, these risks would lead to equity investors anticipating monetary policy to impact brown firms more severely than green firms. In turn, investors invested in brown firms would expect higher returns to compensate for the additional risks they face. As a result, we would expect a significant decrease in stock prices for brown firms relative to green firms as investors expect higher returns from the former.

Furthermore, Patozi (2023) finds that if investors value sustainable firms for non-pecuniary benefits other than risk-adjusted returns, they are more reluctant to unwind their holdings in green companies after a tightening of monetary policy than they are to unwind their holdings in brown companies. Intuitively, this means that if an investor holds two companies that are the same in all aspects, except one company is greener than the other, the investor will be more likely to unwind her holdings in the brown firm in the face of a monetary policy shock. Hence, the non-pecuniary motives of investors might be another reason why the stock prices of brown firms would be more sensitive to monetary policy than the stock prices of green firms.

The research done in this field has been limited. So far, studies on how firm-level greenness impacts the transmission of monetary policy to asset prices have primarily been conducted in a US setting. There, researchers such as Patozi (2023), as well as Döttling and Lam (2023), have been able to show that firm-level greenness has a dampening effect on monetary policy's impact on asset prices. To the best of our knowledge, this is the first paper that tries to explore heterogeneity in the transmission of monetary policy to stock prices based on firm-level greenness done in a Swedish setting. In contrast to previous research, we find that there are no differences in the reactions of stock prices of green and brown firms to monetary policy shocks in Sweden. These results hold for a host of robustness checks, which indicates that the dampening effects greenness has been shown to have on the transmission of monetary policy to asset prices in the US is not generalizable to Sweden. This might be because of inherent differences in Swedish and American firms, climate policy uncertainties, and investor expectations. Regardless of the cause, this means that the Riksbank does not have the same additional, indirect impact on brown firms' cost of capital through stock prices as the US FED has.

The rest of the paper is organized as follows: Section 2 describes the previous literature on the topics of transmission of monetary policy on asset prices and how environmental performance impacts stock market outcomes. Section 3 describes our data. Section 4 outlines our methodology and empirical strategy. In section 5 we present our results, including several robustness checks confirming the insignificant impact of firm-level greenness impact on the transmission of monetary policy on asset prices. Section 6 describes the reasons why our results might deviate from previous literature. In section 7, we present our conclusions.

2. Literature Review

This paper relates to three strands of literature. Firstly, our paper expands on previous research on the transmission of monetary policy to asset prices. Secondly, we further build on studies concerning heterogeneities in how monetary policy is transmitted to asset prices. Lastly, we contribute to existing literature on how environmental variables affect stock market performance.

The literature on the transmission of monetary policy on asset prices is well established. Bernanke and Kuttner (2005) demonstrate that a monetary policy shock either affects the anticipated returns on stocks or the expected future dividends that stocks will yield. During normal times, this means that tighter monetary policy lowers stock prices by raising the expected equity premium. However, this relationship does not always hold true. It is not uncommon to observe large "wrong-sided shock" events where a loosening of monetary policy results in a decrease in stock prices or a tightening of monetary policy results in an increase in stock prices (Jarociński and Karadi 2020, Laséen 2020, Kontonikas et al. 2013, Jarociński and Peter 2020, Bu et al. 2020). These "wrong-sided shocks" occur because a traditional monetary policy shock both reveals new information about the monetary policy rate and information about the central bank's outlook on the economy. Due to these information shocks, an unexpected loosening of monetary policy can result in a decline in stock prices (contrary to textbook economic theory), as central banks communicate higher concern about the state of the economy than previously anticipated by the market (Jarociński and Peter 2020, Bu et al. 2020). We contribute to this strand of literature by showing the extent to which these types of information shocks have impacted the transmission of monetary policy to stock prices in Sweden during different time periods, highlighting the major impact they had during the global financial crisis.

Regarding the literature concerning heterogeneities in how monetary policy is transmitted to asset prices, previous research has mostly explored how firm-level financial variables such as age, leverage, and indebtedness impact the transmission of monetary policy to stock prices (Patozi 2023). This includes, among others, Cloyne et al. (2023) who show that younger firms that do not pay dividends have heightened sensitivity to monetary policy, and Ottonello and Winberry (2020) who show that firms with lower debt burdens and low default risk are more responsive to monetary policy shocks. In contrast, the literature on how a non-financial variable such as environmental performance impacts the transmission of monetary policy on asset prices has so far been limited. While Patozi (2023) and Döttling and Lam (2023) have shown that firm-level greenness has a dampening effect on monetary policy's impact on stock prices in the US, to the best of our knowledge, no similar study has been conducted in a Scandinavian setting. We thus contribute to this strand of literature by being the first to evaluate how firm-level greenness impacts the transmission of monetary policy on stock prices in Sweden.

Finally, the growing literature on how climate change and the green transition impact financial markets and asset prices has so far indicated that environmental variables are of significant importance for stock market performance. Low environmental performance lowers a firm's stock price as more investors, for ethical reasons, exclude these firms from their portfolios (Heinkel et al. 2001). High environmental performance on the other hand has been correlated with higher realized stock market returns due to ESG being considered an increasingly important factor for investors (Pástor et al. 2021). However, high ESG scores have also been theoretically proven to lead to lower expected future returns if such stocks provide a hedge against climate risks or investors have non-pecuniary preferences for holding green stocks (Fama and French 2007, Pastor et al. 2021, Pedersen et al. 2021). Consistent with this notion, Bolton and Kacperczyk (2021) document that carbon transition risk is priced in stock returns. Lastly, Döttling and Lam (2023) and Patozi (2023) show that the asset prices of greener firms are less sensitive to monetary policy shocks than the asset prices of browner firms. We contribute to this strand of literature by following the methodology of Patozi (2023) in a Swedish setting.

3. Data

We have prepared a panel dataset consisting of (1) Daily returns of publicly listed firms on the Stockholm Stock Exchange, observed during the occurrences of the Riksbank repo rate announcement events (101 events in total) spanning the period from 2003 to 2018; (2) High-frequency monetary policy shocks, constructed by Laśeen (2020); (3) Annual greenness scores for the listed firms, sourced from the MSCI ESG ratings and adjusted using the methodology developed by Pástor et al. (2022); (4) Quarterly firm-level financial data obtained from Refinitiv Eikon and standardized following Patozi (2023). The resulting dataset comprises 3270 observations in total for our main period of analysis (2010-2018). Notably, the coverage of MSCI ESG ratings for firms expands over time, making us observe an increasing number of firms each year. In total, we have complete data on 149 distinct firms in the last time periods in our sample.

We gathered data from 2003 to 2018 since this is the period for which we obtained the policy shock series. However, our main sample period extends from 2010 to 2018 to reduce the bias on regression coefficients due to information shocks. We discuss this extensively in section 5. The time dimension of our panel data is the policy event date, and the cross-sectional dimension is the firms. Our observation on price change (dependent variable) is at event day level. We gather the firm-level financials (control variables) from the firms' latest quarterly reports before the announcement day. Furthermore, we also report correlation matrices for different variables in the Appendix. The following sections provide a detailed summary of our panel dataset.

3.1 Selection of firms

Our sample consists of firms listed on the Stockholm Stock Exchange. The firm-level data is obtained from Refinitiv Eikon. Refinitiv is one of the world's largest providers of financial data and gives us access to both a broad set of Swedish firms as well as detailed information on each of the companies of interest. We only include firms that have MSCI ESG ratings as well as complete data on firm-level financial controls. We eliminate the firms with the most extreme stock price change from the analysis since it is driven by events like stock splits. The number of firms in our dataset varies across years, which is mainly a result of the fact that MSCI's (our ESG score provider) coverage of Swedish firms increases over time. Our final dataset consists of 149 distinct firms. **Figure 1** reports how the number of firms in our dataset changes over time. As per the figure, we see a sharp increase in the number of firms post-2014 due to the large increase in the number of firms covered by the MSCI ESG Ratings (see Appendix for more information).

We also divide up the firms in different industries using the Industry Classification Benchmark (ICB) codes. The ICB is an industry classification that segregates markets into sectors. The ICB uses a system of 11 industries, partitioned into 20 super sectors, which are further divided into 45 sectors, which then contain 173 subsectors. In our study, we have chosen to only break down our firms into the 11 main ICB industries as any further breakdown would result in each industry containing just a few firms. As seen in **Table 1**, all ICB industries except for "Utilities" are represented in our dataset. Most of the firms belong to the group "Industrials". The brownest industry in our data is "Energy". However, we only have one firm belonging to that industry. The greenest industry is "Health Care", making up 13% of our data.

Figure 1: *Number of firms over time*

Notes: *The figure shows how the number of firms in our dataset increases over time. The sharp increase in firms covered after 2014 is due to the MSCI's coverage of Swedish firms increased rapidly around this time. Data coverage is from year 2003 to 2018. Data source: Refinitiv Eikon, MSCI ESG Time Series.*

Table 1: *Sample Composition*

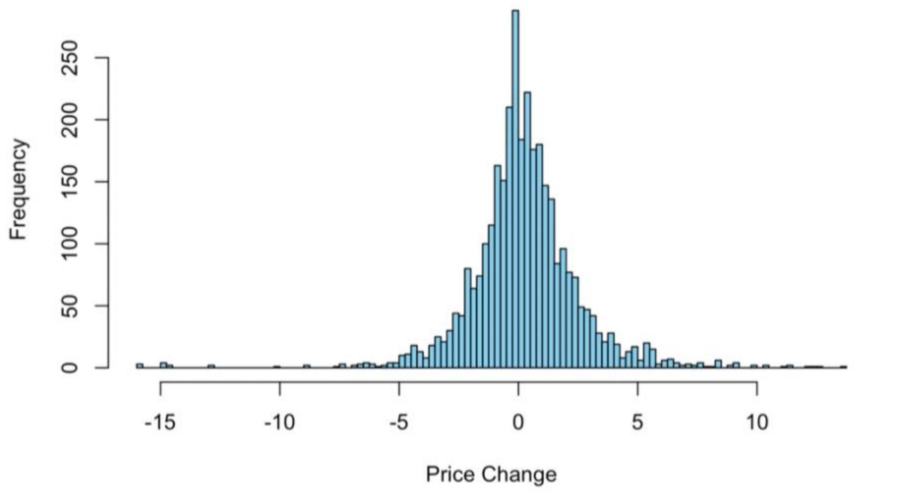
Industry	N firms	Percent	Mean Env_Score
Basic Materials	8	5.298%	-1.050
Consumer Discretionary	30	19.868%	-0.050
Consumer Staples	6	3.974%	-0.990
Energy	1	0.662%	-2.070
Financials	12	7.947%	0.800
Health Care	20	13.245%	0.950
Industrials	37	24.503%	-0.160
Real Estate	15	9.934%	-0.530
Technology	14	9.272%	-0.350
Telecommunications	6	3.974%	0.510
Total	*149*	*100%*	*-0.294*

Notes*: This table reports the number of firms within each industry in our dataset. It also reports the percent composition of the industry and their average env_score across time. Data coverage is from year 2010 to 2018. Data source: Refinitiv Eikon, MSCI ESG Time Series.*

3.2 Daily Returns

We extract daily closing prices on policy announcement dates for all stocks included in our sample from 2003 - 2018 using Refinitiv Eikon. These prices are then used to create our stock price change variable, which measures the percentage change between the closing price of a stock on the day before a monetary policy shock event and the closing price of the same stock on the day of the monetary policy shock event. The frequency distribution of our price change variable is reported in **Figure 2**. We see that the distribution is roughly normally distributed with a large majority of price changes being between -3% and +3%. The mean price change is 0.2% with a standard deviation of 2.6% for our sample. As per the histogram in Figure 2, it can be observed that our data contains a few outliers to the left side of the distribution. We drop these outliers from our main data since these extreme daily returns are a result of firm-specific events like stock splits or dividend payouts.[4] Furthermore, we assume that the monetary policy shock is the only shock at the time of the policy announcement.

