Not All "Doing Good" Become "Doing Well":

Divergent Channels of ESG Impact on Corporate Innovation

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Abstract

In this paper we examine how different components of firm's ESG performance affect its innovation output. Our results suggest that in the short-term, better performance in *Emission* enhances corporate innovation by improving firm R&D's sensitivity to opportunity set, employee innovation productivity, and effective utilization of free cash flows. However, this positive effect can be offset by increased spending on ESG components like *Product Responsibility* and *Shareholders* as firms experience increase in cost of capital and excessive cash holding. In the long-term, both controlled emission and effective use of resources benefit corporate innovation as they significantly improve firm R&D's sensitivity to opportunity set.

Keywords: ESG; technological innovation; Emission

JEL Classifications: O30; Q01; Q50; G30;

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Abstract

In this paper we examine how different components of firm's ESG performance affect its innovation output. Our results suggest that in the short-term, better performance in *Emission* enhances corporate innovation by improving firm R&D's sensitivity to opportunity set, employee innovation productivity, and effective utilization of free cash flows. However, this positive effect can be offset by increased spending on ESG components like *Product Responsibility* and *Shareholders* as firms experience increase in cost of capital and excessive cash holding. In the long-term, both controlled emission and effective use of resources benefit corporate innovation as they significantly improve firm R&D's sensitivity to opportunity set.

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1. Introduction

Investors' growing concern over environmental and social turbulences leads to a burst of research in corporate social responsibility (CSR) and effects of its environmental, social and governance performances (ESG). (e.g. H. Hong et al., 2020; Stroebel & Wurgler, 2021). However, the economic consequences of ESG remains debated in the literature given the mixed empirical evidence, especially on the long-term effect of ESG including innovation (e.g. Brooks & Oikonomou, 2018; Diaye et al., 2022; Qiu et al., 2016). In this paper, we show that the confounding effects of ESG on innovation in existing literature could be at least partially attributed to the contradicting effects of "E" (Environmental), "S" (Social) and "G" (Governance), as well as the diverting channels through which firms' ESG performances affect innovation.

Extant literature mainly debates on two contrasting effects on the relationship between ESG and innovation, the trade-off effect and the synergy effect. The trade-off effect is consistent with the agency view of ESG, arguing that ESG is a product of agency problems inside the firm and therefore value destructive (e.g. Benabou & Tirole, 2010; Cheng et al., 2013; Masulis & Reza, 2015). Managers who conduct intensive ESG investment under resource constraints will essentially crowd out research and development (R&D) activities and thus impedes innovation. However, the good governance view of ESG suggests that ESG can be consistent with shareholder value maximization in well-governed firms and therefore promotes R&D in the long run. Empirical researchers report mixed evidence on both theories. For example, Mithani (2017) provides evidence on the trade-off effect between CSR [1] and innovation. Tanriverdi & Venkatraman (2005), Surroca et al. (2010) and Tsang et al. (2021) document evidence consistent

[1] The concept of CSR is similar to that of ESG. Compared with CSR, ESG has an explicitly defined governance pillar and therefore usually considered more expansive than CSR (Gillan et al., 2021).

with the synergy effect, arguing that ESG and innovation can share specialist knowledge, information and infrastructure, and the synergy of the two helps to form the economics of scope. Findings of Broadstock et al. (2020), Celik et al. (2022) and Fuente et al. (2022) suggest an inverted U-shape between firm's ESG and its performance in long-term commitments like ESG. Fu et al. (2020) conducted a comprehensive study of both effects in a multi-country sample. While research methodology, geographical location, and time coverage of data samples may all affect study outcomes, our findings suggest that while better performance in ESG improves corporate innovation in general, improvements in certain ESG components may reduce firm's innovation in the short-run. Overall, our findings are consistent with the good governance view of ESG, that better ESG performances are practices of good corporate governance and "doing good" can ultimately translate into "doing good" both in the short-term and long-term.

Firms' ESG performances are usually evaluated and rated by various rating agencies. For rating agencies focusing on firms' ESG performances,[2] ESG ratings are obtained as the weighted average score of the environmental ("E"), social ("S"), and governance ("G") pillar, respectively. These three pillars are further divided into ten categories and twenty-five themes.[3] While higher scores in each category or theme indicate better ESG performances, they do not always share the same implication for firms' long-term commitments like corporate innovation. For example, two categories within the social pillar are product responsibility and workforce. Within the product responsibility category, the data privacy theme reflects the firm's capacity to defend customers' data privacy. Nevertheless, the trade-off between privacy and innovation, especially those

[2] ESG ratings can be roughly categorized into risk-based ratings and performance-based ratings. The discussion in this paper is primarily based on performance-based ratings. Further details will be discussed Section 3 Data.
[3] For convenience of reference, here we use the names and categories as provided in Refinitiv ESG score methodology booklet. For a complete list of ESG categories and themes, see Figure 1.

innovations relying on the use of personal data, is well documented by the literature across multiple disciplines (e.g. Acquisti et al., 2016; Goldfarb & Tucker, 2012). Therefore, even within the social pillar, better performance in *Workforce* category usually improves innovation by enhancing employee's innovation productivity, while better performance in *Product Responsibility* could impede innovation due to privacy concerns. The contradicting effects between different categories and pillars of ESG may help explain the non-significant results in some studies (e.g. Borghesi et al., 2014; Masulis & Reza, 2015) and the U-shape relationship as documented in Broadstock et al. (2020), Celik et al. (2022) and Fuente et al. (2022). Our channel study shows that in the short-term, firm's performance on *Emission* dominates the positive effects on innovation output by increasing firm's R&D's sensitivity to opportunity set, enhancing its employee innovation productivity and improving effective utilization of free cash flows. While in the long-term, effective use of *Resource* provides firms significant improvement in its sensitivity of R&D to investment opportunities, effective use of free cash flows, and dividend payments, which lead to an increase in corporate innovation. Meanwhile, *Product Responsibility* and *Shareholder* spending lessen the positive impacts by increasing cost of capital, reduce employee innovation productivity, and holding excessive cash.

The paper will proceed as follows. In section two, we conduct a systematic literature review on innovation and ESG. Data and processing will be discussed in section three. In section four, we include results and discussions, with more discussions and robustness tests in section five. Section six concludes.

2. Literature Review

A growing number of literature has paid attention to the firm-level economic and financial

outcomes of ESG (see Gillan et al., 2021). The conclusions of the existing literature are somewhat mixed, partially because of the differences in research objects, contents, methods, etc. Studies that affirm the positive impacts of ESG on firm value (Wong et al., 2021), firm risk (Albuquerque et al., 2018), cost of capital (El Ghoul et al., 2011), investment efficiency (Benlemlih & Bitar, 2018), etc.. Aforementioned studies highlight ESG's vital roles in increasing product differentiation, alleviating agency problems, promoting stakeholder solidarity and acquiring social capital. These arguments are consistent with the good governance view of ESG, demonstrating that firms' "doing good" can be translated into "doing well". Those who argue for the adverse effects of ESG consider ESG as a product of agency problems, and argues that ESG would crowd out other promising investments and undermine firm value, capital allocation efficiency and the interests of non-shareholders (Bhandari & Javakhadze, 2017; di Giuli & Kostovetsky, 2014; H. Hong & Kostovetsky, 2012). Fuente et al. (Fuente et al., 2022) find an inverted U-form relation between ESG and firm growth options value. Some studies emphasize the heterogeneous influences of different composition dimensions (Ozturkoglu et al., 2021)and content dimensions (Yoo & Managi, 2022) of ESG. To better understand the disagreement in ESG literature, we investigate how each pillar and category of ESG affects innovation, and the channels through which such influence occurs.

2.1. Determinants of firm-level innovation

The new growth theory argue that innovation is the key source of growth and competitiveness. As enterprise is the core subject of innovation, investigating its innovation determinants is an important theme in economic research. From the perspective of sources, the determinants of corporate innovation can be roughly categorized as external and internal elements. The external elements mainly include national-level (Bhattacharya et al., 2017; Boubakri et al., 2021; Collins

& Troilo, 2015), industrial-level (Sheikh, 2018), social-level (Iftekhar Hasan et al., 2020) and consumer-level (Lv & Li, 2021) characteristics, such as country wealth, policy and policy uncertainty, industry cluster, product market competition, social capital and consumer preference. A richer body of literature focuses on internal elements that affect firm's innovation. Corporate events, such as mergers and acquisitions, strategic alliances (Man & Duysters, 2005) and corporate social responsibilities (Chkir et al., 2021) are all major drivers behind corporate innovation. Corporate innovations are also affected by firm structures including ownership structure (Clò et al., 2020) and governance structure (Gaur et al., 2014). Firms' equity performances (Arora et al., 2015) and financial conditions (Cefis et al., 2020) are also important influencers of corporate innovation.

2.2. ESG and firm-level innovation

The relationship between ESG and innovation was less discussed in the finance literature. Early works like Lucas (1988) and Romer (1986) established the new growth theory and argue that innovation is the key source of growth and competitiveness. Existing empirical studies yield mixed results for both trade-off effects and synergy effects between ESG (or CSR) and innovation. Gallego-Álvarez et al. (2011) and Mithani (2017) show that CSR initiatives reduce R&D due to diverted managerial attention. Lauren Cohen et al. (2020) observe a disconnect between ESG fund flows and green patenting using the data of U.S. publicly traded firms. (García-Piqueres & García-Ramos, 2021; Javeed et al., 2021; Tsang et al., 2021) and Wang et al. (2022) provide evidence for synergy effects between CSR and innovation. Fu et al. (2020) and Tsang et al. (2021) confirm the positive connections between innovation and CSR specialists, as well as CSR-based executive compensation, respectively. Chkir et al. (2021) report an inverted U-form linkage between CSR

and innovation among Japanese firms.

The existing literature suggests that the economic consequences of ESG deserve further investigation, and that the ESG-innovation nexus remains debated. Our paper contributes to this debate on the relationship between ESG and innovation, as well as the broader literature on the effects of ESG. As we propose plausible causes of contradicting empirical results, our findings could be helpful to future empirical researchers studying the economic consequences of ESG. Also, our study is related to the corporate finance literature that emphasizes the internal influence of ESG on firms' performances. For example, Becchetti et al. (2015) argue that ESG activities reduce firms' flexibilities in response to productive shocks, leading to higher idiosyncratic risks. Similar theoretical and empirical works have been developed around corporates' systematic risk (Albuquerque et al., 2018; El Ghoul et al., 2016), credit risk (Jiraporn et al., 2014; Stellner et al., 2015), legal risk (H. G. Hong & Liskovich, 2018; Schiller, 2018) and downside risk (Hoepner et al., 2021; Ilhan et al., 2021). Our work contributes to this stream of literature by focusing on the internal mechanism of ESG influences rather than observing market perceived risk and implied cost of capital. In the next section, we will explain data and sample processing.

