HONG KONG MONETARY AUTHORITY

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DOES THE INFLUENCE OF US MONETARY POLICY SHOCKS ON ASIAN AND EUROPEAN STOCKS DEPEND ON THEIR "GREENNESS"?

Key points

- *This memorandum builds upon the existing literature on how firms' environmental, social, and governance (ESG) performance affects their equity returns, by examining the differential impact of a US monetary policy shock on Asian and European companies, conditional on their environmental (or "greenness") scores.*

- *We find that greener firms are less sensitive to US monetary policy shocks. The cushioning impact increases over time in Europe, but not in Asia. The cushioning impact is asymmetric and stronger in case of a contractionary shock, conceivably due to regulations as well as the presence of ESG-aware institutional investors. Additionally, we find that a portfolio of the greenest firms outperforms both the market portfolio and a portfolio of the brownest firms in the face of contractionary monetary policy shocks.*

- *Our study carries two policy implications. First, in the face of uncertain US monetary policy, strengthening the environmental performance of firms could to some extent enhance equity market resilience to spillovers. Second, there appears to be further room for Asian regulators to boost investors' awareness of the virtues of ESG investing.*

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I. INTRODUCTION

Amongst the notable trends in investing since the beginning of the millennia have been the burgeoning influence of ESG criteria on investment decisions, monetary policy's swelling influence on asset prices, and US monetary policy spillovers. At the intersectionality of those trends lies the influence of US monetary policy on Asian and European equities conditional on the companies' "greenness".

In a seminal paper, Patozi (2023) uncovers the impact of US monetary policy on US stock returns conditional on their "greenness". She finds that, ceteris paribus, greener stocks' prices are less affected by monetary policy than their browner counterparts. This study adopts her methodology but – new to this paper – transposes it to a transnational setting by examining the impact of US monetary policy on Asian and European jurisdictions conditional on company "greenness". We also explore a longer time period with a much larger sample of companies.

Monetary policy shock series have been a standard economic feature ever since the seminal work of Kuttner (2001), or Romer and Romer (2004), enabling economists to construct estimates of various central banks' monetary policy impulses. Notable developments in that field include Bu et al. (2019), which built a series that is particularly attractive to us for several reasons explained in section 2.2.

Those monetary policy shocks have been used to study their effect domestically (e.g. Nakamura and Steinsson (2018), Jarocinski and Karadi (2020)), or their spillovers, i.e. their effect on other economies (see Rey (2013), Gilchrist et al. (2014)). Those spillovers typically propagate via three channels: domestic macroeconomic conditions, foreign exchange, and bond premia (Kearns et al. (2018)). Meanwhile, Rogers et al. (2014) document the existence of an asset price spillover channel, which is our channel of interest. Such studies typically estimate the relationship between the change in asset prices (equities, bonds, derivatives, etc.) in reaction to a monetary policy shock. Patozi's (2023) paper is the first to estimate the effect of US monetary policy on domestic firms conditional on their greenness, and we are the first to document the impact of US monetary policy spillovers conditional on company greenness.

Our methodology examines daily stock return around Federal Open Market Committee (FOMC) announcements. More specifically, we regress the log return of stock i, at time t on the monetary policy shock, company greenness, and an interaction term of those two, whilst controlling for factors which could affect the returns.

We find that, ceteris paribus, greener companies are less sensitive to US monetary policy shocks. This effect is stronger and has increased over time in Europe, whilst stagnating in Asia, and materialised in the first half of the 2010s. This impact is asymmetric and depends on the nature of the shock (stronger and more statistically significant in case of a contractionary shock), which we conjecture to arise from regulations or the presence of ESG-aware institutional investors. We also find that equal- or value-weighted portfolios of green stocks are less sensitive to monetary policy shocks than their brown counterparts. Again, this effect is clearest in Europe.

The rest of this paper is structured as follows. Section II discusses our methodology and data, including the construction of the monetary policy shock, and the transformed ESG scores. In Section III, we present our key finding and robustness tests, whilst the remaining two sections present the policy implications and our conclusion.

II. METHODOLOGY AND DATA

2.1 Model

We perform a panel ordinary least square (OLS) regression, where the main coefficient of interest is an interaction term between the monetary policy shock and the (lagged) environmental score of the firm. Formally, our model is

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

with

- $\Delta p_{i,t}$: the return (log difference between closing quotes of stock prices of firm i at time t the day before and the day after an FOMC announcement)
- ε_t^m: the monetary policy shock
- $g_{i,t-1}$: the lagged (1 year) greenness score, as defined in Section 2.4
- $Z_{i,t-1}$: a vector of lagged (1 quarter) firm-specific controls
- $e_{i,t}$: an error term
- α_i, α_{st}, and α_c are respectively firm, sector by time, and country fixed effects.

This model specification, which is adapted from Patozi (2023), enables us to isolate the effect of the monetary policy shock by focusing on the window surrounding the FOMC meetings, which reduces the probability of a market event (or a climate shock) being accidentally captured.[1] We control for factors which could influence firms' sensitivity to monetary policy in $Z_{i,t-1}$ (including size, book leverage, short- and long-term debt, profitability, retained earnings, cash holdings, and market-to-book ratio). Throughout this paper, and unless specified otherwise, we use heteroscedasticity-robust standard errors.[2]

2.2 Monetary policy shock

We follow Bu et al.'s (2019) methodology to build a monetary policy shock series, which relies on changes in zero-coupon yields (with maturities from 1 to 30 years) around FOMC announcements, supposing those are driven by monetary policy shocks and other factors, and positing that employing a Fama-MacBeth two-step procedure and Rigobon-Sack's heteroscedasticity-based estimator would yield an unbiased monetary policy shock series.