Figure 2: *Price Change Frequency Distribution*



Notes: *Price change is measured as the percentage change between the closing price the day before a monetary policy shock event, and the closing price on the day of a monetary policy shock event. Data coverage is from year 2010 to 2018. Data source: Refinitiv Eikon.*

3.3 Monetary Policy Shock

For our Monetary Policy Shock series, we use a high-frequency surprise series developed by Lasèen (2020). He calculates the unexpected part (i.e. the surprise) of a Riksbank repo rate change by examining the change in the price of a one-month Overnight Index Swap (OIS) around the announcement. The OIS swap contract has STIBOR T/N (Stockholm Interbank Offered Rate tomorrow/next) as its underlying variable and represents an average of the expected interest rate for the upcoming month. By

[4] In a stock split the number of outstanding shares increases and the price per share decreases proportionately. Secondly, after the declaration of dividend by a firm, the stock price usually increases. However, after the ex-dividend date, the share price of a stock usually drops by the amount of the dividend. For instance, Fabege AB, had a stock split of 2:1 on 2018-04-26 (policy announcement date) which led to a stock price drop of 48.5%. Hence, we remove outliers from the data which might be due to firm specific events on the policy announcement date.

considering a sufficiently narrow time window around the policy decision and assuming that all anticipated information is already reflected in market prices, any variation in the OIS swap price in the time frame is attributed to only two structural shocks, a monetary policy shock, and a central bank information shock. Lasèen's study employs a time interval of 3 hours, commencing 15 minutes before the policy announcement. The dataset encompasses the period from February 2003 to December 2018, covering a total of 101 shock events. **Table 2** reports the summary statistics of the shocks. The series is in percentage points and its average is -0.007 with a standard deviation of 0.055. We also obtain another policy shock series by Kilman (2023), prepared using the methodology of Romer and Romer (2004), for robustness checks.

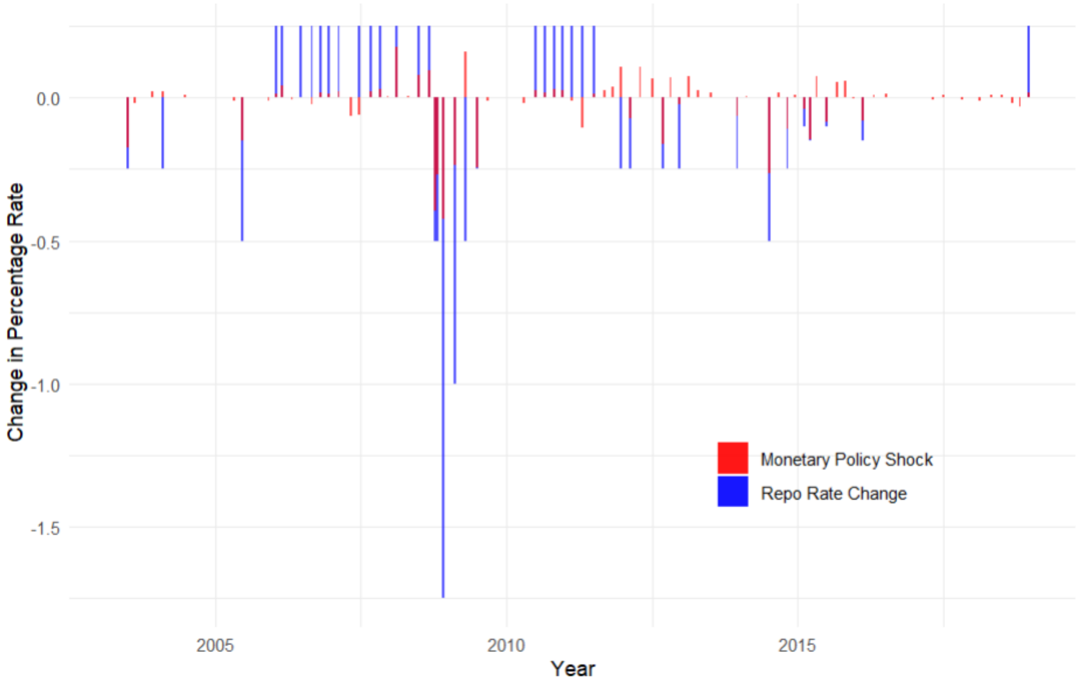
Figure 3 visualizes a summary of our high-frequency shock series together with the accompanying changes in the Riksbank's repo rate. In it, we see that most shocks are rather small, being contained within a span of +-20 basis points, with some notable outliers around the global financial crisis. We can also see that all larger shocks are negative, with no positive shock being larger than 20 basis points. Positive shocks are contractionary and negative shocks are expansionary.

Table 2: *Monetary Policy Shocks Summary Statistics*

Policy Shock	*Mean*	*Median*	*Std Dev*	*P25*	*P75*	*N*
hf_shock	-0.007	0.000	0.055	-0.013	0.011	101
rr_shock	-0.052	-0.065	0.140	-0.128	0.018	101

Notes: *The monetary policy shocks are reported in percentage points. The high-frequency surprise series (in the table the hf_shock variable) has been obtained from Laśeen (2020) and the R&R shock series (in the table the rr_shock variable) has been obtained from Kilman (2022). P25 represents the value under which 25% of the data points are found when arranged in increasing order. P75 is the value under which 75% of data points are found when arranged in increasing order. Data coverage is from year 2003 to 2018. Data source: Laséen (2020), Kilman (2022).*

Figure 3: *High-frequency shocks and changes in the Riksbank repo rate*



Notes: *Units are in percentage points. We see most shocks being between +/- 20 basis points, with large negative outliers around the global financial crisis. Data coverage is from year 2003 to 2018. Data source: Laséen (2020).*

3.4 Greenness Scores

To measure the heterogeneous impact of monetary policy on green and brown firms, we must first construct a measure of firm-level greenness. To accomplish this, we follow the methodology developed by Pástor et al. (2022). We begin by collecting firm-level ESG ratings from the MSCI ESG Timeseries database, which is widely used by asset managers and wealth managers to evaluate firms' sustainability performance. The database enables us to isolate the environmental part of a firm's ESG score, as the MSCI calculates the environmental, social, and governance parts separately before aggregating them into a single ESG score.

As highlighted by MSCI ESG Research LLC's Methodology Document (2023), the environmental part of the ESG score consists of two values: an environmental score and an environmental weight. The environmental score is a value between 0 (worst) to 10 (best) which measures how well a firm performs on 13 environmental issues related to climate change, natural capital, pollution and waste, and environmental opportunities. The environmental weight is a measure between 0-100 which indicates how important the environmental part of a firm's ESG score is relative to the social and governance parts. The environmental weight is typically constant across the industry in which a company operates. Together, the environmental score and the environmental weight create the environmental part of a firm's ESG score, which is the company's *industry-adjusted environmental score.* However, as we are interested in a company's absolute greenness (to enable comparison of firms in different industries), we need to create an *industry unadjusted environmental score,* which we specify in line with Pástor et al. (2022) as:

$$G_{i,t} = -((10 - E_{score,i,t}) * E_{weight,i,t})/100$$

Where $E_{score,i,t}$ and $E_{weight,i,t}$ are company i's environmental score and environmental weight reported by MSCI at time t. MSCI's scores are available on a monthly basis, and each score is updated at least yearly (MSCI ESG Research LLC, 2023), therefore t indicates the month and year of the variables in the equation above. The quantity $(10 - E_{score,i,t})$ measures how far the company is from a perfect environmental score of 10. The product $((10 - E_{score,i,t}) * E_{weight,i,t})/100$ 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. $E_{weight,i,t}/100$). The minus sign at the beginning converts the brownness score to a greenness score. This greenness score is our *unadjusted environmental score,* which we use to measure the absolute greenness of a firm. As an example of why it is important to use the unadjusted environmental score of the MSCI's ESG score, a comparison between Volvo and Tele2 is useful. Their respective environmental scores in 2018 were 5.2 and 7, while their respective environmental weight was 39 and 5. Just using their environmental score Tele2 would have been counted as 35% greener than Volvo. However, if we calculate their *unadjusted environmental score* according to the formula above, Tele2 gets an environmental score of -0.15, and Volvo an environmental score of -1.872. Thus, the fact that a car manufacturer has a substantially larger environmental impact than a telecommunication firm is taken into account.

Figure 4 shows how firms' greenness has developed over our sample period. On average, we see that the greenness of our firms has increased over time. This is not particularly surprising as the environmental performance of a firm has become increasingly important with the rise of ESG investing. According to Baker et al. (2022), at least $35 trillion of institutional assets track firms' ESG ratings, and the value that investors place on ESG has more than tripled in the last four years.

