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Managerial ability and corporate greenhouse gas emissions

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ABSTRACT

Top managers are responsible for important decisions and their efficient implementation. Therefore, higher ability is more likely to lead to effective practice and favourable firm outcomes. This paper examines the association between managerial ability and corporate greenhouse gas emissions. The results suggest that firms with more able managers have lower greenhouse gas emissions. The disaggregation of total greenhouse gas emissions into Scope 1 emissions and Scope 2 emissions shows that managerial ability is negatively associated with both components. The results hold while controlling for various firm and country-level attributes and econometric specifications mitigating endogeneity concerns.

1. Introduction

In recent years, policymakers have intensified their efforts to address environmental concerns and to combat climate change. Their initiatives often take the form of pressures from a formal institutional environment, like national policies and regulations with well-known examples at an international level being the Kyoto protocol, the European Union Emissions Trading Scheme and the Paris Agreement.[1] To give an example of the magnitude of these efforts, it should be noted that European countries alone have reported more than 2000 policies and measures that focus on reducing or preventing greenhouse gas (GHG) emissions (Dauwe et al., 2021).[2] In the U.S there are several environmental rules (Clear Air Act, Toxic Substances Control Act, etc.), while in April 2021 President Biden set a new national goal to reduce emissions by around 50% from 2005 levels by 2030. In line with this agenda, the Securities Exchange Commissions also proposed recently a rule that would require U.S.-listed companies to disclose a range of climate-related risks and greenhouse gas emissions

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[1] For a discussion of the politics of climate finance and the national and international policy initiatives that promote sustainable finance and address ESG issues see D'Orazio (2023a).

[2] The 2021 report of the European Topic Centre on Climate change mitigation and energy by Dauwe et al. (2021) also highlights that the number of reported single national policies and measures to reduce greenhouse gas emissions increased by around 11% between 2019 and 2021.

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(Securities Exchange Commission, 2022).[3] Additionally, several developments in the banking industry put pressure on banking institutions to finance companies that are environmental-friendly. These include climate-risk stress tests (e.g. European Central Bank, Federal Reserve Board, Bank of England) and various other initiatives by central banks around the world.[4] This is complemented by industry-led initiatives, like the UN-convened Net-Zero Banking Alliance, which comprises of a group of banks committed to aligning their lending and investment portfolios with net-zero emissions by 2050.[5] Additionally, firm managers face further pressure from informal institutions, like social norms and beliefs that enhance public awareness of how firms' activities can have an impact on the physical environment and climate change (Gaganis et al., 2021).

In response to these formal and informal institutional pressures from various stakeholder groups, many firms have committed themselves to adopting responsible environmental actions such as increasing investments for innovative and inclusive low-carbon products, reducing the carbon footprint of their production processes, setting emissions reductions targets and improving their energy efficiency (Montalbano and Nenci, 2019). The literature discusses various firm and country-level determinants that drive the adoption of environmental-related policies or carbon emission disclosures (e.g. Finnerty et al., 2018; Banerjee et al., 2019; Kilic and Kuzey, 2019). At the same time a growing number of scholars working in this field have emphasized that managers might play an important role in explaining the diversity of environmental and energy-related practices. For example, Nkuiya and Costello (2016) argue that "*Nearly every environmental management challenge boils down to a tradeoff society must make between the benefits of pollution and the damages that arise from the resulting pollution stock*" (p. 193). Their theoretical model shows that the possibility of a shift in environmental preferences can induce higher, or lower, optimal current emissions. Others focus on specific managerial characteristics. For instance, Lewis et al. (2014) examine how CEO characteristics, such as education and tenure, influence firms' likelihood to voluntarily disclose environmental information. Blass et al. (2014) investigate how top managers influence the adoption of energy-efficiency practices in US SMEs. Chatjuthmard et al. (2016) reveal a nonmonotonic effect of managerial talent on environmentally- related social corporate responsibility (SCR) policies. Cho and Lee (2019) find that more talented managers are less likely to engage in environmentally related CSR policies. Murillo-Luna et al. (2008) also highlight the importance of the managers' personal attitudes, values and beliefs for the interpretation of environmental issues.