3. Data

ESG ratings, based on their methodology, can be roughly categorized into performance-based and risk-based measures. Performance-based ratings like Asset4 (Refinitive) and MSCI KLD are obtained by aggregating firms' performances or activities in each category and subcategory; risk-based ratings like Sustainalytics, MSCI IVA and RepRisk are generated by evaluating firms' exposure to ESG-related matters, as well as their potential equity-market reactions. Based on the

study of Avramov et al. (2022), ratings with different methodologies can vary significantly for the same firm, with an average rating correlation of 0.48. As the research question of our study focus on the internal influence of ESG, we will focus on performance-based ESG measures. We start with all U.S. public firms that have disclosed ESG information at least once in the Refinitiv ESG Database, which has broader firm coverage. Our sample covers the period between 2002 and 2020. We use the ESG score as proxy for ESG performance. As in Pedersen et al. (2021), we use the overall ESG performance score (*Score*) and performance score for each pillar of ESG, the environmental pillar (*EScore*), the social pillar (*SScore*), and the governance pillar (*GScore*) from Refinitiv. Categories and themes covered under each pillar is presented in Figure 1. For comparison purpose, we also provide detailed categories and themes for MSCI, including MSCI KLD and MSCI IVA. Although the two data vendors have minor discrepancies on the contents covered in each pillar, the two systems are inherently similar. To account for correlations among different pillars and dimensions of ESG, we follow Callahan et al. (2003) and use principal component analysis to generate the PCA-based scores as an alternative proxy firm's ESG performance, *Score* $_{PCA,}$ *EScore* $_{PCA,}$ *SScore* $_{PCA}$ and *GScore* $_{PCA}$ as alternative measures of ESG performances in robustness tests. Our sample contains 7064 firm-year observations with complete ESG performance information.

For innovation data, we follow Cohen et al. (2020) and Fang et al. (2014) and use patent data from the KPSS Tech Innovation Database as innovation indicators. Specifically, we take the natural logarithm of number of patent applications (*LnPatent*) and number of corresponding citations (*LnCitation*) as proxies for innovation. As there is usually latency between patent application and patent grant, we also use issued patent data, *LnPatent Iss* and *LnCitation Iss*, as alternative proxies of innovation. Since the process of patent grant is susceptible to artificial factors (Schmookler,

1962), issued patent indicators (*LnPatent Iss* and *LnCitation Iss)* are only used for robustness purpose.

We then match ESG and patent data with a set of firm-level controls on technological innovation from the COMPUSTAT. Our final sample consists of a panel of 359 firms with 2543 firm-year observations. For summary statistics, see Table 1. For a complete list of variable definitions, please see the appendix.

[Insert Table 1 here]

On average, firms in our sample file 1.370 patents and receive 1.716 citations per year. Although a large number of firms have no patent applications or citations, we retain those firms to mitigate sample-selection bias following Atanassov (2013). The mean value of ESG Score is 0.395, compared to a global average of 0.416, which suggest that U.S. public firms have slightly unfavorable ESG performances in general. All ESG measures are positively and significantly related to innovation indicators at the 1% level.

In line with the innovation-related literature, we also control for a group of variables that characterize firm and industry, including R&D expenditure intensity (*R&D Intensity*), firm size (*LnSize*), firm age (*LnAge*), profitability (*ROA*), debt-to-assets ratio (*Leverage*), asset tangibility (*Tangibility*), capital expenditures intensity (*CAPX*), product market competition (*Herfindahl*) and its squared term (*Herfindahl*^{2}),[4] investment opportunity (*TobinQ*), and market-to-book (*M/B*). Based on empirical findings in Cao et al. (2020), Guan et al. (2021) and Hasan et al., (2020), *R&D Intensity, ROA, CAPX, Tobin Q* and *M/B* are positively related to innovation investments and better innovation outcomes, while the cases are opposite for *Leverage, Tangibility and Herfindahl*^{2}.

[4] Aghion et al. (2005) suggests a non-linear relationship between product market competition and innovation. Thus, we follow works like Fang et al. (2014), Guo et al. (2019) and He & Tian (2013) and include squared Herfindahl index in baseline regression.

For channels of ESG influences, we include cost of capital (Brown et al., 2009; Xiang et al., 2019; Xu, 2020), employee innovation productivity (*Innovation Productivity*) and sensitivity of R&D to investment opportunity set (*Sensitivity to Opportunity*) (Tsang et al., 2021). Based on the agency view of ESG, excessive cash flow elicits inefficient managerial spending decisions and diverts firm value (e.g. Ferrell et al., 2016; Jensen, 1976; la Porta et al., 1999). Hence, we follow Ferrell et al. (2016) and propose four cash flow related channels of ESG influence: free cash flow (*FCF*), cash holdings, financial slack and cash dividend (*Dividend*). Prior researchers suggest the importance of a diversified board (Harjoto et al., 2015), CEO pay structure (Ikram et al., 2019), institutional ownership (e.g. Borghesi et al., 2014; Chava, 2014; H. Hong & Kacperczyk, 2009; H. Hong & Kostovetsky, 2012; Nofsinger et al., 2019) and family ownership (Abeysekera & Fernando, 2020) on the corporate benefits of ESG. While the existing literature addresses various aspects of corporate governance, most of them only share weak connections with corporate innovation. Earlier studies like Albuquerque et al. (2019), Fieseler et al. (2009) and Servaes & Tamayo (2013) suggest the prevalence of "greenwashing", when firms could overclaim their ESG-related activities through advertising both internally and externally. Hence, we also include the firm's advertising expense scaled by the total asset (*Ads*) as a possible channel. Summary statistics on variables are also reported in Table 1.

4. Results and Discussion

In this section, we conduct our detailed analysis on the relationship between ESG and innovation. We begin with our baseline regression which establish associations between ESG, along with its sub-categories, and corporate innovation in the short-term. We then explore plausible channels through which each aspect of ESG affects innovation with channel analyses, followed by comparison of channels in the long-term.

4.1. ESG and Innovation

We begin with a set of baseline regression on the relationship between ESG and innovation. To examine whether and how ESG is associated with corporate innovation, we estimate the following regression model:

$$Innovation_{i,t+1} = \beta_0 + \beta_1 \text{ ESG Performance}_{i,t} + \beta_2 \Omega_{i,t} + \epsilon_{i,t}$$

where i indexes the firm, t indexes the calendar year and Ω is the matrix of control variables that affects corporate innovation. The variable *Innovation* is proxied by natural logarithm of firm's patent filings (*LnPatent*) and their corresponding citations (*LnCitation*) in year *t+1* for the short-term, and up to *t+5* for the long-term. In the baseline model, we use firm's overall ESG Score (*Score*) as proxy for firm's ESG performance, which is then substituted by firm's scores in environmental (*EScore*), social (*SScore*) and governance (*GScore*) pillar, respectively. Results are presented in Table 2(a) to 2(d).

[Insert Table 2(a) to 2 (d) here]

Table 2(a) shows the baseline result on the relationship between a firm's ESG score and its innovation outputs. Consistent with prior literature, we find a positive association between ESG

and innovation, which is both statistically significant an economically meaningful. For each unit's increase in ESG score, the firm's innovation output increase by 3.464% in patent filing and 2.975% in citation. In Table 2(b), we report the result for each pillar of a firm's ESG performance. Notably, only performance in environmental pillar (*EScore*), demonstrates a persistent, positive and significant influence on firm's innovation output across various proxies, while performance in the social pillar (*SScore*) lost its significance for both measures of innovation output in Column (4). The findings in social pillar seems to be in contradiction to literature in management and human resources, in which CSR is shown to be positively associated with innovation (Kim et al., 2014; Mishra, 2017). However, we will examine this in greater detail in the next table. The findings are also robust to various alternative measures of ESG performance and innovation outputs, as demonstrated in the robustness section, Table 8 and 9, Panel Bs.

In Table 2(c), we examine each category of ESG in greater detail. In the environmental pillar, firm's emission plays a major role in patent filing. For each unit increase in its emission performance, number of patents filed increase by 0.844% the following year. In Panel B of Table 2(c), the insignificant result on social pillar obtained in Table 2(b) seems to be explained by the opposite effect of workforce category and the product responsibility category. As mentioned earlier, per one unit increase in firm's workforce category increase patent filing by 0.622%, while per one unit increase in firm's product responsibilities reduces patent filing by 0.271%. The opposing effects within the social pillar are highly persistent across various model specifications and alternative measures. For the governance pillar as shown in Panel C, shareholder rights category generates a negative association with patent filing while CSR strategy category generates a significant positive association. However, only the negative effects of shareholder rights remain significant in the full model where all ten categories of ESG scores presents, as in Column (7). In

the full model, coefficient estimates of emission and workforce category are positive and significant, while estimates of product responsibility and CSR strategy are negative and significant. The emission category carries the greatest magnitude of influence, which explains the positive association between firm's overall ESG performance and innovation, as shown in Table 2(a).

We repeat the same exercise with number of citations as proxy of corporate innovation and present results in Table 2(d). The findings and patterns are similar to those in Table 2(c) with patents. Emission is positively associated with innovation and carries greatest magnitude of economic significance. Within the social pillar, the positive effect of workforce is contradicted by the negative effects of human rights and community categories. In the governance pillar, management category demonstrates positive association while shareholder rights and CSR strategy lost their explanatory power.

Our findings in this section suggest that the positive association between ESG and innovation is usually dominated by a firm's level of emission. This is in accordance with the stream of finance literature in which carbon risk is used as a measure for firm's performance on environmental responsibility (e.g. Bolton & Kacperczyk, 2021; Görgen et al., 2020; Jung et al., 2018; Nguyen & Phan, 2020). For the social pillar, as firm's level of workforce, human rights, community and product responsibility varies with research horizon and proxies used, we may observe positive, negative or even "muted" effects from the social pillar, which possibly change the overall effect of ESG on corporate innovation. To further our study, we then examine the potential causal relationship between firm's ESG performances and their innovation output, and *how* such "doing good" translates into "doing well" (or not well).

4.2 Channels of Influence

In this section, we further examine eight potential channels through which firms' ESG activities may affects their innovation output in the short-term and long-term.[5] Following Tsang et al. (2021), we begin with a set of two-step channel analyses on plausible channels, which is then followed by regressions with mediation effects.

4.2.1 Effects of ESG by Cash

As discussed in Section 3, we examine four cash-related plausible channels that may affect innovation: free cash flow, cash holdings, dividend payments, and financial slack. For each potential channel, we estimate the following two-stage model:

$$Cash_{i,t+1} = \beta_0 + \beta_1 \text{ ESG Performance}_{i,t} + e_{i,t}$$

$$Innovation_{i,t+1} = \beta_2 + \beta_3 \text{ ESG Performance}_{i,t} + \beta_4 \, Cash_{i,t+1} + e_{i,t}$$

in which $Cash_{i,t+1}$ represents one of the five potential channels (*FCF, Cash Holdings, Dividend, Financial Slack*) of the firm in year $t+1$, $\text{ESG Performance}_{i,t}$ is the firm's performance score in overall ESG or one of its subcategories in year *t*, and $Innovation_{i,t+1}$ is proxied by natural logarithm of the number of patent filing in year $t+1$. The results are presented in Table 3 Column (1) to (8).

[Insert Table 3 here]

In Column (1) of Table 3, the coefficient estimates presented shows that *Resource, Emission, Innovation, Workforce, Human Rights, Community and CSR Strategy* are all negative and significant when regressed on firm's free cash flow in the following year. While it is intuitive that

[5] Due to space limit, we will only present regression results with *LnPatent* as the dependent variable in our main table for this section. Results for *LnCitation* can be provided upon request.