Figure 4: *Average firm-level greenness over time*

Notes: *The average firm-level greenness increases over time, which is consistent with what has been observed in previous studies. The large drop in average firm-level greenness in 2012 is most likely due to the roll-out of the MSCI ESG Ratings model version 2.0, which included a substantial revision to the MSCI ESG Key Issue structure (MSCI ESG Research LLC, 2023). Data coverage is from year 2003 to 2018. Data source: MSCI ESG Time Series.*

To be consistent with Pástor et al. (2022), the environmental score we use in our final analysis is:

$$env\_score_{i,t} = G_{i,t} - \bar{G}_t$$

where $\bar{G}_t$ is the value-weighted average of $G_{i,t}$ across all firms i at time t. Since we subtract $\bar{G}_t$, $env\_score_{i,t}$ measures a company's cross-sectionally demeaned greenness score as in Pastor et al. (2021). We report the summary statistics for the greenness scores in **Table 3**, together with complementary statistics of two alternative measures of firm-level greenness that we use as robustness checks for our analysis (section 5.4).

Table 3: *Greenness Scores Summary Statistics*

Greenness Score	*Mean*	*Median*	*Std Dev*	*P25*	*P75*	*N*
env_score	0.005	0.027	0.978	-0.759	0.984	3270
environmental.pillar.score	5.994	5.840	1.869	4.800	7.000	3270
carbon.emissions.score	7.210	7.200	2.027	6.000	8.700	3270

Notes: *The greenness scores have been obtained from MSCI ESG ratings. The env_score extends from –3.7 to 3.32 and has been prepared using Pastor's methodology. The environmental pillar scores and carbon emissions scores take values from 0 to 10 and have been directly obtained from MSCI ESG ratings. Data coverage is from year 2003 to 2018. Data source: MSCI ESG Time Series.*

3.5 Control variables

A wide range of literature has explored how firm-level financial characteristics impact monetary policy transmission. Ottonello and Winberry (2020) show that firms with low debt burdens and high "distance to default" are more responsive to monetary policy shocks. As per Cloyne et al. (2023), younger firms paying no dividends exhibit the largest and most significant change in capital expenditure after a monetary policy tightening, as their external finance is mostly exposed to asset value fluctuations. Chava and Hsu (2020) show that financially constrained firms earn a significantly lower return following surprise monetary policy increase as compared to unconstrained firms. Lastly, Gürkaynak et al (2022) show that firms with more cash flow exposure see their stock prices affected more by monetary policy announcements.

Following Patozi (2023), and to be consistent with the literature on firm-level balance sheet heterogeneity and monetary policy shocks, we control for a company's size, book leverage, age, differences in firm profitability, cash holdings (liquidity), market-to-book ratio (growth vs. value stocks), retained earnings, short term and long-term debt and dividends per share. Following Bolton and Kacperczyk (2021), we also interact these variables with monetary policy shocks in our robustness tests (section 5.4). We construct our variables using the methodology in Patozi (2023):

1. Size: Log of total assets.
2. Book leverage: Total debts divided by total assets.

3. Age: Number of years the company has been publicly listed.
4. Profitability: Earnings after operating expenses (but before depreciation) divided by total assets.
5. Cash holdings: Cash and cash equivalents divided by total assets.
6. Market-to-book ratio: The sum of the market value of equity and total debts divided by total assets.
7. Retained earnings: Retained earnings divided by total assets.
8. Short-term debt: Short-term debt divided by total assets.
9. Long-term debt: Long-term debt divided by total debt.
10. Dividends per share: Dividends per share.

Table 4 reports the summary statistics for the firm-level financial data, including the summary statistics for our price change variable.

Table 4: *Firm-Level Financial Variables Summary Statistics*

Variable	*Mean*	*Median*	*Std Dev*	*P25*	*P75*	*N*
age	26.285	26.000	10.442	18.000	35.000	3270
total_assets	7.325	7.372	0.823	6.820	7.747	3270
book_leverage	0.241	0.229	0.156	0.124	0.336	3270
profitability	0.077	0.076	0.154	0.039	0.121	3270
cash	0.101	0.065	0.118	0.031	0.123	3270
market_to_book	1.728	1.155	1.968	0.848	1.744	3270
retained_earnings	0.259	0.286	0.325	0.163	0.394	3270
short_debt	0.065	0.041	0.081	0.007	0.082	3270
long_debt	0.667	0.777	0.320	0.494	0.923	3270
div_per_share	2.618	2.000	2.623	0.900	3.500	3270
pricechange	0.257	0.176	2.337	-0.811	1.288	3270

Notes: *The firm-level financial data has been obtained from Refinitiv Eikon. All the variables have been constructed following Patozi's (2023) methodology. The daily returns have been reported in percentage change. Data coverage is from year 2010 to 2018. Data source: Refinitiv Eikon.*

4. Methodology

We follow the event study panel regressions approach, based on high-frequency data, used by Patozi (2023) to identify the effect firm-level greenness has on the transmission of monetary policy to stock prices. Implicitly, we test the joint hypothesis that monetary policy impacts stock prices in Sweden and that the transmission of monetary policy on stock prices is impacted by firm-level greenness. Our methodology is based on the identifying assumption that the monetary policy shock is the only shock at the time of the monetary policy announcement. This is a reasonable assumption since a small time frame around the announcement reduces the likelihood of new information being released in the market at the same time. Furthermore, it also addresses any endogeneity issues that might occur if the Riksbank would take the stock market into account when making policy decisions. Since the window of time around the policy meeting is so tight, it is not feasible that the Riksbank would be able to take changes in the stock market during this period into account when making their policy decision. (D'Amico and Farka, 2011).

The regression specification for our model is the following:

$$\Delta p_{i,t} = \alpha_i + \delta_1 hf\_shock_t + \Gamma' X_{i,t-1} + \epsilon_{i,t} \tag{1}$$

$$\Delta p_{i,t} = \alpha_i + u_t + \beta\left(hf\_shock_t * env\_score_{i,t-1}\right) + \delta_1 hf\_shock_t + \delta_2 env\_score_{i,t-1} + \Gamma' X_{i,t-1} + \epsilon_{i,t} \tag{2}$$

Where regression (1) identifies what impact monetary policy has on stock prices and regression (2) identifies if the transmission of monetary policy on stock prices is influenced by firm-level greenness.

Our main coefficient of interest is β. Under our main hypothesis, we check if the statistical association between monetary policy shocks and price changes depends on the value of firm-level greenness. $\Delta p_{i,t}$ is the percentage change in the closing stock price from the day before a monetary policy shock and the day of a monetary policy shock for firm i at time t. The time t in our regression defines the event date of the monetary policy shock, which always occurs on the same day as a monetary policy meeting. hf_shock_t is the high-frequency monetary policy shock at event day t, as estimated by Laséen (2020). $env\_score_{i,t-1}$ is the environmental score for firm i lagged by one year from time t to ensure that the market has this information available to them at the time of the monetary policy shock. The MSCI ESG ratings are usually updated on an annual frequency. $X_{i,t-1}$ is our vector of controls which includes firm i's size, book leverage, age, profitability, cash holdings, market-to-book ratio, retained earnings, short-term and long-term debt, and dividends per share. All firm-level control variables are lagged by one quarter from time t to ensure that the market has this information available at the time of the monetary policy shock event. α_i is the firm fixed effects that absorb any time-invariant, unobservable firm heterogeneity. u_t is the event-date (time) fixed effect or industry-by-event-date fixed effects in our most saturated version of regression (2). Time fixed effects absorb any variation that changes over time but not across entities i.e., firms. Industry-by-event-date fixed effects are an interaction between industry and event-date dummies that absorb any difference between industries on a given date. The reported standard errors are heteroskedasticity robust errors.

5. Results

5.1 Results for Regression (1)

Table 5 summarizes the results from regression (1) when run on our complete dataset spanning over the period 2003 to 2018. The positive coefficient on hf_shock_t indicates that an unexpected increase in the monetary policy rate of 1 percentage point translates into a 2.5% increase in stock prices. This effect is significant at the 1% level. The findings of this regression are thus highly surprising, as textbook economic theory would predict a decrease in stock price as a result of tightening of monetary policy since it reduces the expected value of future dividends and raises the discount rate used to discount the dividends.

Table 5: *Baseline Results (2003-2018)*

	Dependent variable:
	Price change
HF Shock	2.545^{***}
	(0.425)
Firm FE	Yes
Event-Date FE	No
Industry-by-Event-Date FE	No
Controls	No
Observations	4,566
R^2	0.016
Adjusted R^2	-0.028
F Statistic	6.314^{***} (df = 11; 4372)
	*p**p***p<0.01

Notes*: This table reports a summary of our baseline results from regression (1). A 1 percentage point surprise increase in the Riksbank repo rate leads to a 2.545% increase in stock prices.*

However, the phenomenon of "wrong-sided shocks" is not entirely unheard of. [5] Jarociński and Peter (2020) highlight that these wrong-sided stock market responses can be due to some other shock that occurs simultaneously with the monetary policy shock on the announcement date. Jarociński and Peter (2020) refer to it as a "central bank information effect". During policy announcements, central banks may reveal data on unexpected strengths or weaknesses in the economy in addition to new information on their monetary policy. This information can serve as a shock to financial markets, leading to rapid adjustments in expectations and stock prices. Hence, information shocks are consistent with scenarios in which central banks simultaneously reveal private information about the current and future economic conditions and tighten or expand policy to counteract overheating or recessionary signs in the economy. These information shocks can lead to a positive correlation between monetary policy shocks and stock price changes, similar to what we observe in **Table 5**. For instance, in the presence of these information shocks, it would be reasonable for a large negative monetary policy shock (an expansionary shock i.e., a large surprise cut in the repo rate) to decrease stock prices. This is because the central bank would