However, these studies focus on the impact of managerial preferences and characteristics on corporate environmental management strategies and approaches rather than on their influence on actual firm-level energy-related outcomes. In the words of Cole et al. (2013) "*A weakness of this literature has always been the uncertain link between environmental management and actual measures of environmental performance such as emissions*" (p. 290). Examining actual environmental performance is particularly important since another strand of the literature argues that the adoption of environmental management systems (e.g. ISO 14,001 and other standards) does not necessarily improve environmental performance, that such systems are often superficially implemented, and that they might be used for marketing and symbolic purposes or as a means of greenwashing (Christmann and Taylor 2006; Boirai, 2007; Boirai and Henri 2012; Testa et al., 2018).

Therefore, a question that remains unanswered is whether managerial attributes result in better measurable outcomes, like CO_2 emissions. To answer this question, we use the measure of managerial ability developed by Demerjian et al. (2012), and examine its impact on direct, indirect and total greenhouse gas emissions. As we discuss in more detail below, this measure has been adopted in numerous studies that relate to other firm outcomes and it outperforms alternative measures of managerial ability in several ways (Demerjian et al., 2012). Our analysis is based on a cross-country sample of 407 publicly listed firms operating in 34 countries during the period 2003–2020, corresponding to an unbalanced dataset of 2329 firm-year observations.

Apparently, our work relates to a recent body of the literature that focuses on the determinants of actual measures of firm-level environmental performance (e.g. toxic air releases, local air pollution, CO2 emissions).[6] For example, Cole et al. (2013) conclude that the key factors driving a firm's CO_2 are its capital-labor ratio, its size, its R&D expenditure, its advertising expenditure, and its exports density. Alam et al. (2019) also conclude that R&D investment negatively affects the energy and carbon emissions intensities. Kudlak (2019) finds that social, national environmental regulations, and environmental subsidies exert a significant influence on CO2 emissions levels. Homroy and Slechten (2019) find that non-executive directors with previous experience in environmental issues and their network connections are associated with lower GHG emissions. In a similar vein, Chen et al. (2021) conclude that investment in human capital - measured by the percentage of workers with at least 16 years of education (4-year college) - significantly and substantially reduces firms' emissions. Apergis et al. (2013) find that R&D expenditures are associated with a decrease in CO2 emissions in the post-IFRS mandatory adoption year. Using a sample of Lithuanian firms, Jaraite and Di Maria (2016) show that participation in the European Union Emissions Trading System is not associated with a reduction in CO2 emissions. Delmas and Montes-Sancho (2010) examine whether participation in the Climate Challenge program (1995–2000) of the U.S. Department of

[3] This rule that was proposed in March 2022 requires registrants to include certain climate-related disclosures in their registration statements and periodic reports, as well as to disclose information about their direct greenhouse gas (GHG) emissions (Scope 1) and indirect emissions from purchased electricity or other forms of energy (Scope 2). In addition, a registrant would be required to disclose GHG emissions from upstream and downstream activities in its value chain (Scope 3), if material or if the registrant has set a GHG emissions target or goal that includes Scope 3 emissions.

[4] For a discussion of the role of bank regulators in the promotion of green and climate finance and the adoption of climate-related financial policies around the world see D'Orazio (2023b).

[5] This group includes 129 banks from 41 countries, currently representing over 40% of global banking assets.

[6] Others explore differences of sectoral CO2 emissions at a cross-country setting (Schipper et al., 2001).

Energy could explain changes in CO2 emissions, to conclude that there is no significant difference between participants and nonparticipants. A related group of studies, consider another objective measure, namely the release of toxic chemicals by firms. They show that such releases are influenced by competition (Simon and Prince, 2016), financial constraints (Xu and Kim, 2022), and weakened litigation rights for shareholders (Do et al., 2023). However, none of the above-mentioned studies explores the role of managerial ability, and we aim to narrow this gap in the literature.

Further to the above, one could say that our work relates broadly to macro-level studies that examine the relationship between human capital and CO2 emissions at the country-level or provincial-level. For example, Yao et al. (2021) find a negative association between human capital and CO2 emissions at the provincial level in China and attribute it to the influences from younger workers and workers with advanced human capital. Using data from 20 OECD countries, Yao et al. (2020) also conclude that human capital is associated with a reduction in CO2 emissions. Similarly, Khan et al. (2021) find that fiscal decentralization is negatively associated with CO2 emissions in OECD countries, and this relationship is strengthened by the development of human capital. However, these studies are not at the firm-level and they cannot consider the role of managerial ability.