The first step involves 30 time-series regressions of changes in zero-coupon yields on changes in the two-year yield using a partial least square approach, to estimate each maturity's sensitivity vis-à-vis the two-year yield. We then perform cross-sectional regressions of changes in yields on the estimated sensitivity index $\widehat{\beta_i}$. The estimated coefficient $e_t^{aligned}$ is the monetary policy shock series. Finally, we normalise this shock series to have a one-to-one relationship with the instrument (variations in the two-year yield).

a) $\Delta R_{i,t} = \alpha_i + \beta_i[\Delta R_{2,t}] + \mu_{i,t}$ with:
   - $i = 1, 2, \ldots, 30$, and
   - $[\Delta R_{2,t}] = (\Delta R_{2,t}, \Delta R_{2,t}^*)$ with:
     - $\Delta R_{i,t}$ the change in the yield of zero-coupon bond with maturity i at time t (around FOMC announcement day), and
     - $\Delta R_{i,t}^*$ the change in the yield one week before.

[1] Our specification differs from Patozi (2023) in two ways. First, we include both constitutive terms of the interaction term, as we see no rationale for removing the stand-alone monetary policy shock term. Additionally, while Patozi's specification only includes firm-level fixed effect and "sector-by-time" fixed effect, we also include country fixed effects due to our international setting.

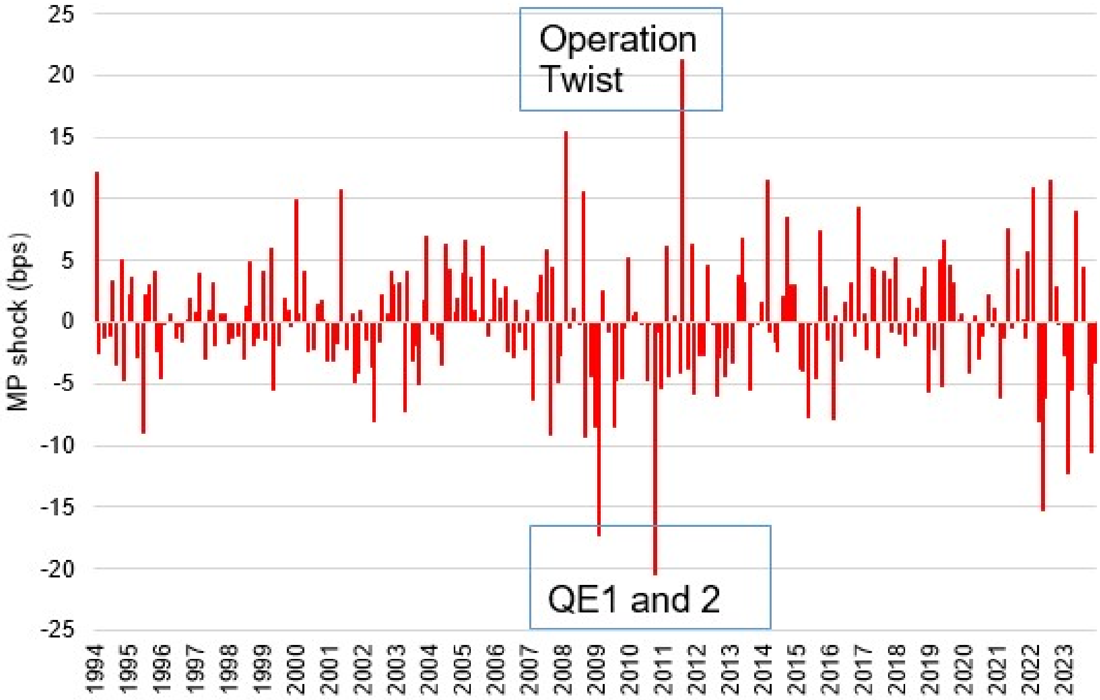
[2] Using conventional standard errors, or standard errors clustering by year to account for potential correlation, does not significantly affect the results.

b) $\Delta R_{i,t} = \alpha_i + e_t^{aligned}\widehat{\beta}_i + v_{i,t}$ with:

- $t = 1, 2, \dots, T$ an index of T FOMC dates,
- $e_t^{aligned}$ the monetary policy shock series, and
- $\widehat{\beta}_i$ our estimated coefficients from the time series regressions.

Our series spans 239 FOMC meetings, from January 1994 (when the FOMC adopted the current announcement format with a two-day meeting followed by a press conference) to January 2024. Expansionary monetary policy shocks result in a negative impulse (bond yields fall), whilst contractionary shocks provide a positive impulse (bond yields rise). For example, the announcement for quantitative easing (QE) 1 and QE2 (Chart 1) are large expansionary shocks. The series is expressed in percentage points.

Chart 1: The constructed monetary policy shock series



Source: HKMA staff calculations.

Looking at the recent past, we can see that the November, December, and January FOMCs of 2023–2024 were expansionary, whilst the March 2022 meeting was contractionary. That the three meetings after the March 2022 one (when the Fed hiked by 0.50, 0.75, and 0.75 respectively) were expansionary shocks highlights a key feature of this series: it solely captures surprise. Any FOMC decision which was already priced in by financial markets prior to the day preceding the FOMC will not affect the yield on treasuries, and is thus not be captured by our series.

This monetary policy shock series is particularly attractive for our design for several reasons. First, it bridges over periods of conventional and unconventional monetary policies, allowing us to use the full range of available ESG scores. Second, due to its daily nature, it avoids aggregation effects. Third, thanks to the author's use of the full range of maturities, it contains very little central bank information effect. Finally, it is largely unpredictable from available information on the economy.

2.3 Firm-level data

We collect daily equity price data from Thomson Reuters' Refinitiv for publicly listed firms with headquarters in Asia (including Oceania) and Europe, and which have received an ESG score from Refinitiv. As Refinitiv provides ESG scores only from 2002 onwards, our final sample for Europe consists of 126, 117 observations over 167 FOMC dates, with 2,271 companies across 38 countries and territories. Our final sample for Asia consists of 162,925 observations over 167 FOMC dates, with 4,054 companies across 32 countries and territories.