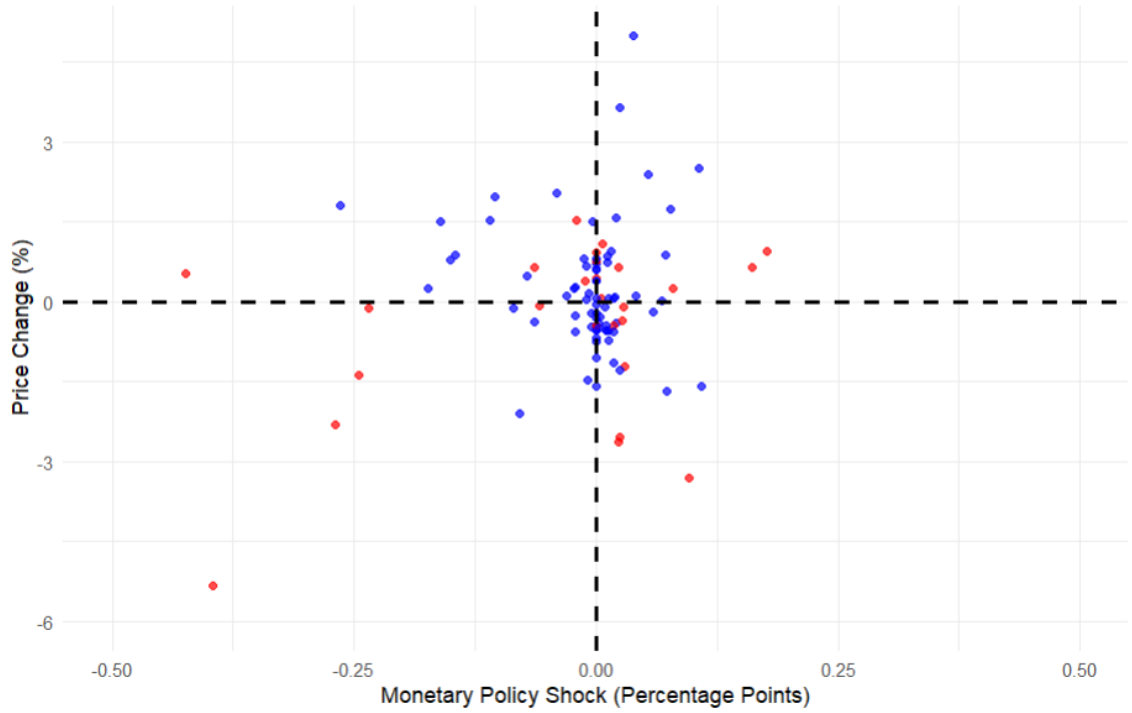
[5] Wrong sided shocks indicate increases in stock prices following a tightening of monetary policy, or a decrease in stock prices following a loosening of monetary policy.

have communicated a surprisingly negative outlook on the economy, which would lower investor confidence translating into lower stock prices.

Figure 6 plots the scatterplot of monetary policy surprises and the price change in the stock market. Each point corresponds to one of the 101 policy announcement events in our sample, plotted against the average price change of all firms on that date. The north-western and south-eastern quadrants represent the negative co-movement between interest rates and stock market reactions, consistent with standard economic theory. The north-eastern and south-western quadrants indicate the "wrong-sided" response of the stock market to monetary policy surprises. In other words, the north-western and south-eastern quadrants indicate standard monetary policy shocks and the north-eastern and south-western quadrants indicate central bank information shocks. This interpretation is based on a simple sign restrictions method suggested by Jarociński and Peter (2020).

Our sample period in **Table 5** spans from 2003 to 2018, which includes the global financial crises, and Jarociński and Peter (2020) document that central bank information shocks were particularly pronounced during this period. We find a consistent observation in our Swedish sample i.e., the large wrong-sided shocks (**Figure 6**) are due to the global financial crisis. Hence, we compare the results of our baseline regression for the pre-crisis period (2003 to 2007), the crisis period (2007 to the end of 2009), and the post-crisis period (2010 to 2018). The results of this analysis are summarized in **Table 6** which indeed show that it seems to be the global financial crisis that drives the coefficient of the hf_shock variable to turn positive. For this reason, we focus exclusively on the post-global financial crisis period as our main sample period to ensure that information shocks do not bias our results strongly. In the main sample (column 3, **Table 6**), we observe that a contractionary monetary policy shock of 1 percentage point translates into a 3.4% decrease in stock prices. This effect is significant at the 1% level. However, we do not exclude the other information shocks from our analysis which are concentrated around the origin (**Figure 6**) in our main sample i.e. 2010-2018. Therefore, the absolute value of the coefficients on hf_shock in all regressions should be slightly higher than reported.

Figure 6: *Average change in stock prices during monetary policy shock events*



Notes: *The points in red are the monetary policy shocks during the global financial crisis (2007-2009) and all points in the north-eastern and south-western quadrants are "wrong-sided" shocks. As seen in the figure, during the global financial crisis we observed significant "wrong-sided" shocks, particularly in the south-western quadrant. Data coverage is from year 2003 to 2018. Data source: Laséen (2020), Refinitiv Eikon.*

Table 6: *Monetary policy's impact on asset prices, divided into pre-crisis, crisis, and post-crisis.*

	Dependent variable:		
		Price Change	
	2003-2007	2007-2010	2010-2018
	(1)	(2)	(3)
HF Shock	-8.903***	4.907***	-3.350***
	(1.441)	(0.804)	(0.749)
Firm FE	Yes	Yes	Yes
Event-Date FE	No	No	No
Industry-by-Event-Date FE	No	No	No
Controls	Yes	Yes	Yes
Observations	841	463	3,270
R^2	0.069	0.157	0.016
Adjusted R^2	0.010	0.050	-0.045
F Statistic	5.330*** (df = 11; 790)	6.919*** (df = 11; 410)	4.512*** (df = 11; 3072)

*p**p***p<0.01

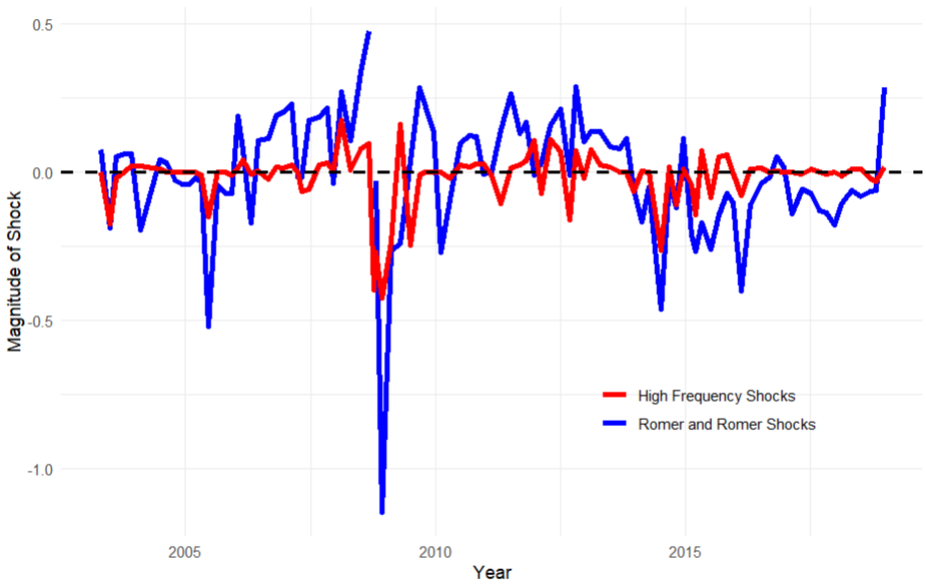
Notes*: This table reports the estimates of regression (1) for different periods. We see that during the period of the global financial crisis central bank information shocks led to the* hf_shock *coefficient turning positive.*

5.2 Robustness Results for Regression (1)

One possibility is that the results might vary depending on which measure of monetary policy shocks are used. We therefore use the Romer and Romer (R&R) monetary policy shocks, developed by Kilman (2022) as a robustness check for the results of regression (1). The R&R shock measure is one of the most used methods to estimate monetary policy surprises and was developed by Romer and Romer (2004). By regressing the repo rate changes on the annual forecast the Riksbank makes on GDP growth and CPI inflation at each monetary policy meeting, Kilman is able to estimate the shock variable for each meeting by measuring the residuals of each event. The main advantage of the R&R approach is the inclusion of forecasts of macroeconomic variables, formed using a multitude of economic variables. The shocks therefore identify changes in policy that are independent of current expectations of future economic conditions (Coibion, 2012).

Figure 7 shows a visualization of the R&R shock series against the high-frequency shock series developed by Laséen (2020). We see that most shocks are contained between +/-25bps for both series but with some clear outliers around the time of the great financial crisis. We also note that the R&R shocks tend to be larger than the high-frequency shocks. We observe differences in these shock series since they depend on what market participants know before policy announcements. Any hints or shifts in policy preferences by the Riksbank *revealed at the time of announcement*, will be identified by HFI shocks. However, if changes in preferences are revealed *before the announcement*, the market prices will adjust before the meeting and HFI shocks will not identify it. In contrast, information that becomes available between monetary policy meetings can be classified as shocks by R&R shocks, and the same information can be counted as a shock during multiple monetary policy events in this series (Sandström 2018).[6] While there exists clear variation between the two shock series, they still are correlated, with a correlation coefficient of 0.43.

Figure 7: *High frequency and Romer and Romer shock series*



Notes: *We see substantial differences in the Romer and Romer shocks and the high-frequency shocks due to differences in how they are estimated. All units are in percentage points. The blue line shows the Romer and Romer shocks developed by Kilman (2022), and the red line shows the high-frequency shocks developed by Laséen (2020). Data Coverage is from year 2003 to 2018. Data source: Laséen (2020), Kilman (2022).*

Table 7 summarizes our results using the R&R shocks. These are consistent with the results from the baseline regression (**Table 6**). The stock prices decrease in response to a tightening of monetary policy and increase in response to a loosening of monetary policy. The reason the estimated coefficient for the R&R shocks is smaller than the estimated coefficient for the high-frequency shocks is due to the higher standard deviation of the R&R shocks (**Table 2**). While more measures for monetary policy shocks exist, R&R and high-frequency shocks are generally considered the most reliable (Kilman 2022).

[6] For example, let's say the Riksbank would only use CPI, GDP, and unemployment when deciding the policy rate. Furthermore, let's say they suddenly would decide to add the EURSEK exchange rate as a determinant of the policy rate. If this decision is made public during the policy meeting, the high frequency shock series would count this sudden change as a shock for that meeting, but no effects would be visible during following meetings as this would now be public information that would be considered in the OIS-swap pricing. If the information would become available before the monetary policy meeting, the OIS-swap prices would adjust before the policy rate decision, and thus this information would not count as a shock. For the R&R series, the timing of this change would not matter, and the information would be counted as a shock regardless. Moreover, the impact of the exchange rate on monetary policy would also be counted as a shock for all subsequent meetings where the exchange rate influences the monetary policy decision.