Finally, our work also relates to various studies on production economics which investigate managerial decisions that consider emissions in inventory planning and transportation decisions (Hovelaque and Bironneau, 2015; Bozorgi, 2016) and the collaboration of supply chain members to reduce carbon emissions (Yang et al., 2017; Lee and Park, 2020; Lee and Choi, 2021). As we discuss in more detail in Section 2 these studies present different solutions to reduce carbon emissions; however, the models that they develop are mostly of theoretical nature, and they do not examine the association between carbon emissions and managerial ability per se.

Understanding the factors that drive corporate carbon efficiency has implications not only for policy makers, but also for managers and shareholders. This is because many studies show that carbon emissions reduce firm value (e.g., Chapple et al., 2013; Matsumura et al., 2014; Griffin et al., 2017), and enhance the cost of equity capital (Kim et al., 2015) and the cost of debt financing (Caragnano et al., 2020). Furthermore, Ma et al. (2022) find that cost of bond financing of firms that violate environmental regulations increases significantly after being penalized. Others show that the carbon footprint is positively associated with corporate default risk (Capasso et al., 2020; Safiullah et al., 2021 Carbone et al., 2021).[7] In general, these studies argue that the transition to a net-zero economy exposes firms to climate-related financial risks that can increase their credit risk. In more detail, as discussed in Capasso et al. (2020), a larger corporate carbon footprint means higher exposure to progressively stricter climate related regulations (e.g. higher carbon taxes, more expensive carbon allowances in emissions trading schemes) with negative implications for future cash flows compared to companies with lesser carbon footprint. Such lower expected cash-flows imply lower firm assets' values, which are associated with lower perceived ability to repay debt and consequently reduced creditworthiness. Along these lines, Brogi et al. (2022) discuss that the integration of Environmental, Social, and Governance (ESG) factors into credit risk assessment is the new frontier for credit risk management, and they document a positive association between ESG awareness and creditworthiness. Similarly, Ehlers et al. (2020) suggest the adoption of a firm-level green rating system based on carbon intensity (i.e. emissions relative to revenue, that is the focus of the present study) to complement existing project-based green labels.

The rest of the manuscript is as follows. Section 2 provides a discussion of the literature and develops our hypothesis. Section 3 outlines the data and methodology. Section 4 discusses the results, and Section 5 concludes.

2. Background discussion

The Upper Echelon Theory put forward by Hambrick and Mason (1984) suggests that organizational outcomes, like strategic choices and performance levels, are partially predicted by managerial background characteristics. Many follow-up empirical studies provide support to this theory, documenting that the composition of the top management team, human capital, and management demographic characteristics influence innovativeness (Bantel and Jackson, 1989), corporate performance (Cheng et al., 2010; Nielsen and Nielsen, 2013), strategic decisions (Hitt and Tyler, 1991), market share growth (Hambrick et al., 1996), and creditworthiness (Papadimitri et al., 2020).

The empirical literature on the upper echelon theory initially focused on attributes like education, age, and experience as observable characteristics that could serve as proxies for unobservable ones. However, as discussed in Carpenter et al. (2004), subsequent studies considered other characteristics, not necessarily mentioned in the seminal work of Hambrick and Mason (1984), such as international assignment (Carpenter et al. (2001), experience at multiple levels of analysis (Kor, 2003), and race and gender diversity (Richard et al., 2004). In the present study, following, Cho and Lee (2019) we view managerial ability as a feasible measure that reflects various traits of managers discussed in the upper echelon theory. Our approach is also consistent with Lee et al. (2018) who mention that "*Rather than extrapolate the ability from managers' characteristics, education background, personality traits, and working experience, we examine the relation by adopting the newly developed measure of managerial ability introduced by Demerjian et al. (2012)…*" (p. 65).

[7] A somewhat related strand of the literature focuses on corporate social responsibility (CSR) that also relates to environmental protection through actions aiming to reduce the corporate impact on the ecosystem and enhance environmental sustainability. These studies show that CSR is negatively related with credit risk (Attig et al., 2013; Bannier et al., 2022) as well as that it offsets both the negative impact of economic policy uncertainty on firm financial performance (Rjiba et al., 2020) and the negative impact of climate policy uncertainty on firm value (Azimli, 2023).