2.4 ESG score data

For each firm in the sample, we transform the industry adjusted "environmental scores" into industry-comparable scores according to Pastor et al. (2022). We first transform the scores into industry-comparable ones (equation a). $E_{score,i,t}$ is company i's environmental score at time t, a number ranging between 0 (worst score) and 100 (best score), as provided by Refinitiv. $\left(10 - E_{score,i,t}/10\right)$ thus measures how far a company is from a perfect score, which we then multiply by $E_{weight,i,t}$ (the environmental weight of i at t) reflecting the importance of the "E" in ESG for that company (a constant for a given industry).[3] We thus obtain a brownness score, which we transform into a greenness score by adding the minus sign. We then demean them (equation b)

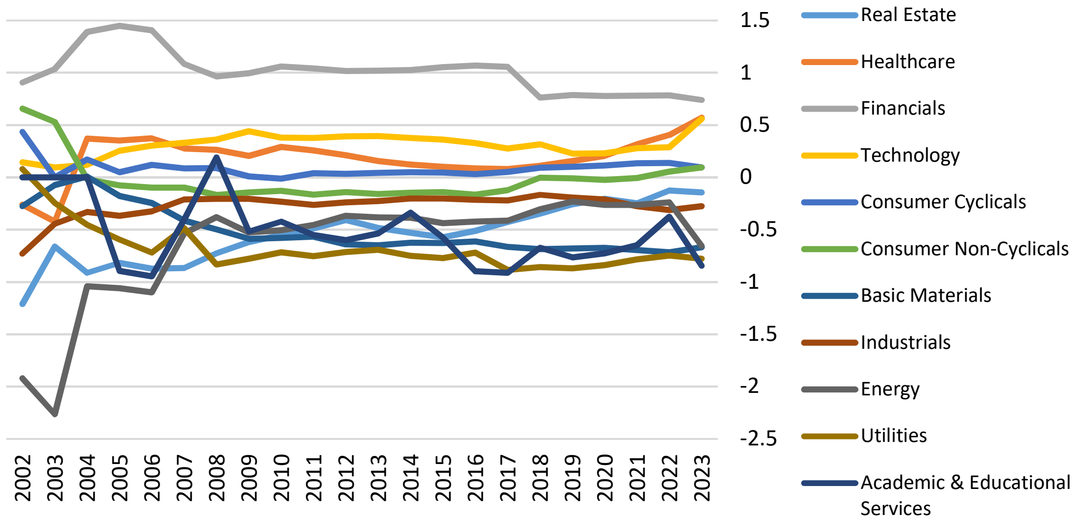
[3] Adjusting the raw scores by weight allows environmental scores to become comparable across industries. With raw scores, some companies within brown industries (e.g. energy) will receive a high score relative to peers (and greener companies in other industries), even as their overall impact on climate remains harmful. Adjusting the scores enables us to create industry-comparable scores, since the weights reflect the relative importance of the "E" pillar compared with the "S" and "G" ones. Our transformed scores give "greener" industries better scores, as shown in Chart 2.

with a market-value-weighted mean. For the purpose of interpreting our regression results, we standardise them.

a) $G_{i,t} = -((10 - E_{score,i,t}/10) \times E_{weigh\ ,i,t})/100$
b) $Env\ score_{i,t} = G_{i,t} - \overline{G_t}$, with $\overline{G_t}$ the value-weighted average of $G_{i,t}$

Since Refinitiv does not provide the time series data for the environmental pillar weights, we infer them using regressions of environmental, social, and governance scores on the overall ESG score at the industry by year level. Results appear consistent across time and with the current published weights.

Chart 2: Greenness scores in Asia



Note: The sectoral pattern of greenness scores in Europe is similar and is not shown for brevity.

Sources: Refinitiv and HKMA staff calculations.

Looking at Chart 2, two results stand out. As expected, polluting industries such as real estate, energy, or utilities have the worst scores, whilst greener ones such as financials or technology fare better. Second, scores do not increase over time, which is concerning both for the environment and for the robustness of our results. We find two explanations: (1) the coverage of the Refinitiv database increased dramatically over the past two decades (newly included firms appear to be relatively less green), and (2) greener firms likely had an incentive to advertise themselves as such from an early date, whilst dirtier ones avoided grading until being forced to. If we look at scores at the firm level, they do increase.

III. EMPIRICAL RESULTS

3.1 Baseline results

In line with Patozi's results, we expect a contractionary monetary policy shock to drive down stock returns (a negative monetary policy shock coefficient), and company greenness to cushion that impact (a positive interaction term). The regression results of Equation (1) are presented in Tables 1, 2, and 3. They are in line with predictions.

- A contractionary monetary policy shock of 100 basis points (bps) has a systematic, negative, and statistically significant (at 0.1% level) impact on stock returns of 6% in Asia and 9% in Europe. The effect is slightly more pronounced in Europe than in Asia.

- Meanwhile, a 1 standard deviation increase in greenness score decreases this impact by about 0.5 percentage points in Asia and 0.8 percentage points in Europe (8.3% and 8.8% of the total effect respectively).[4]

- Finally, a 1 standard deviation increase in the greenness score has a marginally negative and mostly statistically insignificant impact on stock returns.

Table 1: Baseline results and results by region

	(I) Full Sample	(II) Europe	(III) Asia
MP shock ($\boldsymbol{\gamma}$)	-7.36*** (0.15)	-9.09*** (0.23)	-6.08*** (0.19)
MP shock x Env. Score ($\boldsymbol{\beta}$)	0.65*** (0.14)	0.79*** (0.22)	0.54** (0.18)
Env. Score ($\boldsymbol{\delta}$)	-0.05** (0.02)	-0.02 (0.03)	-0.05· (0.03)
Adjusted R-squared	0.08	0.09	0.09
Observations	283,084	120,319	162,765

Note: "MP shock" = Monetary policy shock. "Env. Score" = transformed environmental score. Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

[4] Those figures are calculated as the ratio between Table 1's coefficients in rows 2 and 3 of columns II and III. A 100-basis point shock reduces returns by 9% in Europe, a 1 standard deviation increase in greenness reduced that effect by 0.8 percentage points, or about 8.8% of the total effect.