ESG-related activities reduce firm's free cash flow in the following year, contemporaneous free cash flow in year *t+1* has a negative and significant effect on patent filing in year *t+1* ($LnPatent_{t+1}$), as shown in Column (2). While this result seems counter-intuitive, results in mediation analysis in section 4.5 suggests that reduction in free cash flow to the firm is accompanied by better utilization of cash flows, which promotes innovation. Hence, the positive associations between firm's scores in *Emission*, as well as *Workforce*, and innovation output as documented in Section 4.1 can be explained by the free cash flow channel. Similarly, in Column (3) to (8) of Table 3, we document that *Workforce* and *Shareholder* categories enhances innovation by improving firm's cash holdings. Although the cash dividends channel also carries positive and significant coefficient estimates in Column (5), this channel is latter rejected by our mediation analysis in Section 4.5.

4.2.2 Effects of ESG by Cost of Capital

El Ghoul et al., (2011) show that firms with better CSR performances enjoy the benefits of lower cost of capital. In this section, we test to see if ESG improves corporate innovation by reducing firm's cost of capital. To test this plausible channel, we repeat our exercise in 4.2.1. First, we directly examine whether higher ESG scores reduces firms' cost of capital. In Column (1) of Table 4, we show that higher scores in *Community, Product Responsibility* and *Management* categories are all associated with lower cost of capital in the following year. While lower cost of capital in usually associated better innovation output, only better performance in *Management* categories is then translated into improvements in innovation as documented in Table 3(d).

[Insert Table 4 here]

4.2.3 Effects of ESG by changing Employee Innovation Productivity

We explore whether better performance in ESG improves employees' innovation productivity. Higher employees' innovation productivity is associated with more innovation output when number of employees remains stable. In Table 4 Column (5), the coefficient estimate of *Emission* is positively associated with employee innovation productivity while estimates for *Product Responsibility* and *Shareholders* are negatively associated with innovation productivity in year *t+1*. This is consistent with our findings in Table 3(c) where higher *Emission* scores improve innovation output and higher *Product Responsibility* and *Shareholders* reduce innovation output. Notably, the coefficient estimate of *Shareholder* is nonsignificant when we control for employee innovation productivity in Column (6), suggesting that most of *Shareholder* category's negative association with innovation output is via the employee innovation productivity channel. The *Human Rights* is also negatively associated with employees' innovation productivity, although its negative impact on innovation output is not stable.

4.2.4 Effects of ESG by changing the sensitivity of R&D to firm's investment opportunity set

We discuss whether ESG improves innovation output by enhancing firm's sensitivity of R&D expenses to firm's investment opportunities. In Column (1) of Table 4, all categories in the environmental pillar, all categories except for the *Product Responsibility* in the social pillar, and the *CSR Strategy* in the corporate governance pillar have positive and significant coefficient estimates on innovation output. In other words, as suggested in Table 3(c), *Emission* and *Workforce* categories positively affect innovation output by increasing firm's sensitivity of R&D expenses to firm's investment opportunities.

4.2.5 Effects of ESG by Advertisements

Some argue that when firms advertise their ESG-related activities internally, it may improve corporate innovation. To see if this channel is plausible, we test and present the result in Table (4) Column (7). The coefficient estimate of *Workforce* category is negative and significant as indicated in Column (7). While contemporaneous advertising expenses reduces innovation output as shown in Column (8), the *Workforce* category hence improves innovation output by reducing advertising expenses in *t+1*.

4.3 Channels of ESG Influence in long-term

As innovation is usually considered a long-term firm commitment, we further explore the effects of ESG on innovation in the long-term for up to five years. We repeat our exercises in Section 4.2 and report the results in Table 5(a) to Table 5(d). Due to space limit, we only report signs and significance of coefficient estimates for channel analyses in Table 5(d).

[Insert Table 5(a) to Table 5(d) here]

From Table 5(a) to (d), we observe an identical pattern on channels of influence to those in Section 4.2 in Table 5(d), *Emission* positively affects innovation in year t+5 by reducing the cost of capital (column 1) and contemporaneous free cash flows (column 5). *Workforce* also positively affects innovation in year t+5 by reducing advertisement spending (column 8) and contemporaneous free cash flows (column 5). While the short-term effect of *Product Responsibility* is mostly negative on innovation, its negative influence subsides over the long term as its positive impact on the sensitivity of R&D to investment opportunities grows over time. Nonetheless, the negative effect of *Shareholder* persists due to its reduction in the firm's sensitivity of R&D to investment opportunities and cash holdings over the longer horizon, as suggested in Table 5(d) Column (3) and (7). The *Resource* does not significantly affect innovation over the one-year and three-year

term, but it significantly improves corporate innovation output over the longer horizon given its significant improvement in sensitivity of R&D to investment opportunities and effective use of free cash flows.

4.4 Instrumental Variable Approach

While channel analyses in Section 4.2 fit the purpose of our study, they also received some criticism over endogeneity concerns. To address endogeneity, we use the instrumental variable (IV) method with two potential IVs: firm's overall ESG score when it was first included in the dataset ($Score_{Initial}$) and average ESG score within the industry defined by 2-digt SIC code ($Score_{Industry}$). Results of IV estimations for the relationship between firm's overall ESG score and innovation are presented in Table 6(a).

[Insert Table 6(a) Here]

In Table 6(a), we show the results of a two-stage IV approach for overall ESG score. As the results demonstrate consistent causality between firm overall ESG performances and its innovative output, we repeat the exercise for each pillar and theme of ESG performances. Due to space limit, we only demonstrate the result with the average ESG score within the industry defined by 2-digt SIC code as an instrumental variable ($Score_{Industry}$) in Table 6(b). Results with $Score_{Initial}$ and $Score_{Median}$ as IVs are essentially identical.

[Insert Table 6(b) Here]

The coefficient estimates presented in Table 6(b) are almost identical to those in Table 2(c) without the IVs. *Emission* positively affects innovation output, while *Product Responsibility* impedes innovation. We confirm our earlier statements on the relationship between ESG and its subcategories and corporate innovation.

4.5 Channels of Influence with Mediation Models

To further examine our results on channels of influence, we employee mediation models with an interaction term between firm's ESG performance and potential channel variables. Results of mediation models are presented in Table 7.

[Insert Table 7 Here]

Panel I to IV of Table 7 reports results for the four cash-related channels. Consistent with the result of our channel analysis, contemporary free cash flow is negatively associated with innovation output (Panel I). However, the interaction term of free cash flow and ESG performance scores, when regressed on the natural logarithm of patent filings ($LnPatent_{t+1}$), is positive and significant for *Emission* and *Workforce*, suggesting that better performances in these two categories improve the utilization of free cash flows in terms of innovation. Coefficient estimates of *Product Responsibility* and *Shareholder* channel are not significant, but the signs of estimations are in accordance with the results of channel analysis. In Panel V, advertisement spending is negatively associated with innovation output, but the coefficient estimate of the interaction term $Ads \times Management$ is positive and significant, suggesting that sound corporate management practices could mitigate the negative effects of higher advertisement spending. In Panel VI and VIII, positive coefficient estimates on the interaction term confirm our prior findings that the *Emission* and *Workforce* categories improves innovation output by enhancing firm's R&D sensitivity to opportunity set.

5. Robustness

5.1 Alternative Measures

For robustness purpose, we use alternative proxies of ESG performances and corporate innovation to repeat our exercise. In Table 8, we re-calculate ESG scores as the principal component of each sub-category and use them as proxies for firm's ESG performances. The results are similar to our baseline analysis, in which the environmental pillar positively dominates the influence on innovation.

[Insert Table 8 Here]

Then, we change our proxy for corporate innovation. In place of patent filings and their corresponding citations in year *t+1*, we use the number of patents issued and their corresponding citations as alternative proxies. Note that here we only use output-based innovation measures as there is usually a discrepancy between firms' innovation input (e.g., R&D) and innovation output. While the process of patent issuance is subject to external interventions beyond our topic in this paper, our results are qualitatively similar, with the environmental pillar positively affecting innovation output.

[Insert Table 9 Here]

5.2 Effects of ESG by Industry

As discussed earlier, the relationship between innovation and ESG performances varies significantly across industries and sectors. In this section, we present the results of our analysis by sectors in Table 10.

[Insert Table 10 Here]

The results by industry are similar to our baseline results. In Panel A of Table 10, the *Environmental* pillar significantly improves innovation output in manufacturing, energy & utilities, retail and financial industries. The positive association can be mostly attributed to the positive impacts of

Resource use and *Emission* categories. In Panel B, consistent with our prior findings, better performance in *Product Responsibility* category has negative impacts on innovation output, especially in energy & utilities, as well as the retail industry. In Panel C, we confirm the positive impact of better *CSR strategy* on corporate innovation across multiple industries and sectors, whereas the negative impact of *Shareholder* category mostly derives from the financial industry.

6.Conclusion

In this paper, we investigate the impact of overall ESG score and its respective components on firms' innovation. Our findings suggest that ESG performance promotes firms' innovation for both short-term and long-term. Such results are consistent with the good governance view of ESG that better ESG performances are practices of good corporate governance and "doing well" can ultimately translate into "doing good". With a more detailed analysis on each pillar of ESG measure, we show that only the *Environmental* pillar, more specifically, *Emission*, has a persistent and positive impact on a firm's innovation output. We further examine the possible channels by which the *Environmental* pillar affects innovation. Our results show that in short term, better performance in the *Environmental* pillar enhances corporate innovation via the channels of firm R&D's sensitivity to opportunity set, employee innovation productivity, and free cash flows. This positive effect could be mitigated by excessive spending on the *Social* and *Governance* pillars, especially on *Product Responsibility* and *Shareholder*s as firms experience an increase in the cost of capital and excessive cash holding. In the long-term, both *Emission* and *Resource* benefit firms' innovation via the channel of R&D's sensitivity to the opportunity set.

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Figure 1. Pillars, Categories and Themes of ESG Scoring

Refinitiv Asset4

Pillars	Categories	Themes
Environmental	Emission	Emissions
		Waste
		Biodiversity
		Environmental management systems
	Innovation	Product innovation
		Green revenues, research and development (R&D) and capital expenditures (CapEx)
	Resource use	Water
		Energy
		Sustainable packaging
		Environmental supply chain
Social	Community	Equally important to all industry groups
	Human rights	Human rights
	Product responsibility	Product quality
		Data privacy
		Responsible marketing
	Workforce	Career development and training
		Health and safety
		Working conditions
		Diversity and inclusion
Governance	Management	Structure (independence, diversity, committees)
		Compensation
	CSR strategy	CSR strategy
		ESG reporting and transparency
	Shareholders	Shareholder rights
		Takeover defenses

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Pillars	Categories	Themes
Environmental	Climate Change	Carbon Emissions
		Product Carbon Footprint
		Climate Change Vulnerability
		Financing Environmental Impact
	Pollution & Waste	Electronic Waste
		Packaging Material & Waste
		Toxic Emissions & Waste
	Environmental Opportunities	Opportunities in Clean Tech
		Opportunities in Green Building
		Opportunities in Renewable Energy
	Natural Capital	Water Stress
		Raw Material Sourcing
		Biodiversity & Land Use
Social	Stakeholder Opposition	Community Relations
		Controversial Sourcing
	Product Liability	Product Safety & Quality
		Privacy & Data Security
		Consumer Financial Protection
		Insuring Health & Demographic Risk
		Chemical Safety
		Responsible Investment
	Human Capital	Human Capital Development
		Health & Safety
		Supply Chain Labor Standards
		Labor Management
	Social Opportunities	Access to Finance
		Access to Health Care
		Opportunities in Nutrition & Health
Governance	Corporate Governance	Board
		Ownership & Control
		Pay
		Accounting
	Corporate Behavior	Business Ethics
		Tax Transparency

Figure 1 provides detailed categories and themes division used by data vendors when aggregating their ESG scores. Information retrieved from vendor's methodology booklet.