***Table** 7: Romer and Romer shocks impact on asset prices 2010-2018*

	Dependent variable:
	Price Change
RR Shock	-0.870***
	(0.318)
Firm FE	Yes
Event-Date FE	No
Industry-by-Event-Date FE	No
Controls	Yes
Observations	3,270
R^2	0.012
Adjusted R^2	-0.049
F Statistic	3.362*** (df = 11; 3072)
	*p**p***p<0.01

***Notes**: This table reports the impact of an R&R shock on asset prices. This estimate indicates that a 1 percentage point surprise increase in the Riksbank repo rate leads to a decrease in stock prices by 0.87%.*

5.3 Baseline Results for Regression (2)

Table 8 summarizes our results for the post-global financial crisis period. This sample period excludes the large "wrong-sided shocks" from the global financial crisis. We observe that a surprise increase in the Riksbank repo rate of 1 percentage point translates into a 3.4% decrease in stock prices.

However, we do not observe a statistically significant impact of firm-level greenness in how policy shocks affect stock prices. This means that we find no support for our hypothesis that firm-level greenness impacts the transmission of monetary policy in a Swedish setting. This is contrary to what Patozi (2023) and Döttling and Lam (2023) observe in the US stock market. This holds true as we add event-date fixed effects, to control for unobservable differences across each event date, or industry-by-event-date fixed effects, to control for unobservable differences across industries for each date. Additionally, our robustness checks confirm the insignificance of the interaction term $hf\_shock_t * env\_score_{i,t-1}$. We thus conclude that the results observed by Patozi (2023) and Döttling and Lam (2023) in a US setting are not replicable in Sweden. We discuss the reasons behind these results extensively in section 6.

Table 8: *Baseline results for the period 2010-2018*

	Dependent variable:		
	Price Change		
	(1)	(2)	(3)
HF Shock	-3.352***		
	(0.749)		
Env Score	0.150	0.227*	0.182
	(0.135)	(0.119)	(0.127)
HF Shock*Env Score	0.272	0.225	0.034
	(0.747)	(0.636)	(0.786)
Firm FE	Yes	Yes	Yes
Event-Date FE	No	Yes	No
Industry-by-Event-Date FE	No	No	Yes
Controls	Yes	Yes	Yes
Observations	3,270	3,270	3,270
R^2	0.016	0.300	0.487
Adjusted R^2	-0.045	0.243	0.363
F Statistic	4.146*** (df = 12; 3071)	19.882*** (df = 65; 3018)	5.460*** (df = 457; 2626)

*p**p***p<0.01

Notes*: This table summarizes the results from regression (2). We see insignificant results for the* $hf\_shock * env\_score$ *interaction term across all specifications. As event-date fixed effects and industry-by-event-date fixed effects absorb all the variation caused by the high-frequency shocks, the high-frequency shock coefficient is not reported for any regression specification including event-date or industry-by-event-date fixed effects.*

5.4 Robustness Checks for Regression (2)

Alternative Monetary Policy Shocks*:* **Table 9** summarizes our results for regression (2) using the R&R shocks. These are consistent with the results from the baseline regression (**Table 8**), with the interaction term between monetary policy shocks and firm-level greenness being non-significant. Even as we add event-date fixed effects and industry-by-event-date fixed effects, we observe that our main coefficient of interest remains insignificant. Hence, our results are robust to the measure of monetary policy shocks. While more measures for monetary policy shocks exist, such as structural vector autoregressions (VAR) or R&R, high-frequency shocks are generally considered more reliable than these (Kilman 2022).

Table 9: *Baseline results using a Romer and Romer policy shock series*

	Dependent variable:			
	Price Change			
	(1)	(2)	(3)	(4)
RR Shock	-0.870***	-0.852***		
	(0.318)	(0.320)		
Env Score		0.125	0.220*	0.181
		(0.136)	(0.119)	(0.126)
RR Shock*Env Score		-0.211	-0.420	-0.043
		(0.327)	(0.282)	(0.354)
Firm FE	Yes	Yes	Yes	Yes
Event-Date FE	No	No	Yes	No
Industry-by-Event-Date FE	No	No	No	Yes
Controls	Yes	Yes	Yes	Yes
Observations	3,270	3,270	3,270	3,270
R^2	0.012	0.012	0.300	0.487
Adjusted R^2	-0.049	-0.049	0.244	0.363
F Statistic	3.362*** (df = 11; 3072)	3.116*** (df = 12; 3071)	19.928*** (df = 65; 3018)	5.460*** (df = 457; 2626)

*p**p***p<0.01

Notes: *This table summarizes the results from regression (2) using Romer and Romer shocks. We see insignificant results for the* $hf\_shock * env\_score$ *interaction term across all specifications.*

Alternative greenness scores: The second set of robustness checks are performed using an alternative measure of firms' environmental performance. Döttling and Lam (2023) use scope 1 emission to test if firm-level greenness impacts the transmission of monetary policy to asset prices. Additionally, Patozi (2023) augments her analysis by exploring if the raw environmental scores reported by the MSCI also can explain heterogeneous reactions of stock prices to monetary policy shocks. Following these papers, we test if the raw MSCI environmental pillar score or the MSCI carbon emission score (which we use as a proxy for Swedish Scope 1 emissions) would change our baseline results for the interaction term.[7]The result of this analysis is summarized in **Table 10**. We see that both of these alternative measures of firm-level greenness support our initial results i.e., changing the measure for greenness does not make the interaction term significant. We thus conclude that our baseline results are robust across multiple measures of firm-level greenness.

[7] More details about the greenness scores (MSCI environmental pillar score & MSCI carbon emission score) can be found in the appendix B & G.

Table 10: *Baseline regression using different environmental scores*

	Dependent variable:		
	Price Change		
	Baseline	Baseline with MSCI environmental pillar score	Baseline with MSCI Carbon Emissions score
	(1)	(2)	(3)
HF Shock*Env Score	0.034		
	(0.786)		
HF Shock*Env Raw Pillar Score		0.015	
		(0.293)	
HF Shock*Env Emissions Score			0.478
			(0.354)
Firm FE	Yes	Yes	Yes
Industry-by-Event-Date FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	3,270	1,274	924
R^2	0.487	0.736	0.802
Adjusted R^2	0.363	0.632	0.712
F Statistic	5.460^{***} (df = 457; 2626)	8.999^{***} (df = 283; 912)	10.534^{***} (df = 244; 633)
			*p**p***p<0.01

Notes*: This table summarizes the results from regression (2) for different measures of firm-level greenness. We see insignificant results for the* $hf\_shock * env\_score$ *interaction term across all specifications.*

Industry Sorting: While firm-level greenness does not significantly impact the transmission of monetary policy on an aggregate level, these results might vary between industries. In fact, Patozi (2023) observes that firm-level greenness only has a statistically significant impact on the transmission of monetary policy to stock prices in four out of the nine industries she includes in her dataset. To test if this might be the case for Sweden as well, we divide up our firms into the 10 ICB industries we have included in our dataset and run our baseline regression on each industry.[8] The result of this analysis is summarised in **Table 11**. We see that the interaction term is not statistically significant in any of our 10 industries, thus further strengthening our conclusion from the baseline regression that firm-level greenness does not seem to have a statistically significant impact on the transmission of monetary policy on stock prices in Sweden.

[8] As we do not have any "Utilities" firms in our dataset, we only have 10 ICB industries rather than 11.

Table 11: *Industry Sorting*

	Dependent variable:									
	Price Change									
	Basic Materials	Consumer Discretionary	Consumer Staples	Energy	Financials	Health Care	Industrials	Real Estate	Technology	Telecomm-unications
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
HF Score* Env Score	7.303	0.393	-2.367	-111.041	-2.126	2.240	-1.114	0.075	3.898	-0.049
	(9.365)	(1.354)	(4.429)	(102.437)	(2.982)	(10.519)	(1.724)	(4.138)	(14.123)	(3.966)
Observations	260	723	111	23	459	309	763	241	138	235
R^2	0.100	0.026	0.087	0.384	0.070	0.031	0.034	0.133	0.108	0.092
Adjusted R^2	0.012	-0.042	-0.103	0.097	0.007	-0.086	-0.039	0.014	-0.091	0.012
F Statistic	2.174** (df = 12; 236)	1.508 (df = 12; 675)	0.725 (df = 12; 91)	1.338 (df = 7; 15)	2.693*** (df = 12; 429)	0.728 (df = 12; 275)	2.052** (df = 12; 709)	2.696*** (df = 12; 211)	1.133 (df = 12; 112)	1.820** (df = 12; 215)

*p**p***p<0.01

Notes*: This table summarizes the results from regression (2) for each industry represented in our dataset. We see insignificant results for the* $hf\_shock * env\_score$ *interaction term across all specifications.*

Alternative sample periods: While firm-level greenness does not seem to predict the transmission of monetary policy on stock prices on average, this might vary across different types of monetary policy shocks. To explore this possibility, we divide the monetary policy shocks into expansionary and contractionary shocks. Since the implementation of expansionary and contractionary policies is characterized by different sets of economic conditions, through these tests we check if our results are symmetrical in those periods. **Table 12** summarizes our results for these periods. It confirms our previous results as the interaction term between firm-level greenness and the high-frequency shocks remains insignificant. We thus conclude that there does not exist any heterogeneity in the reaction of green and brown firms' stock prices to monetary policy shocks in a Swedish setting, no matter what period of monetary policy we look at.

Table 12: *Results only accounting for expansionary or contractionary policy shocks*

	Dependent variable:	
	Price Change	
	Contractionary	Expansionary
	(1)	(2)
HF Shock*Env Score	1.867	1.193
	(2.079)	(1.467)
Firm FE	Yes	Yes
Industry-by-Event-Date FE	Yes	Yes
Controls	Yes	Yes
Observations	2,023	1,247
R^2	0.508	0.501
Adjusted R^2	0.358	0.314
F Statistic	5.420^{***} (df = 294; 1544)	5.580^{***} (df = 163; 906)
Note:		*p**p***p<0.01

Notes*: This table summarizes the results from regression (2) while evaluating the contractionary and expansionary shocks separately. We see insignificant results for the* $hf\_shock * env\_score$ *interaction term across both specifications.*

Difference in green and brown firm characteristics: In **Tables 13 and 14**, we observe that firm-level financial characteristics differ substantially for green and brown firms. We perform quartile sorting on env_score and classify Quartile 1 firms as brown firms and Quartile 4 firms as green firms. Q1 firms have the lowest env_score whereas Q4 firms have the highest env_score in the sample. **Tables 13 & 14** show that green firms are less leveraged (*lower book leverage*), and more liquid (*higher cash*), with a higher market-to-book ratio. Jeenas (2023) finds that stock valuations of more liquid firms are less sensitive to borrowing rates. Ottonello and Winberry (2020) find that firms with higher book leverage are more responsive to monetary policy shocks. These differences in firm-level characteristics might be driving our results, hence, we test the following regression specification following Patozi's (2023) methodology:

$$\Delta p_{i,t} = \alpha_i + u_t + \beta\left(hf\_shock_t * env\_score_{i,t-1}\right) + \gamma(hf\_shock_t * c_{i,t-1}) + \delta_1 hf\_shock_t + \delta_2 env\_score_{i,t-1} + \delta_3 c_{i,t-1} + \Gamma' X_{i,t-1} + \epsilon_{i,t} \quad (3)$$

Where $(hf\_shock_t * c_{i,t-1})$ is an interaction term between policy shocks and firm-level characteristics. The other regression terms are the same as in regression (2). The main coefficient of interest, β, can be interpreted as, after controlling for the interaction between policy shock and a firm-level financial characteristic, the impact a monetary policy shock has on the stock prices of green firms relative to brown firms. **Table 15** reports the results from regression (3). We observe that β, is insignificant in all columns. This shows that firm-level characteristics are not driving our baseline results.