Table 2: Regression results for Europe

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
MP shock (γ)	-10.42*** (0.19)	-10.37*** (0.19)	-10.38*** (0.19)	-9.09*** (0.23)	-9.09*** (0.23)		
MP shock x Env. Score (β)			0.76*** (0.19)	0.80*** (0.22)	0.79*** (0.22)	0.70** (0.23)	0.68** (0.23)
Env. Score (δ)			0.00 (0.01)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)
Firm FE	No	No	No	Yes	Yes	Yes	Yes
Sector FE	No	No	No	Yes	No	No	Yes
Time FE	No	No	No	Yes	No	No	Yes
Sector_Time FE	No	No	No	No	Yes	Yes	No
Country FE	No	No	No	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.03	0.03	0.04	0.08	0.09	0.06	0.07
Observations	126,117	126,117	120,319	120,319	120,319	120,319	120,319

Note: Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

Table 3: Regression results for Asia

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
MP shock ($\boldsymbol{\gamma}$)	-6.75*** (0.15)	-6.74*** (0.16)	-6.74*** (0.16)	-6.09*** (0.19)	-6.08*** (0.19)		
MP shock x Env. Score ($\boldsymbol{\beta}$)			0.50** (0.16)	0.48** (0.18)	0.54** (0.15)	0.45* (0.18)	0.51** (0.18)
Env. Score ($\boldsymbol{\delta}$)			0.00 (0.01)	-0.06** (0.02)	-0.05· (0.0.03)	-0.06* (0.02)	-0.05· (0.05)
Firm FE	No	No	No	Yes	Yes	Yes	Yes
Sector FE	No	No	No	Yes	No	No	Yes
Time FE	No	No	No	Yes	No	No	Yes
Sector_Time FE	No	No	No	No	Yes	Yes	No
Country FE	No	No	No	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.0124	0.0126	0.0127	0.0518	0.0608	0.0428	0.0519
Observations	162925	162925	162765	162765	162765	162765	162765

Note: Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

3.2 Regression by quintiles of greenness scores

We can use a non-parametric way to explore the impact of a monetary policy shock conditional on firms' greenness. To do so, we construct "bins" (here quintiles) [5] of companies ordered by greenness scores. We then perform regressions on them according to the equation:

$$\Delta p_{i,t} = \alpha_i + \alpha_{st} + \alpha_c + \gamma \varepsilon_t^m + \Gamma' Z_{i,t-1} + e_{i,t} \quad (2)$$

Since the "greenness" of a company is already accounted for when we construct the bins, we only keep the monetary policy shock term along with the controls and fixed effects. We can thus estimate the slope for each group separately, and explore the existence of potential discontinuities. In Europe (Table 4) and Asia (Table 5), we see that the impact of a monetary policy shock is strongest for brown firms (in quintile 1) and weakest for greenest firms (in

[5] Results are similar when using only four bins, or 10 bins (although less linear in their clarity), and there is no reason to prefer a particular size for the bins other than striking the right balance between statistical significance and additional information.

quintile 5). Moreover, we see that the results vary linearly with greenness, and no bin has an outsized impact on the sensitivity to the monetary policy shock. This confirms our initial finding that greenness shields firms from monetary policy shocks.

Table 4: Bins for Europe

	(I)	(II)	(III)	(IV)	(V)
MP shock (γ)	-10.58*** (0.5572)	-9.33*** (0.5150)	-8.98*** (0.5355)	-8.05*** (0.5145)	-8.61*** (0.4704)
Adjusted R-squared	0.1108	0.1190	0.1136	0.1143	0.1156
Observations	25,202	25,182	25,246	25,187	25,300

Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

Table 5: Bins for Asia

	(I)	(II)	(III)	(IV)	(V)
MP shock ()	-6.79*** (0.4297)	-6.27*** (0.4324)	-6.14*** (0.4281)	-5.91*** (0.4356)	-5.19*** (0.4148)
Adjusted R-squared	0.0973	0.1000	0.0940	0.0939	0.0817
Observations	32,487	32,659	32,515	32,555	32,709

Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

3.3 Expanding window regressions

Our earlier results capture the average effect of greenness across time, but cannot show the differential impact across time. Since there were many developments from 2022 to the present time (e.g. Paris Agreement, rise of ESG investing), we look at the evolution of the coefficients over time using expanding window regressions (Charts 3 to 6).

For the monetary policy shock, we observe a similar strongly negative and statistically significant coefficient, with a slightly more pronounced impact in Europe than in Asia.

As for the interaction term, its coefficient for Asia stagnated during the 2010s at around 1%, before sharply increasing in 2022 and decreasing again thereafter. It has been statistically significantly (95% level) positive since early 2012. In Europe, meanwhile, the significance and level of this term increased gradually over the past decade, peaking in 2022 before slightly decreasing. This appears consistent with the narrative of the rise of ESG investing: as it gained prominence and investors began basing their decisions in part on ESG factors, this was reflected in prices.