Table 1 Summary Statistics

Variable	N	Mean	SD	Min	Median	Max
Panel A ESG Performances						
LnPatent	7064	1.690	1.997	0.000	0.693	7.207
LnCitation	7064	1.490	2.358	0.000	0.000	8.709
Score	7064	0.423	0.202	0.074	0.393	0.874
EScore	7064	0.285	0.280	0.000	0.210	0.901
SScore	7064	0.467	0.223	0.061	0.447	0.942
GScore	7064	0.497	0.218	0.055	0.502	0.921
Resource	7064	0.328	0.344	0.000	0.211	0.988
Emission	7064	0.311	0.332	0.000	0.196	0.987
Innovation	7064	0.215	0.296	0.000	0.000	0.947
Workforce	7064	0.472	0.276	0.017	0.450	0.982
Human Right	7064	0.222	0.311	0.000	0.000	0.952
Community	7064	0.643	0.250	0.048	0.673	0.995
Product Responsibility	7064	0.413	0.306	0.000	0.354	0.981
Management	7064	0.539	0.282	0.023	0.547	0.994
Shareholder	7064	0.533	0.281	0.014	0.545	0.992
CSR Strategy	7064	0.265	0.341	0.000	0.000	0.992
R&D Intensity	7019	0.045	0.083	0.000	0.012	0.500
Panel B Firm Characteristics						
LnSize	7019	8.635	1.857	3.829	8.566	13.180
LnAge	3166	2.633	0.659	0.693	2.833	3.638
ROA	6727	0.112	0.145	-0.672	0.129	0.381
Leverage	6985	0.249	0.182	0.000	0.234	0.920
Tangibility	7009	0.231	0.217	0.003	0.154	0.847
CAPX	6720	0.041	0.035	0.000	0.031	0.186
Herfindahl (in %)	6409	28.728	9.397	20.100	25.560	68.382
Herfindahl^2 (in %)	6409	9.136	7.304	4.040	6.533	46.761
Tobin Q	6153	0.228	0.156	0.081	0.177	0.981
FCF	5634	0.073	0.127	-0.660	0.084	0.352
Cost of capital	4715	0.424	0.356	0.021	0.343	1.000
Cash holdings	4374	0.161	0.169	0.003	0.101	0.826
Innovation Productivity	6993	0.712	1.068	0.000	0.090	4.509
Ads	2876	0.035	0.050	0.000	0.016	0.298
Financial Slack	6487	2.373	1.957	0.499	1.775	11.848
Cash Dividend	6701	0.017	0.022	0.000	0.010	0.108

Table 2(a) ESG and Innovation

	(1) $LnPatent_{t+1}$	(2) $LnPatent_{t+1}$	(3) $LnCitation_{t+1}$	(4) $LnCitation_{t+1}$
Score	3.464***	0.742***	2.975***	0.643**
	(0.095)	(0.205)	(0.115)	(0.253)
R&D INTENSITY		2.824***		2.244***
		(0.424)		(0.440)
LnSzie		0.356***		0.049
		(0.065)		(0.082)
LnAge		-0.162***		-0.070
		(0.044)		(0.049)
ROA		-0.378*		-0.621***
		(0.215)		(0.227)
Leverage		-0.438***		-0.349**
		(0.138)		(0.154)
Tangibility		-0.808***		-0.668**
		(0.284)		(0.328)
CAPX		1.501		1.101
		(1.096)		(1.309)
Herfindal		1.324		6.923*
		(2.670)		(3.799)
$Herfindal^2$		-1.405		-7.374*
		(3.159)		(4.330)
TobinQ		0.096		-0.511
		(0.238)		(0.317)
M/B		0.199***		0.370***
		(0.061)		(0.081)
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	7064	2543	7064	2543
Adj. R^2	0.650	0.701	0.638	0.671

Table 2(a) shows the regression results on the relationship between ESG and innovation. We report results with firm's overall ESG score (*Score*) as proxy for firm's ESG performances. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 2(b) ESG and Innovation by Pillar

Panel A

	(1) $LnPatent_{t+1}$	(2) $LnPatent_{t+1}$	(3) $LnPatent_{t+1}$	(4) $LnPatent_{t+1}$
EScore	1.026***			1.005***
	(0.145)			(0.166)
SScore		0.822***		0.097
		(0.200)		(0.223)
GScore			0.194	-0.067
			(0.136)	(0.140)
All controls	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	2543	2543	2543	2543
Adj. R^2	0.706	0.701	0.699	0.706

Panel B

	(1) $LnPatent_{t+1}$	(2) $LnPatent_{t+1}$	(3) $LnPatent_{t+1}$	(4) $LnPatent_{t+1}$
EScore	1.319***			1.266***
	(0.182)			(0.203)
SScore		0.773***		-0.201
		(0.205)		(0.224)
GScore			0.882***	0.669***
			(0.152)	(0.153)
All controls	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	2543	2543	2543	2543
Adj. R^2	0.615	0.608	0.610	0.617

Table 2(b) shows the regression results on the relationship between ESG and innovation. We report results with firm's environmental (*EScore*), social (*SScore*) and governance score (*GScore*), respectively. Panel A reports results where natural logarithm of number of patents filing in year *t+1* as the dependent variable, and Panel B reports results with natural logarithm of number of citations associated with patents filed in year *t+1* as proxy of innovation as the dependent variable. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 2(c) ESG and Innovation by Category with Patents

Panel A Environment Pillar

	(1)	(2)	(3)	(4)	(5)
EScore	1.032***				
	(0.146)				
Resource		0.679***			0.020
		(0.113)			(0.164)
Emission			0.907***		0.844***
			(0.122)		(0.176)
Innovation				0.452***	0.133
				(0.125)	(0.138)
N	2543	2543	2543	2543	2543
Adj. R^2	0.705	0.702	0.706	0.699	0.706

Panel B Social Pillar

	(1)	(2)	(3)	(4)	(5)	(6)
SScore	0.551***					
	(0.171)					
Workforce		0.568***				0.622***
		(0.120)				(0.132)
Human Rights			0.173			0.071
			(0.110)			(0.112)
Community				0.221*		0.016
				(0.127)		(0.133)
Product					(0.126)	-0.271**
Responsibility					(0.104)	(0.108)
N	2543	2543	2543	2543	2543	2543
Adj. R^2	0.699	0.700	0.698	0.698	0.697	0.701

Panel C Governance Pillar

	(1)	(2)	(3)	(4)	(5)
GScore	0.212				
	(0.136)				
Management		0.131			0.099
		(0.094)			(0.094)
Shareholder			-0.151*		-0.208**
			(0.091)		(0.091)
CSR Strategy				0.626***	0.643***
				(0.121)	(0.121)
N	2543	2543	2543	2543	2543
Adj. R^2	0.698	0.697	0.698	0.701	0.702

Table 2(c) shows the regression results on the relationship between ESG and innovation, with natural logarithm of number of patents filed in year $t+1$ ($LnPatent_{t+1}$) as proxy for innovation. Panel A reports results with firm's score in each category of the environmental pillar as proxy for firm's ESG performances, Panel B with social pillar and Panel C with the governance pillar, respectively. All regression models include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 2(d) ESG and Innovation by Category with Citations

Panel A Environment Pillar

	(1)	(2)	(3)	(4)	(5)
EScore	0.624***				
	(0.182)				
Resource		0.310**			(0.249)
		(0.142)			(0.214)
Emission			0.545***		0.650***
			(0.151)		(0.224)
Innovation				0.393**	0.249
				(0.155)	(0.170)
N	2543	2543	2543	2543	2543
Adj. R^2	0.691	0.69	0.691	0.69	0.692

Panel B Social Pillar

	(1)	(2)	(3)	(4)	(5)	(6)
SScore	0.336					
	(0.206)					
Workforce		0.448***				0.624***
		(0.144)				(0.164)
Human Rights			-0.093			(0.204)
			(0.140)			(0.144)
Community				-0.080		(0.272)
				(0.154)		(0.165)
Product					0.016	(0.036)
Responsibility					(0.126)	(0.129)
N	2543	2543	2543	2543	2543	2543
Adj. R^2	0.69	0.691	0.689	0.689	0.689	0.691

Panel C Governance Pillar

	(1)	(2)	(3)	(4)	(5)
GScore	0.482***				
	(0.166)				
Management		0.304***			0.283**
		(0.116)			(0.117)
Shareholder			0.079		0.043
			(0.111)		(0.111)
CSR Strategy				0.285*	0.251
				(0.156)	(0.156)
N	2543	2543	2543	2543	2543
Adj. R^2	0.69	0.69	0.689	0.69	0.691

Table 2(d) shows the regression results on the relationship between ESG and innovation, with natural logarithm of number of citations for patents filed in year *t+1* ($LnPatent_{t+1}$) as proxy for innovation. Panel A reports results with firm's score in each category of the environmental pillar as proxy for firm's ESG performances, Panel B with social pillar and Panel C with the governance pillar, respectively. All regression models include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 3 Cash-related Channels of ESG Influence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FCF	$LnPatent_{t+1}$	*Cash Holdings*	$LnPatent_{t+1}$	*Div*	$LnPatent_{t+1}$	*Financial Slack*	$LnPatent_{t+1}$
Panel A Environmental Pillar								
Score	-0.059***	0.750***	-0.002	0.091	3.271***	0.696***	0.11	0.592***
	(0.013)	(0.236)	(0.034)	(0.261)	(0.343)	(0.215)	(0.321)	(0.203)
Channel Variable		-0.902**		1.439***		0.023		0.056***
		(0.382)		(0.245)		(0.015)		(0.012)
EScore	-0.050***	0.985***	-0.049**	0.381**	1.971***	1.010***	0.297	0.891***
	(0.009)	(0.163)	(0.023)	(0.180)	(0.258)	(0.152)	(0.223)	(0.147)
Channel Variable		-0.751*		1.468***		0.015		0.054***
		(0.385)		(0.244)		(0.015)		(0.012)
Resource	-0.040***	0.634***	-0.035*	0.242*	1.550***	0.652***	0.236	0.564***
	(0.007)	(0.128)	(0.018)	(0.143)	(0.207)	(0.118)	(0.162)	(0.113)
Channel Variable		-0.799**		1.460***		0.018		0.054***
		(0.384)		(0.245)		(0.015)		(0.012)
Emission	-0.038***	0.858***	-0.009	0.322**	1.367***	0.873***	0.267	0.802***
	(0.008)	(0.134)	(0.020)	(0.147)	(0.223)	(0.126)	(0.180)	(0.123)
Channel Variable		-0.747*		1.445***		0.028*		0.054***
		(0.388)		(0.244)		(0.015)		(0.012)
Innovation	-0.019***	0.403***	-0.050***	0.171	1.020***	0.461***	0.073	0.379***
	(0.006)	(0.137)	(0.016)	(0.138)	(0.200)	(0.130)	(0.185)	(0.126)
Channel Variable		-0.970**		1.461***		0.028*		0.056***
		(0.388)		(0.245)		(0.015)		(0.012)
N	2007	2007	1354	1354	2527	2527	2456	2456
Avg. R^2	0.852	0.733	0.669	0.760	0.570	0.703	0.407	0.715