Table 13: *Q1(brown firms) Summary Statistics*

Variable	*Mean*	*Median*	*Std Dev*	*P25*	*P75*
env_score	-1.211	-1.143	0.547	-1.463	-0.837
age	22.831	24.000	9.363	17.000	26.000
total_assets	7.145	7.196	0.493	6.835	7.575
book_leverage	0.259	0.214	0.158	0.153	0.343
profitability	0.082	0.074	0.057	0.044	0.115
cash	0.068	0.041	0.078	0.027	0.092
market_to_book	1.293	0.987	0.702	0.885	1.464
retained_earnings	0.302	0.355	0.213	0.199	0.431
short_debt	0.062	0.042	0.071	0.013	0.086
long_debt	0.713	0.804	0.277	0.624	0.925
div_per_share	2.075	1.550	1.683	0.750	3.020
environmental.pillar.score	4.911	5.200	1.188	4.300	5.680
carbon.emissions.score	6.453	6.300	1.852	5.400	7.800
pricechange	0.203	0.199	2.779	-0.891	1.302

Table 14: *Q4 (green firms) Summary Statistics*

Variable	*Mean*	*Median*	*Std Dev*	*P25*	*P75*
env_score	1.138	1.134	0.195	1.062	1.246
age	24.285	26.000	9.073	22.000	30.000
total_assets	7.046	7.149	0.679	6.741	7.504
book_leverage	0.210	0.209	0.135	0.105	0.316
profitability	0.057	0.069	0.221	0.034	0.131
cash	0.112	0.078	0.110	0.044	0.147
market_to_book	1.881	1.160	2.212	0.804	1.953
retained_earnings	0.285	0.280	0.301	0.160	0.346
short_debt	0.054	0.030	0.081	0.001	0.078
long_debt	0.676	0.809	0.342	0.429	0.968
div_per_share	2.124	2.000	1.881	0.750	3.000
environmental.pillar.score	7.248	7.000	2.431	6.000	10.000
carbon.emissions.score	7.214	7.000	1.979	6.000	8.900
pricechange	0.223	0.075	2.173	-0.970	1.263

Variable	*t_statistic*	*p_value*
age	-3.1	0.0019
total_assets	3.2	0.0013
book_leverage	6.7	2.8e-11
profitability	3	0.0031
cash	-8.8	4.1e-18
market_to_book	-6.8	1.7e-11
retained_earnings	1.3	0.19
short_debt	2	0.042
long_debt	2.3	0.021
div_per_share	-0.53	0.59
env_score	-116	0
pricechange	-0.16	0.87

Notes*: Data coverage is from year 2010 to 2018. Data source: Refinitiv Eikon, MSCI ESG Time Series.*

Table 15: *Results from regression (3)*

	Dependent variable:										
	Price Change										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
HF Shock*Env Score	0.034	0.014	0.079	0.202	0.245	-0.018	0.203	0.079	0.107	-0.029	0.159
	(0.786)	(0.786)	(0.789)	(0.796)	(0.795)	(0.787)	(0.791)	(0.789)	(0.787)	(0.807)	(0.838)
HF Shock*Age		-0.089									-0.098
		(0.082)									(0.113)
HF Shock*Total Assets			0.704								0.289
			(1.099)								(1.635)
HF Shock*Book Leverage				6.538							-3.499
				(4.888)							(7.838)
HF Shock*Profitability					-12.303*						-2.699
					(7.110)						(9.685)
HF Shock*Cash						-9.032					4.140
						(7.823)					(10.395)
HF Shock*Market to Book							-0.911*				-0.599
							(0.501)				(0.770)
HF Shock*Short Debt								5.129			12.362
								(8.321)			(15.271)
HF Shock*Long Debt									3.104		4.291
									(2.143)		(3.875)
HF Shock* Dividend Per Share										0.094	0.261
										(0.274)	(0.318)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-by-Event-Date FE	`	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,270	3,270	3,270	3,270	3,270	3,270	3,270	3,270	3,270	3,270	3,270
R^2	0.487	0.487	0.487	0.488	0.488	0.487	0.488	0.487	0.488	0.487	0.488
Adjusted R^2	0.363	0.363	0.363	0.363	0.364	0.363	0.364	0.363	0.363	0.363	0.362
F Statistic	5.460*** (df = 457; 2626)	5.451*** (df = 458; 2625)	5.447*** (df = 458; 2625)	5.453*** (df = 458; 2625)	5.458*** (df = 458; 2625)	5.451*** (df = 458; 2625)	5.460*** (df = 458; 2625)	5.447*** (df = 458; 2625)	5.454*** (df = 458; 2625)	5.446*** (df = 458; 2625)	5.360*** (df = 465; 2618)

*p**p***p<0.01

Notes: *This table summarizes the results from regression (3). We see insignificant results for the $hf\_shock * env\_score$ interaction term across both specifications.*

6. Discussion

While we are able to confirm the findings that monetary policy indeed does have an impact on stock prices, our results suggest that monetary policy shocks do not have a heterogeneous impact on the stock prices of green and brown firms. However, Patozi (2023) and Döttling and Lam (2023) find that firm-level greenness has a statistically significant impact on the transmission of monetary policy to asset prices for US firms. As our study takes place in a different setting, Sweden, there are several reasons why we might see different results compared to the previous studies conducted on this topic. The differences in the results can primarily be attributed to investor expectations, risks, and differences in data.

6.1 Investor Expectations

Firstly, it's essential to understand why stock prices might react to policy shocks. According to Bernanke and Kuttner (2004), there is a robust response of stock markets to surprises in monetary policy. They demonstrate that the impact of these surprises on stock prices occurs through two main channels: expected future excess return and expected future dividends. In simpler terms, when there is a surprise in monetary policy, it influences what investors expect to earn in the future from holding stocks. The surprise can either affect the anticipated returns on stocks (excess return) or the expected future dividends that stocks will yield. To break it down further, in an environment of higher interest rates prompted by monetary policy changes, stock prices are expected to decrease. This is because investors anticipate a higher premium (extra return) on stocks to compensate for the increased risk associated with holding equities during periods of tight monetary policy.[9] In other words, when interest rates rise, investors become less willing to take on risk, and they expect higher returns on stocks as compensation for bearing that increased risk.

In our study, if monetary policy shocks would differently influence investors' willingness to bear risk for green and brown assets, it would be reflected in a significant interaction term. However, our observations indicate that monetary policy shocks do not have a differential impact on green and brown asset prices. This suggests that investors do not alter their expectations regarding the performance of green or brown assets in response to changes in monetary policy. In simpler terms, unexpected shifts in interest rates do not prompt investors to hold more green assets relative to brown. Consequently, it can be inferred that unanticipated changes in monetary policy do not influence investors' willingness to favor green assets.

6.2 Risk

Döttling and Lam (2023) find that "the heterogeneous reaction of the stock price of green and brown firms following a monetary policy shock is driven primarily by climate-related policy and legal risks as well as technological risks". They argue that as monetary policy tightens, it becomes more expensive for brown firms to borrow the money needed to replace dirty or polluting assets with greener, more environmentally friendly ones. This firstly creates a climate-related policy and legal risk for brown

[9] Higher interest rates make borrowing more expensive for businesses and consumers. This leads to reduced spending, lower corporate profits, and a general economic slowdown. As monetary policy tightens and economic conditions become more challenging, investors demand higher expected returns to compensate for the increased uncertainty and risk associated with holding stocks.

firms as they then are put in a more vulnerable position related to future changes in carbon emission standards and carbon taxes, which might induce extra operational costs for these firms. Moreover, this might also lead to the technological risk they refer to; the stranded asset risk. According to the University of Oxford's Smith School of Enterprise and the Environment (2014), stranded assets are "assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities". This might happen for several climate-related reasons such as changing resource landscapes, falling clean technology costs, evolving social norms, litigation, and changing statutory interpretations. Hence, investors might factor environmental risk into their decisions because of the costs that the aforementioned risks (regulatory risk and stranded asset risk) entail (Krueger et al. 2020).

In short, as interest rates increase, brown assets might become more exposed to regulatory and technological risks as the cost of capital, required to fund newer projects for transition, increases. This leads to a difference in the performance of green and brown assets in the short run. As American investors expect this change in performance in the short term, due to the unexpected monetary policy shock, stock prices for green and brown firms react differently. Hence, Döttling and Lam (2023) find significant results.

The results of our study suggest that monetary policy shocks do not alter the way Swedish investors assess the risk associated with brown stock. In simpler terms, unexpected changes in monetary policy are not anticipated to influence the performance of brown stocks differently than the performance of green stocks. Consequently, there is no discernible difference in the reaction of stock prices for green and brown firms because investors do not foresee any immediate changes in performance due to fluctuations in interest rates. This lack of sensitivity in the Swedish market could potentially be attributed to lower policy uncertainty compared to the US. If companies in Sweden face fewer technological, regulatory, and climate-related risks than their American counterparts, it implies that the dampening effect of a firm's environmental responsibility on the transmission of monetary policy to asset prices may not be as pronounced. This is to some extent supported by evidence, such as Sweden's early adoption of a carbon tax in 1991, making it one of the first countries to do so, and currently boasting the third-highest carbon tax rate globally (The World Bank, 2023). In contrast, the US lacks a national carbon pricing initiative.