Chart 3: Europe, interaction term coefficient

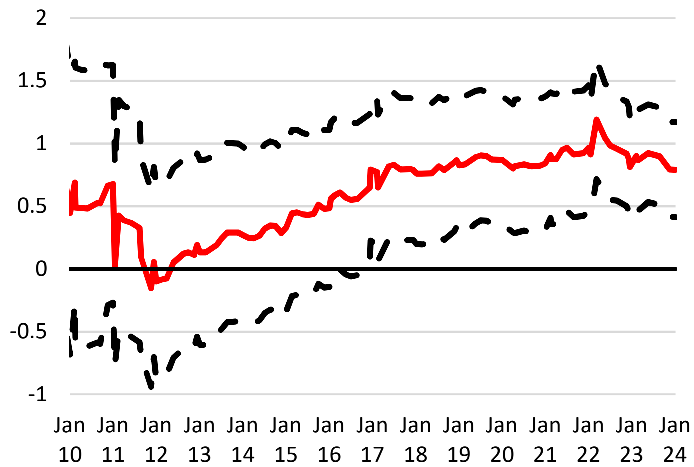


Chart 4: Europe, monetary policy term coefficient

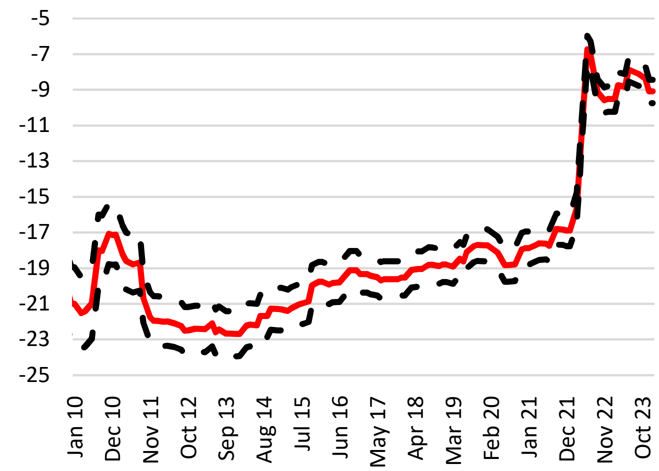


Chart 5: Asia, interaction term coefficient

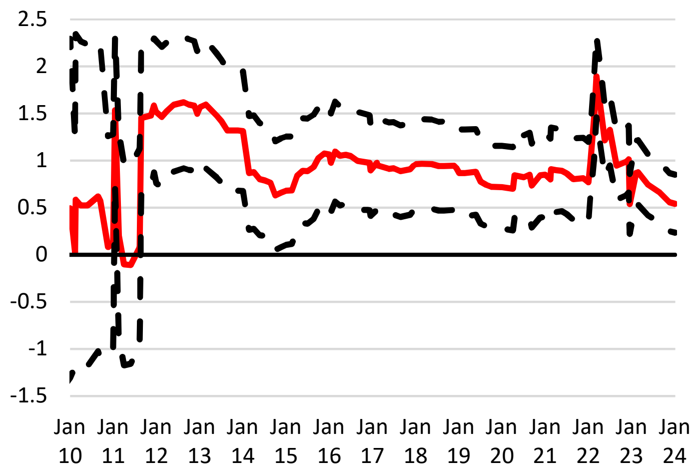
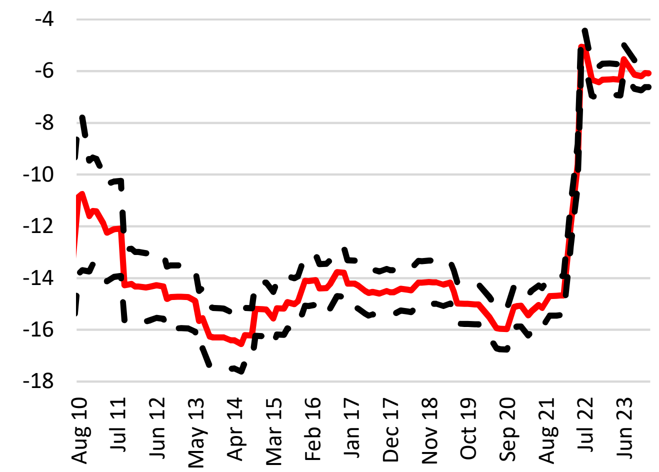


Chart 6: Asia, monetary policy term coefficient



Source: HKMA staff estimations.

To further refine our historical analysis, we investigate the differential impact across various periods (Tables 6 to 9). The overarching goal is to examine the evolution of our coefficients across time and through different Fed regimes. We propose to investigate the following:

- Pre-global financial crisis (GFC) (before December 2007), GFC (December 2007 to June 2009), and prior to the end of the GFC (i.e. up to June 2009, when the US recession was declared to have ended by the National Bureau of Economic Research). The goal is to check that our results are not driven by strong outliers at the time of the GFC.

- Zero lower bound period (ZLB) (December 2008 to December 2015), post-ZLB period (after December 2015), post-ZLB period and pre-COVID-19 period (December 2015 to February 2020). The goal is to examine the differentiated impact in unconventional versus conventional monetary policy settings during these periods and throughout the 2010s.

- COVID-19 period (March 2020 to December 2021), and the post-COVID-19 / current tightening era.

- Various periods prior to and after the Paris Agreement on climate change (12 December 2015), which was adopted at the 2015 UN Climate Change Conference (COP21). We are curious to see if this agreement, hailed as a landmark in climate awareness, has made a difference.

For the monetary policy shock coefficient, our results are roughly similar across periods: the coefficient remains significant and negative throughout the periods studied (except for the post-COVID-19 period in Asia), and decreases slightly in magnitude until dropping sharply in the post-COVID-19 period.

For the interaction term, the story is different:

- In Asia, the entire significance of our interaction term is driven by the ZLB and COVID-19 periods. We do not observe an increase over time, nor do we see that the Paris Agreement made a positive difference. In other words, our coefficient does not significantly change in level after the Paris Agreement, which we can see in Chart 5. Such findings underpin one of the key policy implications of this paper, which is that there is still room for further heightening of investor awareness on ESG investing in Asia.

- Meanwhile in Europe we observe an increase over time in the interaction term's significance, and a clear difference in the post- and pre-Paris Agreement periods. This result appears to reflect increasing appetite for green assets amongst investors purchasing European securities, and reinforces the narrative that as ESG investing gained prominence, it had an impact on prices.

Table 6: Regressions for Asia by selected sub-periods

	(I) Baseline	(II) Pre-GFC	(III) GFC	(IV) Pre-GFC + GFC	(V) Post-GFC	(VI) ZLB	(VII) Post-ZLB	(VIII) Post-ZLB & Pre-COVID-19	(IX) COVID-19	(X) Post-COVID-19
MP shock ($\boldsymbol{\gamma}$)	-6.08*** (0.19)	-26.11*** (1.30)	-9.98*** (0.18)	-15.42*** (1.41)	-5.77*** (0.19)	-13.23*** (0.33)	-3.12*** (0.22)	-17.20*** (0.40)	-12.08*** (0.65)	0.87*** (0.26)
MP shock x Env. Score ($\boldsymbol{\beta}$)	0.54** (0.28)	-4.00*** (0.00)	0.52 (0.22)	-0.06 (0.16)	0.50** (0.18)	0.93** (0.31)	0.33 (0.21)	-0.17 (0.42)	1.13* (0.67)	0.30 (0.26)
Env. Score ($\boldsymbol{\delta}$)	-0.05* (0.03)	0.03 (0.19)	0.51 (0.42)	0.05 (0.16)	-0.06* (0.07)	-0.09* (0.07)	-0.02 (0.04)	0.13· (0.07)	-0.29* (0.17)	-0.29* (0.13)
Adjusted R-squared	0.06	0.19	0.23	0.17	0.06	0.12	0.05	0.14	0.10	0.07
Observations	162,765	4,218	2,823	7,041	155,860	40,867	116,278	39,886	30,894	45,498

Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

Table 7: Influence of Paris Agreement, Asia

	(I) Pre- COP21	(II) Post-COP21	(III) Post-GFC & Pre-COP21	(IV) Post-COP21 & Pre-COVID-19	(V) Post-COP21 & Pre-2022
MP shock ($\boldsymbol{\gamma}$)	-14.89*** (0.34)	-3.12*** (0.22)	-14.95*** (0.33)	-17.20*** (0.40)	-15.56*** (0.35)
MP shock x Env. Score ($\boldsymbol{\beta}$)	1.03** (0.34)	0.35 (0.21)	1.04*** (0.31)	-0.09 (0.42)	0.47 (0.36)
Env. Score ($\boldsymbol{\delta}$)	-0.03 (0.06)	-0.02· (0.04)	-0.11 (0.07)	0.12· (0.06)	0.07 (0.05)
Adjusted R-squared	0.14	0.05	0.13	0.15	0.10
Observations	45,415	117,350	38,420	40,958	71,852

Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

Table 8: Regressions for Europe by selected sub-periods

	(I) Baseline	(II) Pre-GFC	(III) GFC	(IV) Pre-GFC + GFC	(V) Post-GFC	(VI) ZLB	(VII) Post-ZLB	(VIII) Post-ZLB & Pre-COVID-19	(IX) COVID-19	(X) Post-COVID-19
MP shock ($\boldsymbol{\gamma}$)	-9.09*** (0.29)	-6.08*** (0.19)	-1.97*** (0.49)	-9.49*** (0.36)	-7.66*** (0.23)	-17.85*** (0.41)	-3.79*** (0.22)	-11.44*** (0.49)	-11.63*** (0.74)	-1.01** 0.37
MP shock x Env. Score ($\boldsymbol{\beta}$)	0.80** (0.22)	0.54** (0.02)	2.93*** (0.05)	-0.17 (0.34)	0.80*** (0.23)	0.25 (0.40)	1.00*** (0.26)	2.04*** (0.49)	1.15 (0.72)	0.80* 0.33
Env. Score ($\boldsymbol{\delta}$)	-0.02 (0.03)	-0.05* (0.03)	-0.08. (0.04)	-0.13*** (0.03)	-0.01· (0.04)	-0.01 (0.08)	0.00 (0.08)	0.09 (0.09)	-0.36· (0.19)	-0.01 0.20
Adjusted R-squared	0.08	0.18	0.21	0.18	0.07	0.19	0.06	0.12	0.08	0.10
Observations	120,319	8,197	4,817	13,014	107,305	28,464	80,912	28,221	23,830	28,861

Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

Table 9: Influence of Paris Agreement, Europe

	(I) Pre- COP21	(II) Post-COP21	(III) Post-GFC & Pre-COP21	(IV) Post-COP21 & Pre-COVID	(V) Post-COP21 & Pre-2022
MP shock ($\boldsymbol{\gamma}$)	-19.96*** (0.40)	-3.79*** (0.26)	-19.73*** (0.40)	-11.45*** (0.49)	-11.60*** (0.41)
MP shock x Env. Score ($\boldsymbol{\beta}$)	0.51 (0.38)	1.00*** (0.26)	0.38 (0.39)	2.00*** (0.49)	1.77*** (0.41)
Env. Score ($\boldsymbol{\delta}$)	-0.05 (0.05)	-0.00 (0.05)	-0.05 (0.09)	0.06 (0.08)	0.03 (0.06)
Adjusted R-squared	0.19	0.06	0.17	0.12	0.07
Observations	38,800	81,519	25,786	28,828	52,658

Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

3.4 Nature of monetary policy shock and the role of institutional investors

After establishing the level and evolution of the cushioning impact, we seek to uncover whether it also depends on the nature of monetary policy shocks. To do so, we explore asymmetries between contractionary and expansionary monetary policy shocks. As such, we focus on the coefficients associated with the interaction terms. Results are presented in Table 10.

For the interaction term, results are particularly interesting. First, we see that the coefficient is only statistically significant in case of a contractionary shock. Second, we see that the magnitude of such coefficient decreases sharply in case of an expansionary shock.

This means that in the case of a contractionary shock, the monetary policy term has a lesser impact on stock returns, whilst the greenness of the company has a stronger cushioning impact. The result is a particularly strong cushioning effect relative to the size of the shock. Meanwhile in the case of an expansionary shock, with a stronger sensitivity to a monetary policy shock, and an insignificant cushioning effect, company greenness does not play much of a role.

This result sheds light on the reason why greenness plays a role in shielding companies from monetary policy shocks. The asymmetry reveals that some constraint or friction exists only in the case of a contractionary shock. It limits the ability of investors to react to contractionary monetary policy shocks by selling assets, whilst not hindering their faculty to buy more equities in the case of an expansionary shock. Two explanations spring to mind.

The first one is regulatory: funds that label themselves as green must hold a certain percentage of green assets (or reach a certain average ESG score), and those which use an exclusion strategy only invest in the greenest company in each sector, and divest from the most polluting ones. As those investors are constrained by rules with regard to their green holdings, they may not be capable (or willing) to react to monetary policy shocks by selling their green assets, which would mute their volatility without affecting that of brown ones.