Table 3 Cash-related Channels of ESG Influence (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FCF	*LnPatent$_{t+1}$*	*Cash Holdings*	*LnPatent$_{t+1}$*	*Div*	*LnPatent$_{t+1}$*	*Financial Slack*	*LnPatent$_{t+1}$*
Panel B Social Pillar								
SScore	-0.047***	0.579***	0.065**	-0.049	2.240***	0.491***	0.237	0.361**
	(0.013)	(0.196)	(0.030)	(0.224)	(0.277)	(0.177)	(0.292)	(0.170)
Channel Variable		-0.921**		1.442***		0.026*		0.056***
		(0.388)		(0.246)		(0.015)		(0.012)
Workforce	-0.033***	0.623***	0.050**	-0.033	1.293***	0.529***	0.099	0.469***
	(0.012)	(0.138)	(0.022)	(0.162)	(0.190)	(0.123)	(0.232)	(0.120)
Channel Variable		-0.876**		1.442***		0.025*		0.056***
		(0.390)		(0.245)		(0.015)		(0.012)
Human Rights	-0.025***	0.139	-0.005	0.145	1.307***	0.132	-0.103	0.124
	(0.005)	(0.120)	(0.017)	(0.136)	(0.202)	(0.111)	(0.152)	(0.108)
Channel Variable		-0.996**		1.441***		0.031**		0.056***
		(0.389)		(0.245)		(0.015)		(0.012)
Community	-0.021**	0.192	0.046**	0.174	0.484**	0.211	0.156	0.105
	(0.009)	(0.145)	(0.023)	(0.157)	(0.198)	(0.129)	(0.232)	(0.126)
Channel Variable		-1.005***		1.422***		0.033**		0.056***
		(0.389)		(0.246)		(0.015)		(0.012)
Product Responsibility	-0.006	-0.103	0.02	-0.237*	1.068***	-0.164	0.249	-0.217**
	(0.007)	(0.119)	(0.016)	(0.131)	(0.165)	(0.105)	(0.189)	(0.104)
Channel Variable		-1.039***		1.456***		0.037**		0.057***
		(0.391)		(0.245)		(0.015)		(0.012)
N	2007	2007	1354	1354	2527	2527	2456	2456
Avg. R^2	0.850	0.726	0.670	0.759	0.567	0.699	0.407	0.711

Table 3 Cash-related Channels of ESG Influence (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FCF	*LnPatent$_{t+1}$*	*Cash Holdings*	*LnPatent$_{t+1}$*	*Dividend*	*LnPatent$_{t+1}$*	*Financial Slack*	*LnPatent$_{t+1}$*
Panel C Governance Pillar								
GScore	-0.025**	0.161	0.03	-0.032	1.441***	0.167	-0.046	0.181
	(0.011)	(0.154)	(0.025)	(0.180)	(0.226)	(0.138)	(0.238)	(0.136)
Channel Variable		-1.008***		1.440***		0.031**		0.056***
		(0.386)		(0.246)		(0.015)		(0.012)
Management	-0.012	0.124	0.005	-0.107	0.544***	0.116	0.123	0.103
	(0.008)	(0.107)	(0.017)	(0.125)	(0.152)	(0.095)	(0.169)	(0.095)
Channel Variable		-1.014***		1.440***		0.033**		0.056***
		(0.386)		(0.246)		(0.015)		(0.012)
Shareholder	-0.004	-0.248**	0.040***	0.003	0.786***	-0.183**	-0.271	-0.105
	(0.007)	(0.103)	(0.016)	(0.118)	(0.149)	(0.091)	(0.171)	(0.090)
Channel Variable		-1.045***		1.438***		0.037**		0.056***
		(0.393)		(0.248)		(0.015)		(0.012)
CSR Strategy	-0.034***	0.578***	0.023	0.472***	1.772***	0.585***	-0.219	0.527***
	(0.007)	(0.132)	(0.018)	(0.145)	(0.230)	(0.125)	(0.160)	(0.121)
Channel Variable		-0.853**		1.412***		0.019		0.057***
		(0.388)		(0.244)		(0.015)		(0.012)
N	2007	2007	1354	1354	2527	2527	2456	2456
Avg. R^2	0.850	0.726	0.668	0.760	0.568	0.700	0.407	0.712

Table 3 reports results of cash-related channel analyses on ESG scores and its sub-category scores. For each potential channel of ESG influence, we report results of two-stage channel analysis. We first report the coefficient estimates when regress ESG performances on the channel variable in odd-numbered columns and then we report the coefficient estimates when regress both the channel variable and ESG performances on innovation in *t+1* in even-numbered columns. For all regression models, we include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 4 Other Channels of ESG Influence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Cost of Capital	*LnPatent$_{t+1}$*	*Sensitivity to Opportunity*	*LnPatent$_{t+1}$*	*Innovation Productivity*	*LnPatent$_{t+1}$*	*Ads*	*LnPatent$_{t+1}$*
Panel A Environmental Pillar								
Score	-0.230**	0.143	0.255***	0.377	-0.229	0.977***	-0.044***	-0.095
	(0.091)	(0.265)	(0.062)	(0.982)	(0.164)	(0.125)	(0.016)	(0.296)
Channel Variable		-0.073		1.053***		0.908***		-2.001*
		(0.082)		(0.366)		(0.022)		(1.045)
EScore	-0.032	0.315*	0.172***	-0.869	0.155	0.905***	-0.009	0.529***
	(0.066)	(0.181)	(0.037)	(0.704)	(0.106)	(0.092)	(0.010)	(0.201)
Channel Variable		-0.074		1.260***		0.900***		-1.902*
		(0.082)		(0.191)		(0.022)		(1.041)
Resource	-0.002	0.187	0.104***	-0.498	0.06	0.634***	-0.009	0.153
	(0.051)	(0.143)	(0.031)	(0.572)	(0.082)	(0.071)	(0.007)	(0.147)
Channel Variable		-0.076		1.252***		0.902***		-1.937*
		(0.082)		(0.191)		(0.022)		(1.047)
Emission	-0.025	0.325**	0.202***	-0.455	0.182**	0.754***	-0.003	0.359**
	(0.055)	(0.147)	(0.035)	(0.643)	(0.089)	(0.074)	(0.007)	(0.159)
Channel Variable		-0.074		1.233***		0.898***		-1.947*
		(0.082)		(0.193)		(0.022)		(1.039)
Innovation	-0.032	0.097	0.086**	-1.101	0.065	0.397***	-0.006	0.646***
	(0.049)	(0.139)	(0.043)	(0.757)	(0.093)	(0.075)	(0.007)	(0.183)
Channel Variable		-0.075		1.303***		0.903***		-1.905*
		(0.082)		(0.185)		(0.022)		(1.042)
N	1412	1412	2087	2087	2530	2530	1049	1049
Avg. R^2	0.199	0.751	0.665	0.727	0.524	0.888	0.495	0.776

Table 4 Other Channels of ESG Influence (continued)

	(1) *Cost of Capital*	(2) *LnPatent$_{t+1}$*	(3) *Sensitivity to Opportunity*	(4) *LnPatent$_{t+1}$*	(5) *Innovation Productivity*	(6) *LnPatent$_{t+1}$*	(7) *Ads*	(8) *LnPatent$_{t+1}$*
Panel B Social Pillar								
SScore	-0.131	0.052	0.258***	-0.496	-0.236*	0.769***	-0.030***	-0.164
	(0.081)	(0.225)	(0.062)	(0.778)	(0.141)	(0.108)	(0.011)	(0.244)
Channel Variable		-0.075		1.367***		0.908***		-2.019*
		(0.082)		(0.364)		(0.022)		(1.049)
Workforce	-0.063	0.029	0.143***	-0.504	0.088	0.487***	-0.022**	-0.011
	(0.061)	(0.162)	(0.051)	(0.549)	(0.108)	(0.078)	(0.009)	(0.181)
Channel Variable		-0.076		1.356***		0.902***		-1.975*
		(0.082)		(0.305)		(0.022)		(1.048)
Human Rights	0.061	0.135	0.089**	-1.439**	-0.188**	0.349***	0.002	-0.098
	(0.048)	(0.138)	(0.041)	(0.653)	(0.082)	(0.068)	(0.007)	(0.158)
Channel Variable		-0.079		1.362***		0.908***		-1.967*
		(0.082)		(0.191)		(0.022)		(1.048)
Community	-0.109*	0.268*	0.224***	1.062*	-0.066	0.286***	-0.013**	0.155
	(0.059)	(0.157)	(0.051)	(0.599)	(0.107)	(0.077)	(0.007)	(0.184)
Channel Variable		-0.069		0.61		0.905***		-1.937*
		(0.082)		(0.409)		(0.022)		(1.049)
Product Responsibility	-0.097**	-0.199	0.037	-1.064*	-0.415***	0.255***	-0.015***	-0.369**
	(0.044)	(0.130)	(0.046)	(0.601)	(0.090)	(0.064)	(0.006)	(0.150)
Channel Variable		-0.085		1.609***		0.911***		-2.111**
		(0.082)		(0.242)		(0.022)		(1.059)
N	1412	1412	2087	2087	2530	2530	1049	1049
Avg. R^2	0.200	0.751	0.668	0.723	0.525	0.886	0.497	0.775

Table 4 Other Channels of ESG Influence (continued)

	(1) *Cost of Capital*	(2) *LnPatent$_{t+1}$*	(3) *Sensitivity to Opportunity*	(4) *LnPatent$_{t+1}$*	(5) *Innovation Productivity*	(6) *LnPatent$_{t+1}$*	(7) *Ads*	(8) *LnPatent$_{t+1}$*
Panel C Governance Pillar								
GScore	-0.205***	0.056	0.02	1.239*	-0.12	0.316***	-0.033***	-0.051
	(0.062)	(0.182)	(0.063)	(0.711)	(0.117)	(0.084)	(0.010)	(0.208)
Channel Variable		-0.074		0.740**		0.905***		-1.996*
		(0.082)		(0.326)		(0.022)		(1.047)
Management	-0.142***	-0.063	0.025	0.927*	0.017	0.112*	-0.024***	0.065
	(0.044)	(0.125)	(0.048)	(0.527)	(0.083)	(0.058)	(0.007)	(0.149)
Channel Variable		-0.08		0.819***		0.904***		-1.927*
		(0.082)		(0.292)		(0.022)		(1.043)
Shareholder	-0.069	0.058	-0.057	1.237**	-0.260***	0.081	-0.006	-0.202
	(0.044)	(0.118)	(0.040)	(0.497)	(0.081)	(0.057)	(0.005)	(0.133)
Channel Variable		-0.074		0.687**		0.906***		-2.015*
		(0.082)		(0.286)		(0.022)		(1.047)
CSR Strategy	0.045	0.497***	0.077**	-1.545**	-0.031	0.659***	-0.002	-0.054
	(0.052)	(0.144)	(0.031)	(0.634)	(0.085)	(0.074)	(0.006)	(0.150)
Channel Variable		-0.083		1.341***		0.905***		-1.974*
		(0.081)		(0.190)		(0.022)		(1.050)
N	1412	1412	2087	2087	2530	2530	1049	1049
Avg. R^2	0.204	0.751	0.668	0.760	0.525	0.884	0.500	0.775