The proactive climate policy framework in Sweden, including a well-established carbon pricing mechanism, suggests that firms in Sweden have had over a decade to adapt to a business environment with artificially increased carbon prices even before our sample period began. Consequently, carbon prices are an integral and natural aspect of the Swedish business landscape, making companies well-adapted and less vulnerable to sudden shocks in carbon pricing. In essence, Swedish firms are considered to be better prepared for and less affected by new carbon price shocks. Given that the Swedish climate policy framework is more advanced than its American counterpart, monetary policy shocks may not result in brown firms facing heightened exposure to regulatory risks. As a result, investors may not anticipate a significant change in the relative performance of green and brown firms in response to unexpected shifts in monetary policy. Consequently, the prices of green and brown assets demonstrate a uniform response to policy shocks in the Swedish context.

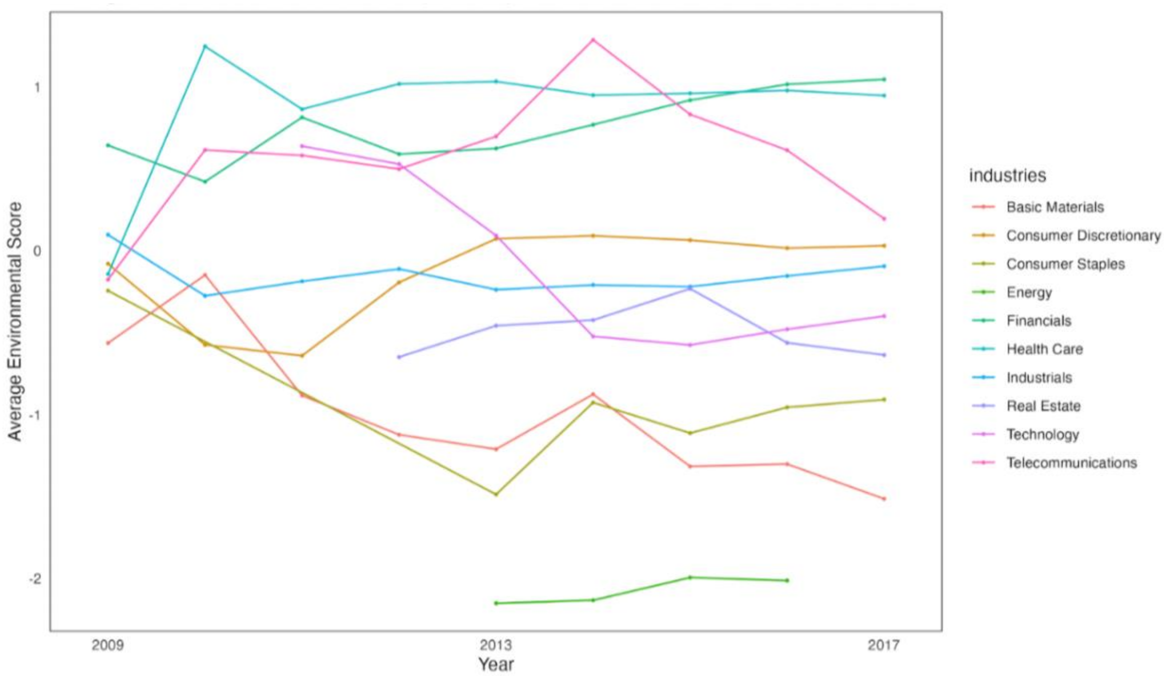
6.3 Differences in Data

There are some important differences in our dataset compared to those of previous studies. These differences enable previous studies to capture greater variations in green vs brown firms' stock prices' reaction to monetary policy shocks.

Firstly, we observe that Swedish firms are much greener than American firms on average. Patozi (2023) reports that the average greenness scores for the greenest and brownest firms in her dataset are -0.3 and -4.1 respectively. Since we have followed the same methodology to construct our greenness scores, we can directly compare the firms in our dataset. The average greenness scores, in our dataset, for the greenest and the brownest firms are 1.1 and -1.2 respectively (refer to Table: Q1 & Q5 summary statistics). This observation highlights the smaller relative difference between the environmental performance of green and brown firms in Sweden compared to the US. **Figure 8** plots the final average environmental score, across time, for the different industries. Compared to Figure 1 in Patozi (2023), which plots the average environmental score across time for her dataset, we also observe that most of the industries in Sweden exhibit a higher average greenness score over time. Secondly, the number of firms covered in previous studies differs significantly from ours. The American stock market is comprised of far more individual firms than the Swedish stock market, and among those firms, a much higher percentage is also covered by the MSCI ESG Ratings.

Furthermore, since we only include the firms for which the MSCI greenness score is available, our sample might face sample selection bias. Previous studies also face this challenge. MSCI ESG ratings are contingent on firm-level greenness data availability. It is reasonable to assume that greener firms would be more inclined to make their data available compared to brown firms. Hence, our sample firms might be greener than average and might not be entirely representative of all firms in the Stockholm Stock Exchange.

Figure 8: *Average Environmental Performance by industry over time*



Notes*: This figure plots the final average environmental score, across time, for the different industries. We observe that Energy is the least green industry in our sample. On the other hand, Financial and Health care are the greenest. Table 1: Panel B reports that the average env_score for our data is 0.005. This can be observed in this figure as well since most trend lines average around 0. Data coverage is from year 2009 to 2017. Data source: Refinitiv Eikon, MSCI ESG Time Series.*

7. Conclusion

This study has documented how monetary policy shocks impact the Swedish stock market and if firm-level greenness affects how monetary policy impacts stock prices. We find evidence for information shocks, which were heightened during the GFC crisis. Due to these information shocks, we chose 2010-2018 as our main sample to reduce the bias in our monetary policy shock estimate. As part of this empirical investigation, we observe that a surprise increase of the Riksbank repo rate of 1 percentage point translates into a -3.4% decrease in stock prices.

While previous studies have found that firm-level greenness dampens the transmission of monetary policy on asset prices in the US, we find no support for these results in Sweden. Instead, we find that the greenness of a firm has no impact on how strongly its stock market price reacts to monetary policy shocks. The results of our study suggest that monetary policy shocks do not alter the way Swedish investors assess the risk associated with brown assets. Consequently, there is no discernible difference in the reaction of stock prices for green and brown assets because investors do not foresee any immediate changes in performance due to fluctuations in interest rates. We speculate that this lack of sensitivity in the Swedish market could be attributed to lower policy uncertainty compared to the United States, differences in investor expectations, or inherent differences between Swedish and American firms.

Regardless of the cause, our results indicate that the Riksbank does not have the same indirect and disproportionately large impact on the cost of capital of brown firms that the US FED has through the stock market. This implies that, through the stock market channel, the FED will play a more important role in the green transition in the US than the Riksbank will play in the green transition in Sweden. However, further research is needed to explain why firm-level greenness has different impacts on the transmission of monetary policy to stock prices in Sweden compared to the US. Specifically, our results indicate that a monetary policy shock does not increase the relative risks held by Swedish investors in brown firms, which is evident from a homogenous response of green and brown stock prices to policy shocks. However, significant heterogeneous responses of green and brown stock prices are observed in the US. An empirical investigation of how and why monetary policy affects the relative risk between green and brown firms, across nations, would therefore be insightful to expand our understanding of how monetary policy will impact the green transition across the world. To delve further into this policy dynamic, it would be interesting to explore how changes in fiscal policy might impact green and brown assets. If investors anticipate that alterations in fiscal policy would affect the performance of these stocks differently, we might expect to observe a significant interaction term between fiscal policy shocks and the environmental performance of firms.

8. References

Baker, M. et al. (2022) How Do Investors Value ESG? *NBER Working Paper Series*.

Barth, M. J. & Ramey, V. A. (2000) The Cost Channel of Monetary Transmission. *NBER Working Paper Series*.

Bernanke, B. S. & Kuttner, K. N. (2005) What Explains the Stock Market's Reaction to Federal Reserve Policy? *The Journal of finance (New York)*. 60 (3), 1221–1257

Bolton, P. & Kacperczyk, M. (2021) Do investors care about carbon risk? *Journal of financial economics*. 142 (2), 517–549.

Bu, C. et al. (2021) A unified measure of Fed monetary policy shocks. *Journal of monetary economics*. 118331–349.

Caldecott, B. et al. (2014), *Stranded asset scenarios*. Available at: https://www.smithschool.ox.ac.uk/sites/default/files/2022-04/Stranded-Assets-and-Scenarios-Discussion-Paper.pdf [2023, November 15].

Chava, S. & Hsu, A. (2020) Financial Constraints, Monetary Policy Shocks, and the Cross-Section of Equity Returns. *The Review of financial studies*. 33 (9), 4367–4402.

Chudik, A. & Georgiadis, G. (2022) Estimation of Impulse Response Functions When Shocks Are Observed at a Higher Frequency Than Outcome Variables. *Journal of business & economic statistics*. 40 (3), 965–979.

Cloyne, J. et al. (2023) Monetary Policy, Corporate Finance, and Investment. *Journal of the European Economic Association*.

Coibion, O. (2012) Are the Effects of Monetary Policy Shocks Big or Small? *American economic journal. Macroeconomics*. 4 (2), 1–32.

D'Amico, S. & Farka, M. (2011) The Fed and the Stock Market: An Identification Based on Intraday Futures Data. *Journal of business & economic statistics*. 29 (1), 126–137.

Döttling, R. & Lam, A. (2023) Does Monetary Policy Shape the Path to Carbon Neutrality? *SSRN Research Papper*.

Fama, E. F. & French, K. R. (2007) Disagreement, tastes, and asset prices. *Journal of financial economics*. 83 (3), 667–689.

Gertler, M. & Karadi, P. (2015) Monetary Policy Surprises, Credit Costs, and Economic Activity. *American economic journal. Macroeconomics*. 7 (1), 44–76.

Gürkaynak, R. et al. (2022) Stock Market's Assessment of Monetary Policy Transmission: The Cash Flow Effect. *The Journal of finance (New York)*. 77 (4), 2375–2421.

Hartzmark, M. & Shue, K. (2022) Counterproductive Sustainable Investing: The Impact Elasticity of Brown and Green Firms. *SSRN Working Paper*.

Heinkel, R. et al. (2001) The Effect of Green Investment on Corporate Behavior. *Journal of financial and quantitative analysis*. 36 (4), 431–449.

Ioannidis, C. & Kontonikas, A. (2008) The Impact of Monetary Policy on Stock Prices. *Journal of policy modeling* 30 (1), 33–53.

Jarociński, M. & Karadi, P. (2020) Deconstructing Monetary Policy Surprises— The Role of Information Shocks. *American economic journal. Macroeconomics*. 12 (2), 1–43.