The second is preferences: certain investors have a stronger appetite for greener assets, either because of personal convictions or because of regulatory constraints. Those investors may be less sensitive to short-term fluctuations and may value sustainable investing for reasons unrelated to risk and returns, and be willing to pay a premium to hold green assets.[6]

It is therefore likely that investors' preferences materialised via investments in green funds (which are themselves constrained by their own rules),

[6] In her paper, Patozi (2023) develops a stylised model which incorporates investors' preference for green assets, which has three important implications that can explain the lower volatility of green assets: "(i) the semi-elasticity of equity prices to interest rates is lower for green firms compared to their brown counterparts; (ii) the differential response of green-vs-brown firms to interest rates gets amplified in states of the world with stronger preferences for sustainable investing; (iii) a contractionary monetary policy shock generates an increase in the portfolio weight of green securities."

as revealed by the asymmetric effect between a contractionary and an expansionary shock. This is consistent with the work of Patozi (2023), which finds that institutional ownership by ESG-mandated funds is a key driver in the differential sensitivity of green versus brown shocks. She also shows that institutional investors respond to contractionary shocks by increasing their holdings of green assets, owing to their preference for sustainable investing.

Table 10: Estimated impact of contractionary versus expansionary monetary policy shocks by region

	Europe			**Asia**		
	(I) Baseline	(II) Contractionary	(III) Expansionary	(IV) Baseline	(V) Contractionary	(VI) Expansionary
MP shock ($\boldsymbol{\gamma}$)	-9.09*** (0.23)	-6.19*** (0.54)	-13.33*** (0.48)	-6.08*** (0.19)	-1.97*** (0.49)	-9.49*** (0.36)
MP shock x Env. Score ($\boldsymbol{\beta}$)	0.80*** (0.22)	1.30* (0.51)	0.04 (0.44)	0.54** (0.28)	2.93*** (0.05)	0.17 (0.34)
Env. Score ($\boldsymbol{\delta}$)	-0.02 (0.03)	-0.10· (0.05)	-0.01 (0.04)	-0.05 (0.03)	-0.08· (0.04)	-0.13 (0.03)
Adjusted R-squared	0.08	0.14	0.15	0.06	0.10	0.11
Observations	120,319	56,857	63,462	162,765	76,223	86,542

Robust standard errors are reported in parentheses. ***, **, *, and · indicate significance at 0.1%, 1%, 5%, and 10% levels respectively.
Source: HKMA staff estimation.

3.5 Portfolios

To investigate the market impact of the dampening effect of greenness, we can construct portfolios using our aforementioned bins (in Section 3.2), and compare their performance across time. Because the dampening effect only became significant at the turn of the last decade, and the number of companies only significantly increased after the GFC, we chose to start our analysis with the first FOMC of 2010, excluding the previous ones.

Our previous results would predict that the green portfolio should be less volatile than the brown portfolio, meaning that the green portfolio should incur fewer losses in case of a contractionary shock, but make fewer gains in case of an expansionary shock. Table 12 reports the results, whilst Charts 8–9 and Charts 10–11 show the evolution for Europe and Asia respectively in the case of a contractionary and expansionary shock.

We build both equal- and value-weighted portfolios. The returns are constructed as follow: we buy the securities on the day prior to the FOMC and sell them on the day after. This ensures we avoid capturing other shocks. Each portfolio will then face either contractionary or expansionary shocks separately, and reinvest the proceeds at the next FOMC date of the same nature (contractionary or expansionary). Each portfolio starts at a value of 100, and thus functions akin to an index, tracking the performance of each portfolio type in each region when facing each type of shock.

First, we build equal-weighted portfolios. Those will purchase one stock from each company on the day preceding the FOMC announcement, and sell it on the day after (similar to the way we constructed our returns earlier). We see that in Europe, the green portfolio is clearly less volatile in both types of shocks, by around 20 percentage points. However, in Asia, this is clearly not the case, with the green and brown portfolio returns being almost equal.

Next, we build market value-weighted portfolios. Those will purchase $\frac{Market\ Cap_i}{\sum_{i=1}^{N} Market\ Cap_i}$ (with *N* the total number of companies with an E score at that date) stock from each company on the day preceding the FOMC announcement, and sell it on the day after (similar to the way we constructed our returns earlier). Again, our green European portfolio is clearly less affected, although this is more pronounced in the case of an expansionary shock. Interestingly, our results for Asia show that the green portfolio outperformed the brown one in both cases, suggesting that green stocks apparently offer better risk–return trade-offs than their brown counterparts.

Table 12: Returns of portfolios, index, January 2010 = 100

		Equal weighted		Market value-weighted	
		Green	Brown	Green	Brown
Europe	Contractionary	76	57	65	59
	Expansionary	128	145	110	161
Asia	Contractionary	82	84	85	81
	Expansionary	134	132	140	128