Many studies provide support to this view, pointing to a positive association between managerial ability and firm outcomes and policies. For example, Cho and Lee (2019) show that managerial ability is positively associated with subsequent changes in corporate social performance. Furthermore, the literature suggests that managerial ability is associated with reduced corporate income tax payments (Koester et al., 2017), innovative output (Chen et al., 2015), higher earnings quality (Demerjian et al., 2013), lower credit risk (Bonsall et al., 2017), more favourable loan terms (Francis et al., 2016; De Franco et al., 2017), franchise value and risk-taking (Curi and Lozano-Vivas, 2020), liquidity creation (Andreou et al., 2016), higher profitability growth (Francis et al., 2016) and market share growth (Yung and Nguyen, 2020). Finally, Andreou et al. (2017) document a strong positive relation between pre-crisis managerial ability and corporate investment during the crisis period. Therefore, these studies tend to conclude that managerial ability is an important corporate asset that is beneficial to the firm, and firms with high-ability managers perform better than the ones with low-ability managers across many dimensions (Yung and Nguyen, 2020). Taken together it seems that managerial ability reflects managerial talent, and it is an intrinsic managerial characteristic (Kwon and Ye, 2019) that is distinct from the firm (Demerjian et al., 2012, 2013). Andreou et al. (2017) add that the most prominent channel through which managerial ability affects firm policy is through the reputational capital that managers accumulate over the course of their career. Furthermore, Curi and Lozano-Vivas (2020) find that managerial ability directly affects the value of intangible assets. All these findings suggest that managerial ability is an intangible asset itself (Curi and Lozano-Vivas, 2020).

There are various reasons for which managerial ability might be a crucial factor in reducing emissions. For example, Demerjian et al. (2012) discuss that more able managers are expected to "*better understand technology and industry trends, reliably predict product demand, invest in higher value projects, and manager their employees more efficiently than less able managers*" (p. 1229). In our context, managers will have to address various challenges like dealing with a trade-off between the costs and benefits of alternative environmental policies.[8] Therefore, we expect high-ability managers not only to be more efficient in utilizing corporate resources, but also to be more capable in distinguishing between judicious and unwise policies and better equipped to adopt policies that enhance firm performance (Chatjuthamard et al., 2016). Nonetheless, adopting good environmental policies might not be enough, since their actual utilization in practice is another crucial factor. For example, the environmental practices are internally focused on operational, tactical and strategic level practices that facilitate training, reporting to top management and the setting of environmental goals, and Sroufe et al. (2002) point out that without an appropriate integration into monitoring, measuring and managing at all levels of the organization, firms may not realize the full potential of their environmental efforts. Evangelinos et al. (2013) also discusses various barriers that are associated with the implementation of environmental management practices and relate to implementation costs, technical and technological barriers. Thus, the ability of managers might be instrumental in this regard. This is in line with the findings of Homroy and Slecthen (2019), which suggest that resource provision (proxied by the presence of non-executive directors with previous experience in environmental issues and their network connections) is associated with lower GHG emissions. Additionally, the literature suggests that managerial ability is associated with employee productivity (Ghosh et al., 2020), and the capability of integrating employee stakeholders has been associated with a firm's proactive environmental strategies and performance (Alt et al., 2015).

The production economics literature also provides various insights as for how managerial decisions could influence carbon emissions through the adopted inventory, transportation, and supply chain policies. For example, the results of Bonney and Jaber (2011) suggest that ordering items less frequently and in larger quantities, reduces transportation costs and CO2 emissions, compared to the traditional economic order quantity (EOQ) model. Chen et al. (2013) suggest that appropriate operational adjustments might results in important reductions of emissions without significantly increasing cost. Along these lines, they provide conditions under which: (i) it is possible to reduce emissions by modifying order quantities, and (ii) the relative reduction in emissions is greater than the relative increase in cost. Hovelaque and Bironneau (2015) propose a model that considers the link between an inventory policy, total carbon emissions, and both price and environmental dependent demands. Konur (2014) focuses on the EOQ model with truckload transportation and carbon emissions constraint, to conclude that both costs and emissions can be reduced by considering heterogenous trucks for inbound transportation. Finally, Hammami et al. (2015) adopt a general inventory policy and propose a deterministic optimization model that outperforms the widely used base stock policy and fixed order quantity in terms of carbon emissions. Hence, in the context of the present study, the ability of managers to select among these alternative models and implement them efficiently could have implications for the carbon emissions for their corporations.