Table 4 reports results of cash-related channel analyses on ESG scores and its sub-category scores. For each potential channel of ESG influence, we report results of two-stage channel analysis. We first report the coefficient estimates when regress ESG performances on the channel variable in odd-numbered columns and then we report the coefficient estimates when regress both the channel variable and ESG performances on innovation in *t+1* in even-numbered columns. For all regression models, we include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 5(a) ESG and Innovation (long-term effect)

	(1)	(2)	(3)	(4)
	$LnPatent_{t+1,t+3}$	$LnCitation_{t+1,t+3}$	$LnPatent_{t+1,t+5}$	$LnCitation_{t+1,t+5}$
Score	0.672***	0.490	0.469*	0.125
	(0.234)	(0.302)	(0.260)	(0.321)
RDTA	4.747***	4.205***	5.016***	4.068***
	(0.586)	(0.727)	(0.800)	(1.123)
LnSzie	0.476***	0.098	0.463***	0.156
	(0.080)	(0.109)	(0.094)	(0.125)
LnAge	-0.245***	-0.121*	-0.334***	-0.095
	(0.053)	(0.064)	(0.085)	(0.111)
ROA	0.023	-0.461	-0.536	-1.440***
	(0.260)	(0.368)	(0.343)	(0.503)
Leverage	-0.398**	-0.283	-0.023	0.372
	(0.172)	(0.212)	(0.236)	(0.289)
Tangibility	-1.179***	-0.987**	-1.621***	-1.682***
	(0.369)	(0.462)	(0.430)	(0.528)
CAPX	2.783**	2.163	2.835**	3.601*
	(1.234)	(1.575)	(1.340)	(1.839)
Herfindal	-0.383	7.612*	2.385	10.880***
	(2.776)	(3.895)	(2.815)	(3.659)
$Herfindal^2$	1.232	-8.006*	-1.380	-11.914***
	(3.367)	(4.515)	(3.342)	(4.095)
TobinQ	0.286	-0.444	0.176	-0.177
	(0.291)	(0.426)	(0.367)	(0.528)
M/B	0.240***	0.537***	0.396***	0.733***
	(0.076)	(0.108)	(0.093)	(0.125)
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	1637	1637	1037	1037
adj. R^2	0.785	0.732	0.845	0.807

Table 5(a) shows the regression results on the long-term relationship between ESG and innovation. Dependent variable is the natural logarithm of total number of firm's patent filings from year *t+1* to *t+3*, firm's citation from year *t+1* to *t+3*, firm's patent filings from year *t+1* to *t+5* and firm's citation from year *t+1* to *t+5*, respectively. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 5(b) ESG and Innovation by Category with Patents in *t+3* (long-term effect)

Panel A Environment Pillar

	(1)	(2)	(3)	(4)	(5)
EScore	0.839***				
	(0.162)				
Resource		0.598***			0.137
		(0.122)			(0.168)
Emission			0.762***		0.649***
			(0.136)		(0.187)
Innovation				0.293**	0.013
				(0.136)	(0.147)
N	1637	1637	1637	1637	1637
Adj. R^2	0.787	0.786	0.787	0.783	0.787

Panel B Social Pillar

	(1)	(2)	(3)	(4)	(5)	(6)
SScore	0.501***					
	(0.193)					
Workforce		0.532***				0.577***
		(0.137)				(0.152)
Human Rights			0.125			0.032
			(0.113)			(0.118)
Community				0.242*		0.091
				(0.141)		(0.146)
Product Responsibility					-0.135	-0.276**
					(0.121)	(0.125)
N	1637	1637	1637	1637	1637	1637
Adj. R^2	0.783	0.784	0.782	0.782	0.782	0.785

Panel C Governance Pillar

	(1)	(2)	(3)	(4)	(5)
GScore	0.205				
	(0.156)				
Management		0.185*			0.171
		(0.111)			(0.110)
Shareholder			-0.253**		-0.313***
			(0.104)		(0.105)
CSR Strategy				0.439***	0.470***
				(0.129)	(0.129)
N	1637	1637	1637	1637	1637
Adj. R^2	0.782	0.782	0.783	0.784	0.785

Table 5(b) shows the regression results on the relationship between ESG and innovation, with natural logarithm of number of patents filed in year *t+5* ($LnPatent_{t+1}$) as proxy for innovation. Panel A reports results with firm's score in each category of the environmental pillar as proxy for firm's ESG performances, Panel B with social pillar and Panel C with the governance pillar, respectively. All regression models include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 5(c) ESG and Innovation by Category with Patents in *t+5* (long-term effect)

Panel A Environment Pillar

	(1)	(2)	(3)	(4)	(5)
EScore	0.770***				
	(0.168)				
Resource		0.634***			0.420**
		(0.126)			(0.178)
Emission			0.653***		0.326*
			(0.140)		(0.195)
Innovation				0.225	-0.039
				(0.148)	(0.158)
N	1037	1037	1037	1037	1037
Adj. R^2	0.844	0.845	0.844	0.841	0.845

Panel B Social Pillar

	(1)	(2)	(3)	(4)	(5)	(6)
SScore	0.333					
	(0.222)					
Workforce		0.441***				0.505***
		(0.164)				(0.183)
Human Rights			0.196			0.172
			(0.120)			(0.130)
Community				0.024		-0.111
				(0.150)		(0.157)
Product Responsibility					-0.145	-0.274*
					(0.138)	(0.143)
N	1037	1037	1037	1037	1037	1037
Adj. R^2	0.841	0.842	0.841	0.84	0.841	0.842

Panel C Governance Pillar

	(1)	(2)	(3)	(4)	(5)
GScore	-0.075				
	(0.189)				
Management		0.036			0.004
		(0.133)			(0.131)
Shareholder			-0.434***		-0.491***
			(0.128)		(0.129)
CSR Strategy				0.341**	0.422***
				(0.134)	(0.132)
N	1037	1037	1037	1037	1037
Adj. R^2	0.84	0.84	0.843	0.842	0.844

Table 5(c) shows the regression results on the relationship between ESG and innovation, with natural logarithm of number of patents filed in year *t+5* ($LnPatent_{t+5}$) as proxy for innovation. Panel A reports results with firm's score in each category of the environmental pillar as proxy for firm's ESG performances, Panel B with social pillar and Panel C with the governance pillar, respectively. All regression models include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 5(d) ESG and Channels of Influence (long-term effect)

	(1) Cost of Capital	(2) Cash Dividends	(3) Cash Holdings	(4) Financial Slack	(5) Free Cash Flow	(6) Innovation Productivity	(7) Sensitivity to Opportunity	(8) Ads
Score	-*,+,-**	+***,+*,+	-,+***,-	-,+**,+	-***,-*,+	-, +***,+***	+***,+*,+	-**,-,-
EScore	-,+,-***	+***,+,+***	-*,+**,-	-,+**,+**	-**,-,+***	+, +***,+***	+***,+***,-	+,-,+*
Resource	+,+,+	+***,+,+***	-,+***,+	-,+**,+**	-***,-,+***	+, +***,+***	+***,+***,-	-,-,+
Emission	-*,+,-	+***,+,+***	-,+**,-	-,+**,+***	-**,-,+***	+, +***,+***	+***,+***,-	+,-,+*
Innovation	-*,+,-	+***,+*,+	-**,+***,+	-,+**,+	-***,-*,+	+, +***,+***	+***,+***,-	+,-,+*
SScore	-,+,-***	+***,+*,+	+,+***,-	-,+**,+	-**,-*,+	-*, +***,+***	+***,+**,-	-**,-,-
Workforce	-,+,-	+***,+*,+	-,+***,-	-,+**,+	-***,-*,+	+, +***,+***	+**,+**,-	-***,-,-
Human Rights	+,+,+*	+***,+*,+	+***,+***,+	-,+**,+	-***,-*	-*, +***,+***	+,+**,-***	+,-,-***
Community	+,+,+**	+,+*,+	+,+**,+**	-,+**,+	+,-**,-	-, +**,-	+***,+***,+**	-,-,+
Product Responsibility	-*,+,-**	-***,+**,-**	-,+***,-**	+,+**,-**	+,-**,-	-, +**,-	+**,+***,-*	-*,-,-**
GScore	-***,+,-**	+**,+**,-	+*,+***,-***	+,+**,-	+,-*,-	-,+*,-	-,+***,+	-**,-,-
Management	-*,+,-	+,+*,-	+,+***,-	+,+**,-	+,-*,-	-,+*,-	-,+,+*	-**,-,+
Shareholder	-,+*,-***	+*,+**,-***	-***,+***,-***	-,+**,-***	+,-*,-***	-,+*,-***	-*,+**,+*	-,-,-*
CSR Strategy	+**,+,+	+**,+*,+	-,+***,+	-**,+**,+**	-***,-*,+*	-***,-*,+	+**,+***,-***	-,-,-,

Table 5(d) summarize regression results of channels analyses on the relationship between ESG scores, along with its sub-category scores, and firm's innovation output in the long-term (t+5). Each cell in the table reports three coefficient estimates (sign and significance): 1) coefficient of the ESG score component when regressed on the channel variable; 2) coefficient of the channel variable when regressed on innovation ($LnPatent_{t+5}$); and 3) coefficient of the ESG score component when regressed on innovation ($LnPatent_{t+5}$) after controlling for the channel variable. All regression models include a set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 6(a) ESG and innovation (IV-2SLS)

	(1) *Score*	(2) $LnPatent_{t+1}$	(3) $LnCitation_{t+1}$	(4) *Score*	(5) $LnPatent_{t+1}$	(6) $LnCitation_{t+1}$	(7) *Score*	(8) $LnPatent_{t+1}$	(9) $LnCitation_{t+1}$
$Score_{Initial}$	0.624***			0.659***					
	(0.019)			(0.020)					
$Score_{Industry}$	0.646***						0.710***		
	(0.024)						(0.029)		
Score		1.301***	2.060***		1.605***	1.597***		0.816**	2.710***
		(0.207)	(0.225)		(0.362)	(0.389)		(0.380)	(0.548)
All Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	4193	3488	3488	4093	3390	3390	4093	3390	3390
Adj. R^2	0.735			0.682			0.637		
p-value		0.169	0.439		0.645	0.445		0.576	0.391
LM statistic	16.248			344.905			302.496		
Wald F statistic	1573.543			445.952			294.842		

Table 6(a) shows the regression results on the relationship between ESG and innovation with IV-2SLS. *Score* is the firm's fitted overall ESG score. For the set of instrumental variables, $Score_{Initial}$ is the firm's ESG score when it was first included in the dataset. $Score_{Industry}$ is the average ESG score within the industry defined by 2-digt SIC code. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 6(b) ESG and innovation by Pillar (IV-2SLS)