Chart 8: Europe, contractionary shock, value-weighted

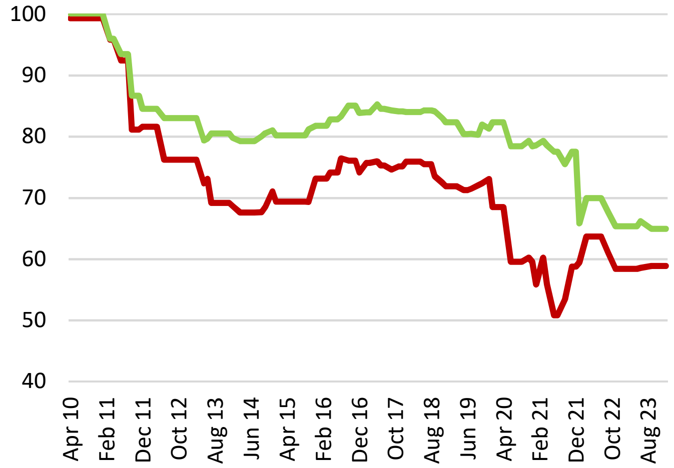


Chart 9: Europe, expansionary shock, value-weighted

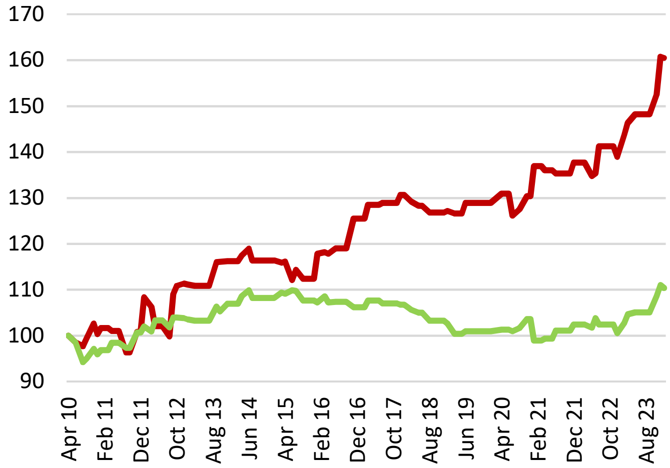


Chart 10: Asia, contractionary shock, value-weighted

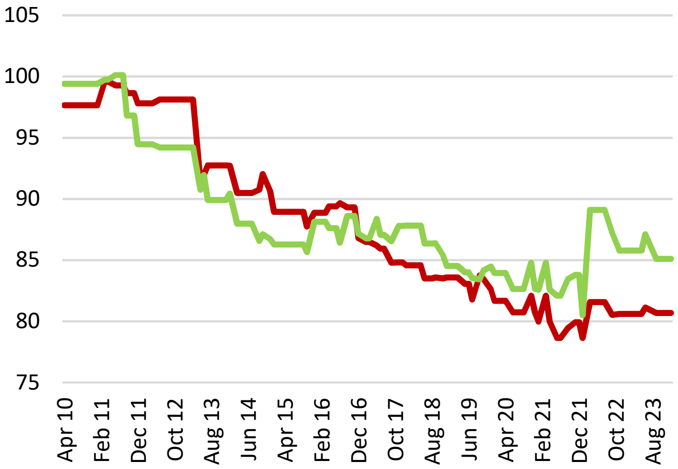
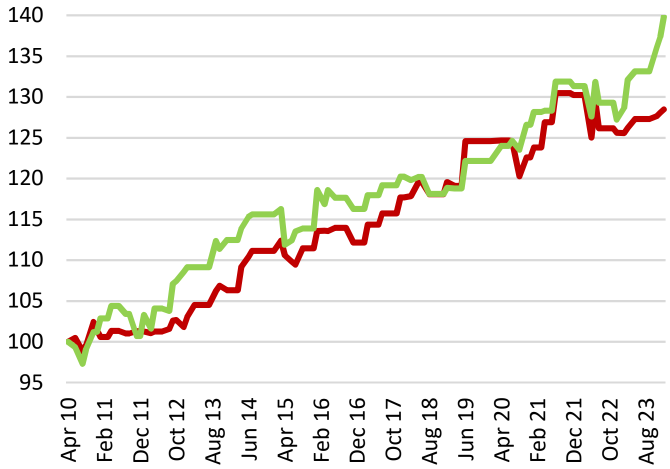


Chart 11: Asia, expansionary shock, value-weighted



Note: Green and red lines represent the evolution of a green and brown portfolio respectively.

Source: HKMA staff calculations.

IV. POLICY IMPLICATIONS

We believe that regulators may account for this volatility-dampening effect of greenness in several ways.

- First, since the relationship varies in strength across time, geography, and nature of shocks, the dampening effect should not be treated as a static factor but as a dynamic one. Both Asia and Europe have seen that relationship partly reverse since the pandemic.

- Second, those different reaction functions (depending on greenness) signal friction, likely owing to regulations. In times of market stress and uncertainty regarding future monetary policy, this warrants extra scrutiny and care, since those frictions could lead to sudden unforeseen movement linked to price discovery.

- Third, greenness might be seen as a double-edged sword by central banks:
    - On the one hand, greener companies could hinder the "asset price" transmission channel of monetary policy. As companies strive towards net zero, monetary policy could become less powerful. The overall effectiveness of monetary policy is likely to follow a reverse bell shape, decreasing as more companies become green before a threshold is reached and "greenness" loses its significance.

    - On the other hand, "greenness" should be regarded a powerful tool to shield equity markets from monetary policy spillovers and enhance their resilience. This is particularly important when monetary policy cycles are not synchronised, as in the current juncture. This implication is probably particularly judicious in the case of Asia, since the impact of greenness there is smaller (and there is therefore more potential for progress) and the sensitivity to US rates remains high.

- Fourth, green regulations could have unintended impacts on share prices. Green rules should therefore be studied and calibrated in this light.

- Finally, greenness could be incorporated in banks' risk management model, since it has an impact on asset prices.

With regard to the differential effect across geographies, we believe that Asian economies may make reference to the European experience when promoting ESG awareness among investors in the region. Indeed, results across time and different findings in Europe seem to indicate a clearer and more significant effect of company greenness. Since Europe is often hailed as a leader in the green transition and ESG investing, and as a global standard setter ("the Brussels effect"), Asian policymakers could import some of Brussels' playbook:

- If the regulatory channel is the main one, it could hint that green funds in Asia are not sufficiently regulated or, at the very least, that changes in the regulatory landscape over the past 15 years have not impacted investors' behaviour vis-à-vis green assets. Strengthening disclosure and transparency requirements, and adopting methodological standards and a unified taxonomy are all steps worth considering.

- Meanwhile, if the investors' preference channel is the primary driver behind the impact of greenness, it would mean that there is still room for policymakers to instil greater ESG awareness among investors.

V. Conclusion

Our findings reveal the importance of non-price factors, namely, a firm's environmental performance, on determining their share price sensitivity to US monetary policy. This result is asymmetric in three ways: (1) across geographies, with a larger impact in Europe; (2) across time, with an increasing impact in Europe; and (3) across shocks, with a much stronger impact in the case of a contractionary shock. We conjecture that regulatory requirements on the portfolio holdings of green funds, as well as preferences for ESG among institutional investors, may have contributed to the increased resilience to monetary policy shocks among greener firms. Additionally, we show that in Europe, a portfolio of green stocks outperformed one composed of brown stocks in the face of monetary policy shocks, and such a phenomenon was absent for Asian stocks.

Our study carries two policy implications. First, in the face of uncertain US monetary policy, strengthening the environmental performance of firms could to some extent strengthen and/or enhance equity market resilience to spillovers. Second, there appears to be further room for Asian regulators to boost investors' awareness of the virtues of ESG investing.

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