Jeenas, P. (2023) Firm Balance Sheet Liquidity, Monetary Policy Shocks, and Investment Dynamics. *Barcelona School of Economics Working Paper* (1409).

Kilman, J. (2022) Monetary Policy Shocks for Sweden, *Lund University Working Paper Series*, (2022:18).

Kontonikas, A. et al. (2013) Stock market reaction to fed funds rate surprises: State dependence and the financial crisis. *Journal of banking & finance*. 37 (11), 4025–4037.

Krueger, P. et al. (2020) The Importance of Climate Risks for Institutional Investors. *The Review of financial studies*. 33 (3), 1067–1111

Laséen, S. (2020) Monetary Policy Surprises, Central Bank Information Shocks, and Economic Activity in a Small Open Economy, *Sveriges Riksbank Working Paper Series*. (396).

MSCI ESG Research LLC (2023) *ESG Ratings Methodology*. Available at: https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology.pdf [2023, November 23].

Nakamura, E. & Steinsson, J. (2018) High-Frequency Identification of Monetary Non-Neutrality: The Information Effect. *The Quarterly journal of economics*. 133 (3), 1283–1330.

Ottonello, P. & Winberry, T. (2020) Financial heterogeneity and the investment channel of monetary policy. *Econometrica*. 88 (6), 2473–2502.

Pástor, Ľ. et al. (2022) Dissecting green returns. *Journal of financial economics*. 146 (2), 403–424.

Pástor, Ľ. et al. (2021) Sustainable investing in equilibrium. *Journal of financial economics*. 142 (2), 550–571.

Patozi, A. (2023) Green Transmission: Monetary Policy in the Age of ESG. *SSRN Working Paper.*

Pedersen, L. H. et al. (2021) Responsible investing: The ESG-efficient frontier. *Journal of financial economics*. 142 (2), 572–597.

Powell, J. (2023) *Panel on Central Bank Independence and the Mandate—Evolving Views*. Available at: https://www.federalreserve.gov/newsevents/speech/powell20230110a.htm [2023, November 30]

Ramey, V. A. (2016) Macroeconomic Shocks and Their Propagation. *NBER Working Paper Series*. 21978-.

Romer, C. D. & Romer, D. H. (2004) A New Measure of Monetary Shocks: Derivation and Implications. *The American economic review*. 94 (4), 1055–1084.

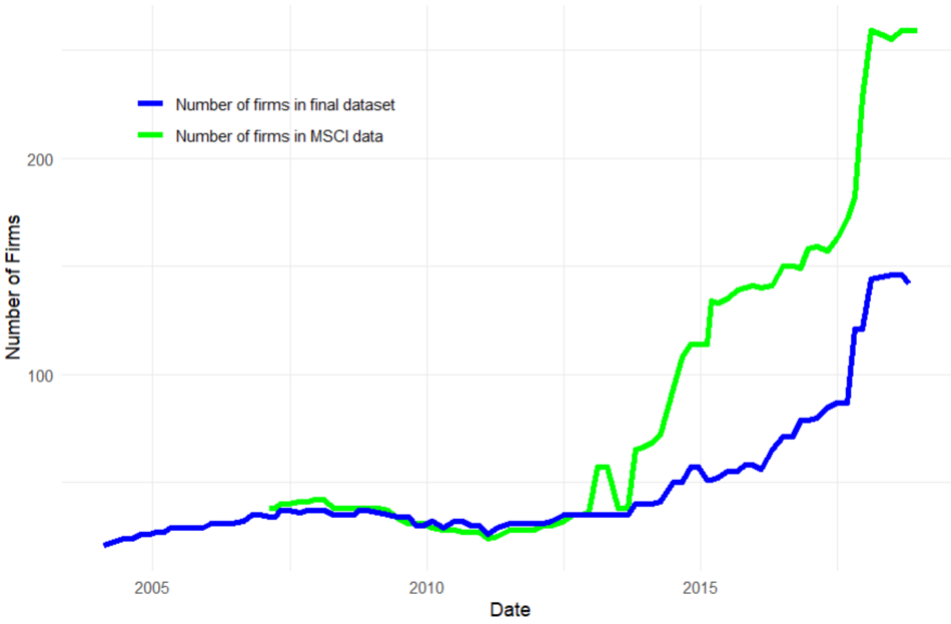
Sandström, M. (2018) The Impact of Monetary Policy on Household Borrowing - A High Frequency IV Identification. *Sveriges Riksbank Working Paper Series* (351).

Schnabel, I. (2023) *Monetary policy tightening and the green transition*. Available at: https://www.ecb.europa.eu/press/key/date/2023/html/ecb.sp230110~21c89bef1b.en.html [2023, November 30]

The World Bank (2023) *Carbon Pricing Dashboard*. Available at: https://carbonpricingdashboard.worldbank.org/ [2023, November 27]

9. Appendix

Appendix A: Number of securities over time in our dataset vs number of firms in the MSCI database



Notes*: The figure shows that the number of firms in our dataset roughly changes with the number of firms covered by the MSCI. The figure only shows the number of firms covered by the MSCI since 2007 since that is when the MSCI started to report which country the covered firm was located in. For the period 2010-2012, we see more firms in our final dataset than firms covered by the MSCI because some firms have more than one security listed (A-class stocks and B-class stocks for example). Data coverage is from 2003 to 2018. Data source: Refinitiv Eikon, MSCI ESG Time Series.*

Appendix B: The MSCI raw environmental pillar score

MSCI's ESG environmental score is categorized into 4 themes and 13 key issues. Companies receive a score from 0-10 for each key issue, reflecting their performance—0 being the worst, and 10 being the best. These scores assess the company's risk exposure and management capabilities for specific issues. The Key Issue Exposure Score measures exposure, while the Key Issue Management Score evaluates management effectiveness. Theme scores are weighted averages of key issue scores, and the overall environmental score is the weighted average of all key issue scores. See the summary table below for themes and key issues.

Environmental	Climate Change	Carbon Emissions Climate Change Vulnerability
		Financing Environmental Impact
		Product Carbon Footprint
	Natural Capital	Biodiversity & Land Use
		Raw Material Sourcing
		Water Stress
	Pollution & Waste	Electronic Waste
		Packaging Material & Waste
		Toxic Emissions & Waste
	Environmental Opportunities	Opportunities in Clean Tech
		Opportunities in Green Building
		Opportunities in Renewable Energy

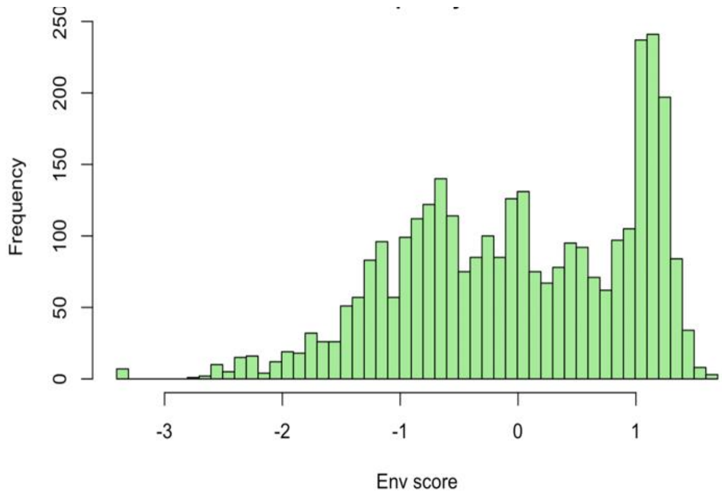
Notes: *Source:* MSCI ESG Research LLC (2023) *ESG Ratings Methodology*. Available at: https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology.pdf

Appendix C: Correlation matrix of all variables

	book_leverage	short_debt	hf_shock	total_assets	div_per_share	retained_earnings	profitability	market_to_book	cash	env_score	long_debt	pricechange
book_leverage	1	0.56	0.01	0.24	-0.03	-0.33	-0.4	-0.26	-0.36	-0.05	0.2	0.01
short_debt	0.56	1	0.01	0.28	0.17	-0.11	-0.29	-0.27	-0.35	-0.04	-0.49	0.01
hf_shock	0.01	0.01	1	0.12	0.05	0.02	0.02	-0.01	0.01	0	0.02	-0.1
total_assets	0.24	0.28	0.12	1	0.43	0.03	-0.22	-0.39	-0.12	0.11	0.08	0.06
div_per_share	-0.03	0.17	0.05	0.43	1	0.11	0.05	-0.18	-0.11	0.14	-0.12	0.02
retained_earnings	-0.33	-0.11	0.02	0.03	0.11	1	0.46	0.23	-0.03	-0.12	-0.15	0.05
profitability	-0.4	-0.29	0.02	-0.22	0.05	0.46	1	0.64	0.18	-0.07	-0.04	0.01
market_to_book	-0.26	-0.27	-0.01	-0.39	-0.18	0.23	0.64	1	0.21	-0.02	-0.08	-0.01
cash	-0.36	-0.35	0.01	-0.12	-0.11	-0.03	0.18	0.21	1	0.16	-0.09	-0.01
env_score	-0.05	-0.04	0	0.11	0.14	-0.12	-0.07	-0.02	0.16	1	0.01	0
long_debt	0.2	-0.49	0.02	0.08	-0.12	-0.15	-0.04	-0.08	-0.09	0.01	1	0.01
pricechange	0.01	0.01	-0.1	0.06	0.02	0.05	0.01	-0.01	-0.01	0	0.01	1

Notes: *This figure reports the correlation between different firm-level financial data points used in the main study. Data coverage is from 2003 to 2018. Data source: Refinitiv Eikon, MSCI ESG Time Series.*

Appendix D: Frequency distribution of environmental scores across our dataset



Notes: *The env_score frequency distribution has a mean around 0. Few firms achieve an env_score higher than 1, but we see a long tail of firms with low env_score. Data coverage is from 2003 to 2018. Data source: MSCI ESG Time Series.*

Appendix E: MSCI carbon emission score

In the MSCI ESG Ratings model, Carbon Emissions play a crucial role in the Environmental Pillar. Companies are evaluated based on carbon intensity and their efforts to manage climate risks. The Carbon Emissions Key Issue Score considers Exposure and Management Scores. The Exposure Score involves Business and Geographic Exposure Scores, where the latter acts as a multiplier. Both scores are on a 0-10 scale, with 10 indicating the highest risk. The Business Exposure Score is a weighted average of business segment scores, and the Geographic Exposure Score is a weighted average of country and region scores (MSCI ESG Research LLC, 2023).