To sum up, based on the above discussion we would expect managerial ability to be negatively associated with firm greenhouse gas emissions. However, there are also reasons for which managerial ability might not impact a firm's emissions. For example, despite their ability to understand the operating environment and act accordingly, managers may not have the technical knowledge needed to plan and implement appropriate environmental strategies. As discussed in Koester et al. (2017) while higher-ability managers could hire individuals or engage consultants with the required expertise, this opportunity could also be available to lower-ability managers. Additionally, it is possible that higher ability managers do not consider environmental-related aspects as a priority for their firm. For example, past studies discuss that firms adopt heterogenous sets of environmental management practices because they interpret the institutional pressures differ-

[8] Evangelinos et al. (2013) discusses various environmental practices, like environmental management systems, environmental indicators assessment methodologies, and cleaner productions methods), along with the strengths and weaknesses of using such tools.

ently (Delmas and Toffel, 2004) as well as that such interpretations and subsequent actions depend on the skills and experience of the board members (Walls and Hoffman, 2013). Furthermore, Zhang et al. (2018) mention that it is the top management's support rather than their environmental concerns alone that will be related to a firm's energy-saving behavior. Consequently, whether the ability of managers to efficiently use resources translates into better environmental performance remains an open question to be answered empirically.

3. Variables, methodology, and data

3.1. Variables

3.1.1. Dependent variable

Following earlier studies we measure environmental performance with an indicator of emissions intensity (Lee and Min, 2015; Ganda and Milondzo, 2018; Kim et al., 2015; Alam et al., 2019; Boffo et al., 2020; Ehlers et al., 2020; Caragnano et al., 2020). This is the ratio of total GHG emissions to a firm's total revenues.[9]

There are various reasons for which the literature suggests the use of this measure of emissions intensity rather than the absolute number of (unscaled) emissions.[10] For example, as discussed in Lee and Min (2015) and Alam et al. (2019), scaling minimizes the issue of heterogeneity that arises from different size firms that pollute more simply because they produce more. This is particularly important in our context, as is possibly unfair when examining the role of managerial ability to expect the CO2 emissions of a firm with a large production basis to be the same as the ones of a firm with smaller production basis. After all, as discussed in Ehlers et al. (2020) while refereeing to the ratio of carbon emissions to revenue: "*Unlike a simple absolute measure of carbon emissions, it measures the firm's carbon efficiency*" (p. 34). Along the same lines, Capasso et al. (2020) argue that scaling the total emissions by the firm revenues captures the operational configuration of companies and therefore their ability to switch to less polluting technology. Finally, Aswani et al. (2023) question the use of unscaled emissions in some earlier studies. They argue that unscaled emissions is possibly an important indicator for society; however, in the case of individuals firms, emissions intensity is actually the appropriate measurement choice to assess carbon performance.

We start the analysis with the use of total greenhouse gasses; however, in further analysis we examine separately scope 1 and scope 2 emissions.[11] Scope 1 emissions are greenhouse gas emissions released to the atmosphere as a direct result of an activity, or series of activities of an entity. Therefore, these emissions are also known as direct emissions, and they come from sources that are owned or controlled by the reporting entity. Examples of scope 1 greenhouse emissions include emissions produced from manufacturing processes (e.g. manufacture of cement), from the burning of diesel fuel in trucks, fugitive emissions (e.g. methane emissions from coal mines) etc. Scope 2 emissions are indirect emissions from purchased or acquired electricity, steam, heat, and cooling. While these emissions physically occur at the facility where electricity, steam and cooling or heating are generated, it is the consuming party that bears the responsible for their creation. Consequently, we employ both scope 1 and 2 emissions as separate indicators in additional analysis to evaluate the impact of managerial ability on each one of them.

3.1.2. Key independent variable

As already mentioned, we follow a growing number of studies that capture managerial ability with the index constructed by Demerjian et al. (2012) and provided via their website.[12] This indicator reflects the ability of managers, relative to their peers, in transforming corporate resources to firm revenues. Demerjian et al. (2012) construct it in two stages.

In the first stage, they use data envelopment analysis (DEA) to estimate the firm-level efficiency within year,[13] comparing the sales generated by each firm, conditional on the following inputs used by the firm: (i) net property, plant, and equipment, (ii) net operating leases, (iii) net research and development, (iv) purchased goodwill, (v) other intangible assets, (vi)

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[9] These are the greenhouse gas emissions (i.e. carbon dioxide (CO_2) and CO_2 equivalents emission), reported in accordance with the Greenhouse Gas Protocol. This standard covers the accounting and reporting of the following seven greenhouse gases covered by the Kyoto Protocol: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PCFs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3). The emissions of each GHG (CO2, CH4, N2O, etc.) are calculated separately and then converted to CO2equivalents based on their global warming potential (World Resources Institute and World Business Council for Sustainable Development, 2014). Lee and Min (2015) and Caragnano et al. (2020), scale emissions by total assets rather than revenues.