	(1) *Score*	(2) $LnPatent_{t+1}$	(3) *EScore*	(4) $LnPatent_{t+1}$	(5) *Resource*	(6) $LnPatent_{t+1}$	(7) *Emission*	(8) $LnPatent_{t+1}$	(9) *Innovation*	(10) $LnPatent_{t+1}$
Panel A Environmental Pillar										
ESG Performance		3.099***		1.951***		1.332***		1.629***		0.514**
		(0.565)		(0.438)		(0.334)		(0.326)		(0.262)
$Score_{Industry}$	0.618***		0.627***		0.627***		0.655***		0.833***	
	(0.042)		(0.043)		(0.041)		(0.041)		(0.040)	
Adj. R^2	0.629	0.679	0.623	0.699	0.584	0.698	0.608	0.7	0.555	0.699
Panel B Social Pillar										
	SScore	$LnPatent_{t+1}$	*Workforce*	$LnPatent_{t+1}$	*Human Rights*	$LnPatent_{t+1}$	*Community*	$LnPatent_{t+1}$	*Product Responsibility*	$LnPatent_{t+1}$
ESG Performance		2.669***		-1.920***		0.417		0.821***		-0.487**
		(0.506)		(-0.307)		(0.263)		(0.285)		(-0.241)
$Score_{Industry}$	0.627***		0.742***		0.761***		0.814***		0.555***	
	(0.039)		(0.035)		(0.040)		(0.034)		(0.068)	
Adj. R^2	0.581	0.675	0.532	0.682	0.467	0.697	0.544	0.694	0.363	0.692
Panel C Governance Pillar										
	GScore	$LnPatent_{t+1}$	*Management*	$LnPatent_{t+1}$	*Shareholder*	$LnPatent_{t+1}$	*CSR Strategy*	$LnPatent_{t+1}$		
ESG Performance		1.091***		0.570***		-0.357*		1.197***		
		(0.282)		(0.185)		(-0.192)		(0.294)		
$Score_{Industry}$	0.866***		0.905***		1.005***		0.688***			
	(0.032)		(0.028)		(0.036)		(0.041)			
Adj. R^2	0.497	0.692	0.43	0.694	0.386	0.693	0.554	0.698		

All controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	2543	2543	2543	2543	2543	2543	2543	2543	2543	2543

Table 6(b) shows the regression results on the relationship between ESG and innovation with IV-2SLS. *ESG Performance* is the coefficient estimate for fitted ESG or its sub-category score when regressed on innovation output. $Score_{Industry}$ is the average ESG score within the industry defined by 2-digt SIC code. All regression models include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 7 Channels of Influence with Mediation Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Score	EScore	Resource	Emission	Innovation	SScore	Workforce	Human Rights	Community	Product Responsibility	GScore	Management	Shareholder	CSR Strategy
Panel I. Free Cash Flow Channel														
ESG Performance	0.637**	0.703***	0.388**	0.607***	0.301	0.507**	0.588***	0.056	0.155	-0.091	0.216	0.15	-0.215**	0.633***
	(0.258)	(0.202)	(0.165)	(0.165)	(0.206)	(0.197)	(0.137)	(0.144)	(0.146)	(0.120)	(0.156)	(0.106)	(0.102)	(0.192)
Free Cash Flow	-1.274**	-1.014***	-1.016***	-1.016***	-1.048***	-1.561***	-1.613***	-1.058***	-1.542***	-0.961**	-0.711	-0.822*	-0.816*	-0.811**
	(0.517)	(0.383)	(0.383)	(0.384)	(0.383)	(0.479)	(0.448)	(0.386)	(0.502)	(0.409)	(0.472)	(0.442)	(0.436)	(0.385)
FCF×Score	1.223	2.766**	2.319**	2.424**	0.944	1.605**	1.628***	0.917	0.960*	-0.267	-0.834	-0.478	-0.545	-0.498
	(1.199)	(1.273)	(1.060)	(1.078)	(1.480)	(0.755)	(0.526)	(0.883)	(0.575)	(0.536)	(0.743)	(0.493)	(0.497)	(1.289)
N	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007
Adj. R^2	0.727	0.732	0.73	0.733	0.726	0.727	0.73	0.725	0.725	0.725	0.725	0.725	0.726	0.728
Panel II. Cash Holdings Channel														
ESG Performance	0.049	0.016	0.028	0.129	-0.31	0.454	0.353	0.408**	0.518**	-0.173	-0.371	-0.229	-0.396**	0.224
	(0.359)	(0.256)	(0.203)	(0.208)	(0.210)	(0.318)	(0.238)	(0.200)	(0.224)	(0.205)	(0.265)	(0.185)	(0.196)	(0.229)
Cash Holdings	1.372***	1.191***	1.272***	1.292***	1.135***	2.270***	2.023***	1.639***	2.120***	1.554***	0.885**	1.223***	0.736*	1.243***
	(0.461)	(0.283)	(0.278)	(0.275)	(0.266)	(0.454)	(0.369)	(0.274)	(0.432)	(0.336)	(0.412)	(0.346)	(0.386)	(0.269)
Cash Holding×Score	0.186	1.729*	1.054	0.889	2.565***	-1.972**	-1.384**	-1.154	-1.233**	-0.244	1.310*	0.463	1.462**	1.18
	(1.069)	(0.882)	(0.730)	(0.737)	(0.787)	(0.909)	(0.650)	(0.703)	(0.606)	(0.574)	(0.754)	(0.507)	(0.587)	(0.795)
N	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354
Adj. R^2	0.759	0.76	0.76	0.76	0.761	0.76	0.76	0.76	0.76	0.759	0.759	0.759	0.76	0.761
Panel III. Cash Dividends Channel														
ESG Performance	0.413	1.017***	0.661***	0.915***	0.372*	0.203	0.342**	-0.027	0.017	-0.310**	0.002	0.025	-0.191*	0.424***
	(0.255)	(0.192)	(0.143)	(0.154)	(0.194)	(0.194)	(0.134)	(0.144)	(0.140)	(0.123)	(0.165)	(0.116)	(0.107)	(0.160)
Cash Dividends	-0.031	0.016	0.02	0.024	0.019	-0.057*	-0.038	0.014	-0.056	-0.007	-0.012	0.004	0.035	0.003
	(0.029)	(0.019)	(0.019)	(0.019)	(0.016)	(0.030)	(0.026)	(0.018)	(0.035)	(0.024)	(0.028)	(0.024)	(0.025)	(0.018)
Dividends×Score	0.113**	-0.003	-0.003	-0.017	0.034	0.155***	0.115***	0.059*	0.131***	0.089**	0.082*	0.051	0.005	0.054
	(0.054)	(0.042)	(0.034)	(0.035)	(0.043)	(0.049)	(0.041)	(0.034)	(0.047)	(0.039)	(0.046)	(0.035)	(0.037)	
N	2527	2527	2527	2527	2527	2527	2527	2527	2527	2527	2527	2527	2527	2527
Adj. R^2	0.700	0.705	0.703	0.706	0.700	0.701	0.702	0.699	0.700	0.699	0.699	0.698	0.699	0.702

Table 7 Channels of Influence with Mediation Analysis (continued)

	(1) Score	(2) EScore	(3) Resource	(4) Emission	(5) Innovation	(6) SScore	(7) Workforce	(8) Human Rights	(9) Community	(10) Product Responsibility	(11) GScore	(12) Management	(13) Shareholder	(14) CSR Strategy
Panel IV. Financial Slack Channel														
ESG Performance	0.357	0.525**	0.232	0.521***	0.134	0.519**	0.553***	0.137	0.340*	-0.179	-0.214	-0.148	-0.265*	0.28
	(0.282)	(0.211)	(0.166)	(0.174)	(0.206)	(0.244)	(0.179)	(0.174)	(0.176)	(0.164)	(0.206)	(0.143)	(0.139)	(0.207)
Financial Slack	0.03	0.040***	0.040***	0.042***	0.049***	0.074***	0.065***	0.057***	0.096***	0.061***	0.007	0.022	0.033	0.053***
	(0.025)	(0.013)	(0.013)	(0.013)	(0.013)	(0.023)	(0.018)	(0.013)	(0.023)	(0.017)	(0.023)	(0.019)	(0.021)	(0.012)
Financial Slack ×Score	0.089	0.155**	0.145**	0.119*	0.096	-0.054	-0.027	-0.005	-0.080**	-0.012	0.132**	0.081**	0.051	0.111
	(0.077)	(0.074)	(0.058)	(0.061)	(0.074)	(0.057)	(0.040)	(0.058)	(0.039)	(0.037)	(0.053)	(0.036)	(0.035)	(0.080)
N	2456	2456	2456	2456	2456	2456	2456	2456	2456	2456	2456	2456	2456	2456
Adj. R^2	0.712	0.717	0.715	0.718	0.712	0.711	0.712	0.71	0.711	0.711	0.711	0.711	0.711	0.714
Panel V. Advertisement Channel														
ESG Performance	-0.269	0.576***	0.14	0.405**	0.726***	-0.271	-0.121	-0.117	0.16	-0.481***	-0.377*	-0.177	-0.251*	0.023
	(0.304)	(0.204)	(0.150)	(0.164)	(0.189)	(0.255)	(0.200)	(0.165)	(0.200)	(0.151)	(0.225)	(0.162)	(0.148)	(0.158)
Ads	-3.501***	-1.741	-1.986*	-1.776*	-1.643	-3.200**	-3.032**	-2.036*	-1.854	-3.552***	-5.755***	-4.752***	-2.669*	-1.721
	(1.345)	(1.069)	(1.080)	(1.057)	(1.080)	(1.385)	(1.330)	(1.081)	(1.732)	(1.233)	(1.635)	(1.342)	(1.511)	(1.068)
Ads×Score	5.777*	-1.649	0.454	-1.551	-3.627	3.904	3.917	0.604	-0.167	5.312*	12.346***	8.833***	1.605	-3.036
	(3.471)	(2.443)	(2.209)	(1.874)	(2.980)	(3.250)	(3.210)	(2.154)	(2.823)	(3.086)	(4.056)	(2.652)	(2.464)	(2.049)
N	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049
Adj. R^2	0.776	0.777	0.775	0.776	0.778	0.775	0.775	0.775	0.775	0.777	0.778	0.778	0.776	0.775
Panel VI. R&D Sensitivity to Opportunity Set Channel														
ESG Performance	-0.053***	-0.030**	-0.016*	-0.038***	-0.018	-0.030*	-0.006	-0.023**	-0.045***	-0.005	-0.017	-0.014	0.007	-0.013
	(0.018)	(0.012)	(0.009)	(0.011)	(0.011)	(0.017)	(0.015)	(0.011)	(0.014)	(0.012)	(0.017)	(0.013)	(0.011)	(0.009)
Sensitivity to Opportunity	-0.011	0.054***	0.061***	0.048***	0.067***	-0.031	0.01	0.068***	-0.055	0.063***	0.069**	0.065**	0.101***	0.068***
	(0.030)	(0.019)	(0.019)	(0.018)	(0.018)	(0.030)	(0.027)	(0.018)	(0.034)	(0.022)	(0.034)	(0.031)	(0.024)	(0.018)
Sensitivity to Opportunity × Score	0.255***	0.172***	0.104***	0.202***	0.086**	0.258***	0.143***	0.089**	0.224***	0.037	0.02	0.025	-0.057	0.077**
	(0.062)	(0.037)	(0.031)	(0.035)	(0.043)	(0.062)	(0.051)	(0.041)	(0.051)	(0.046)	(0.063)	(0.048)	(0.040)	(0.031)
N	2087	2087	2087	2087	2087	2087	2087	2087	2087	2087	2087	2087	2087	2087
Adj. R^2	0.666	0.665	0.664	0.669	0.662	0.671	0.669	0.662	0.671	0.661	0.661	0.661	0.662	0.662

Table 7 Channels of Influence with Mediation Analysis (continued)

	(1) Score	(2) EScore	(3) Resource	(4) Emission	(5) Innovation	(6) SScore	(7) Workforce	(8) Human Rights	(9) Community	(10) Product Responsibility	(11) GScore	(12) Management	(13) Shareholder	(14) CSR Strategy
Panel VII. Cost of Capital Channel														
ESG Performance	0.801**	0.809***	0.460**	0.720***	0.570***	0.789***	0.621***	0.443**	0.700***	0.082	0.194	-0.043	0.101	0.878***
	(0.332)	(0.224)	(0.180)	(0.191)	(0.179)	(0.304)	(0.228)	(0.198)	(0.224)	(0.192)	(0.250)	(0.180)	(0.171)	(0.187)
Cost of Capital	0.433**	0.155	0.074	0.104	0.118	0.528***	0.379**	0.043	0.394**	0.141	0.059	-0.059	-0.03	0.049
	(0.183)	(0.104)	(0.101)	(0.099)	(0.097)	(0.185)	(0.150)	(0.095)	(0.194)	(0.140)	(0.181)	(0.155)	(0.155)	(0.092)
Cost of Capital ×Score	-1.372***	-1.105***	-0.655**	-0.861***	-1.027***	-1.478***	-1.147***	-0.687**	-0.803***	-0.579**	-0.301	-0.044	-0.088	-0.828***
	(0.443)	(0.308)	(0.259)	(0.269)	(0.272)	(0.401)	(0.308)	(0.296)	(0.302)	(0.282)	(0.369)	(0.272)	(0.260)	(0.283)
N	1412	1412	1412	1412	1412	1412	1412	1412	1412	1412	1412	1412	1412	1412
Adj. R^2	0.753	0.754	0.753	0.754	0.754	0.754	0.754	0.752	0.753	0.752	0.751	0.751	0.751	0.755
Panel VIII. Employee Innovation Productivity Channel														
ESG Performance	-0.343**	-0.119	-0.160*	-0.046	-0.304***	-0.229*	-0.05	-0.251***	-0.390***	-0.184**	-0.344***	-0.235***	-0.116*	-0.071
	(0.142)	(0.103)	(0.082)	(0.085)	(0.090)	(0.119)	(0.088)	(0.082)	(0.092)	(0.079)	(0.099)	(0.069)	(0.068)	(0.088)
Innovation Productivity	0.584***	0.817***	0.841***	0.843***	0.853***	0.620***	0.754***	0.889***	0.629***	0.817***	0.703***	0.791***	0.854***	0.884***
	(0.031)	(0.021)	(0.021)	(0.021)	(0.022)	(0.030)	(0.027)	(0.021)	(0.032)	(0.026)	(0.031)	(0.028)	(0.029)	(0.021)
Innovation Productivity×Score	1.155***	0.880***	0.704***	0.656***	0.634***	0.881***	0.465***	0.563***	0.594***	0.398***	0.613***	0.336***	0.184***	0.626***
	(0.077)	(0.053)	(0.044)	(0.046)	(0.055)	(0.066)	(0.053)	(0.061)	(0.051)	(0.053)	(0.065)	(0.051)	(0.044)	(0.051)
N	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530	2530
Adj. R^2	0.905	0.909	0.905	0.906	0.897	0.9	0.894	0.896	0.895	0.892	0.893	0.89	0.887	0.901

Table 7 reports results of channels of influence from firm's ESG performances via mediation analysis. In each panel, we report estimation results of one plausible channel of influence, over each theme of ESG performance, respectively. For each column, *ESG Performance* is proxied by firms overall ESG score or one of its subcategories. The dependent variable of all regressions is the natural logarithm of number of patent filings in year *t+1*. All regression models include a set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 8 ESG and innovation (alternative measures of ESG)

Panel A

	(1) $LnPatent_{t+1}$	(2) $LnPatent_{t+1}$	(3) $LnPatent_{t+1}$	(4) $LnPatent_{t+1}$
Score $_{PCA}$		0.116***		0.075***
		(0.023)		(0.029)
All controls	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	2543	2543	2543	2543
adj. R^2	0.699	0.702	0.670	0.671

Panel B

	(1) $LnPatent_{t+1}$	(2) $LnPatent_{t+1}$	(3) $LnPatent_{t+1}$	(4) $LnPatent_{t+1}$
EScore $_{PCA}$	0.184***			0.162***
	(0.024)			(0.028)
SScore $_{PCA}$		0.088***		-0.024
		(0.022)		(0.024)
GScore $_{PCA}$			0.159***	0.102***
			(0.023)	(0.024)
All controls	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	3488	3488	3488	3488
R^2	0.671	0.665	0.668	0.673
adj. R^2	0.649	0.642	0.645	0.650

Panel C

	(1) $LnCitation_{t+1}$	(2) $LnCitation_{t+1}$	(3) $LnCitation_{t+1}$	(4) $LnCitation_{t+1}$
EScore $_{PCA}$	0.137***			0.112***
	(0.029)			(0.034)
SScore $_{PCA}$		0.043		-0.066**
		(0.026)		(0.029)
GScore $_{PCA}$			0.201***	0.180***
			(0.029)	(0.030)
All controls	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	3488	3488	3488	3488
R^2	0.606	0.602	0.609	0.611
adj. R^2	0.578	0.575	0.582	0.584

Table 8 shows the regression results on the relationship between alternative measures of ESG and innovation. In Panel A, we calculate overall ESG score as the principal component (*Score* $_{PCA}$) instead of the weighted average of each pillar. Panel B and C reports results for each pillar of ESG, proxied by firm's PCA-calculated score in each pillar. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 9 ESG and innovation (alternative measures of innovation)

Panel A

	(1) *LnPatent Iss$_{t+1}$*	(2) *LnPatent Iss$_{t+1}$*	(3) *LnPatent Iss$_{t+1}$*	(4) *LnPatent Iss$_{t+1}$*	(5) *LnPatent Iss$_{t+1}$*
Score	1.288***				
	(0.186)				
EScore		1.361***			1.180***
		(0.139)			(0.155)
SScore			1.146***		0.406**
			(0.157)		(0.173)
GScore				0.258**	-0.039
				(0.118)	(0.118)
All controls	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	3488	3488	3488	3488	3488
R^2	0.682	0.689	0.682	0.676	0.689
adj. R^2	0.660	0.667	0.661	0.654	0.668

Panel B

	(1) *LnCitation Iss$_{t+1}$*	(2) *LnCitation Iss$_{t+1}$*	(3) *LnCitation Iss$_{t+1}$*	(4) *LnCitation Iss$_{t+1}$*	(5) *LnCitation Iss$_{t+1}$*
Score	1.583***				
	(0.243)				
EScore		1.319***			1.266***
		(0.182)			(0.203)
SScore			0.773***		-0.201
			(0.205)		(0.224)
GScore				0.882***	0.669***
				(0.152)	(0.153)
All controls	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	3488	3488	3488	3488	3488
R^2	0.638	0.640	0.634	0.636	0.642
adj. R^2	0.613	0.615	0.608	0.610	0.617

Table 9 shows the regression results on the relationship between ESG and alternative measures of innovation. In Panel A, we use the natural logarithm of number of patents issued in year *t+1* as proxy for firm's level of innovation activities. In Panel B, we use the natural logarithm of number of citations for issued patents in year *t+1* as proxy for firm's level of innovation activities. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.

Table 10 ESG and Innovation by Industry

	(1) Consumer Goods	(2) Manufa-cture	(3) Telecom	(4) Energy & Utilities	(5) Retail	(6) Health	(7) Financials
Panel A Environmental Pillar							
	$LnPatent_{t+1}$	$LnPatent_{t+1}$	$LnPatent_{t+1}$	$LnPatent_{t+1}$	$LnPatent_{t+1}$	$LnPatent_{t+1}$	$LnPatent_{t+1}$
Score	1.133	2.011***	-2.819*	0.368	0.744*	(0.125)	1.080*
	(1.263)	(0.625)	(1.511)	(0.623)	(0.437)	(0.429)	(0.615)
EScore	0.629	1.028*	-0.976	1.451***	1.119***	0.610	1.169***
	(1.219)	(0.523)	(0.867)	(0.470)	(0.285)	(0.413)	(0.429)
Resource	0.948	0.557	-0.535	1.278***	0.689***	0.096	0.855**
	(0.658)	(0.424)	(0.655)	(0.387)	(0.215)	(0.243)	(0.352)
Emission	0.963	0.465	-1.789**	0.062	1.111***	0.915***	0.696**
	(0.629)	(0.484)	(0.790)	(0.445)	(0.239)	(0.296)	(0.352)
Innovation	-0.542	0.595**	0.455	1.097***	0.527*	-1.851***	1.214**
	(0.465)	(0.295)	(0.815)	(0.342)	(0.281)	(0.562)	(0.472)
N	98	295	98	187	550	531	182
Avg. R^2	0.645	0.800	0.733	0.527	0.723	0.667	0.562
Panel B Social Pillar							
SScore	0.775	2.579***	-1.639	-0.354	0.006	-0.251	1.913***
	(1.008)	(0.438)	(1.766)	(0.668)	(0.381)	(0.245)	(0.567)
Workforce	0.276	2.330***	1.282	0.682	0.295	-0.047	1.402***
	(0.710)	(0.364)	(1.258)	(0.509)	(0.275)	(0.152)	(0.421)
Human Rights	0.514	-0.499	0.255	-0.438	0.228	-0.454*	0.014
	(0.604)	(0.371)	(0.531)	(0.378)	(0.257)	(0.246)	(0.360)
Community	-0.372	1.096***	-4.663***	1.042*	0.163	-0.066	0.944**
	(0.931)	(0.367)	(1.116)	(0.540)	(0.267)	(0.181)	(0.391)
Product Responsibility	0.531	1.401***	-1.690	-1.738***	-0.789***	-0.090	1.075*
	(0.492)	(0.249)	(1.525)	(0.362)	(0.250)	(0.166)	(0.568)
N	98	295	98	187	550	531	182
Avg. R^2	0.633	0.812	0.752	0.511	0.717	0.663	0.563

Table 10 ESG and Innovation by Industry (continued)

	(1) Consumer Goods	(2) Manufa-cture	(3) Telecom	(4) Energy & Utilities	(5) Retail	(6) Health	(7) Financials
Panel C Governance Pillar							
GScore	0.515	0.311	-1.111	-0.777	0.592*	0.014	-0.284
	(0.780)	(0.481)	(0.908)	(0.480)	(0.312)	(0.253)	(0.519)
Management	0.333	0.299	-0.874	-0.795**	0.327	0.042	0.018
	(0.458)	(0.330)	(0.603)	(0.340)	(0.220)	(0.168)	(0.382)
Shareholder	0.353	-0.377	0.053	-0.069	0.116	-0.069	-0.915***
	(0.616)	(0.277)	(0.710)	(0.432)	(0.209)	(0.150)	(0.326)
CSR Strategy	-0.123	1.176**	-0.851	0.844*	0.518**	-0.007	1.044***
	(0.521)	(0.400)	(0.837)	(0.437)	(0.223)	(0.279)	(0.371)
N	98	295	98	187	550	531	182
Avg. R^2	0.633	0.801	0.730	0.516	0.718	0.662	0.564

Table 10 reports the relationship between ESG and innovation by industry. with natural logarithm of number of citations for patents filed in year t+1 (LnPatentt+1) as proxy for innovation. Panel A reports results with firm's score in each category of the environmental pillar as proxy for firm's ESG performances, Panel B with social pillar and Panel C with the governance pillar, respectively. All regression models include the set of firm-specific control variables, industry fixed effects and year fixed effects. Robust standard errors in parentheses. *,** and *** denote significance at 10%,5% and 1% level, respectively.