[10] This approach is similar to the one used in macro studies which scale emissions by per population and express them on a per capita basis (Li and Lin, 2013; Duro and Padilla, 2013; Li et al., 2021).

[11] A third category of emissions is known as Scope 3 emissions. These are indirect greenhouse gas emissions other than scope 2 emissions that are generated in the wider economy. While they are related to the entity's activities, they are associated with sources not owned or controlled by that entity's business. An example is the supply chain of the company, with scope 3 emissions being the ones caused by vendors within the supply chain, outsourced activities, and employee travel and commuting. We do not consider Scope 3 emissions for two reasons. First, they are not controlled by the company. Second, regulations require the reporting of Scope 1 and Scope 2 emissions but not Scope 3 emissions, which may explain why we only had information on 140 firm-year observations in the case of Scope 3.

[12] Data is available through to 2020 (at the time of writing this manuscript) via the first author's personal website: https://peterdemerjian.weebly.com/managerialability.html

[13] The authors provide the following note about the updated estimates that they make available for free: "In prior iterations, we estimated both the first and second stage by Fama-French 48 industry. In this updated version, we estimate not byindustry but rather by year for both stages." See: https://peterdemerjian.weebly.com/uploads/1/3/2/5/132532695/ma_score_description_2020.txt

cost of inventory, (vii) selling, general, and administrative expenses. As they discuss, all these inputs contribute to the generation of revenue and are affected by managerial ability, as each of the inputs is subject to managerial discretion. Therefore, an able management team will generate the highest level of revenue from a given set of inputs. However, the resulting DEA generated firm efficiency is affected by both firm-specific factors and management characteristics.

Therefore, in the second stage, Demerjian et al. (2012) use the DEA total firm efficiency by regressing it on six firm-specific determinants of efficiency, namely: (i) firm size, (ii) firm market share, (iii) cash availability, (iv) life cycle, (v) operational complexity, and (vi) foreign operations. Additionally, to remove the effects of industry and time they run the second stage Tobit regressions by industry, they include year fixed effects, and they cluster standard errors by firm and year. Following this procedure, the authors decompose total firm efficiency into firm efficiency and managerial ability, the latter being captured by the residual of the second stage Tobit regression. Consistent with this study and a broad literature mentioned before, we also perceive this residual as a managerial ability score that can be attributed to the management team and we use it as our proxy.[14]

3.1.3. Control variables

The literature suggests that corporate environmental performance might be influenced by financial performance, slack, firm size, growth opportunities and R&D investment (Konar and Cohen, 2000; Cole et al., 2013; Lee and Min, 2015; Zhang et al., 2019; Alam et al., 2019). Therefore, all the regressions include control variables for firm profitability (return on assets), leverage (total liabilities to total assets), size (natural logarithm of total revenues), market to book value (market capitalization to net book value), capital intensity (total assets to total revenues) and R&D investment (R&D expenses scaled by total revenues).

The literature also suggests that there might be a possible relationship between corporate governance and environmental performance, although the results are mixed. For example, after reviewing the literature, Miroshnychenko et al. (2019) conclude that internal corporate governance mechanisms are important determinants of environmental performance. For example, Lu and Herremans (2019) report a positive association between gender diversity and firm environmental performance (measured with scores from Sustainalytics). Others report that the percentage of female directors increases renewable energy consumption (Atif et al., 2020), environmental consciousness (Kassinis et al., 2016), and the likelihood of voluntary climate change disclosure (Ben-Amar et al., 2017). Martin and Herrero (2020) investigate the association between board features and environmental performance in EU-based corporations, finding that gender diversity and the presence of a corporate social responsibility committee are positively associated with the firms' environmental performance. Along the same lines, Naciti (2019) concludes that both board diversity and separation of board chair and CEO role enhance environmental performance. However, the results of Walls et al. (2012) show that there is no statistically significant association between the KLD index of environmental strengths and well-known corporate governance variables, like gender diversity, board size, and CEO duality. Likewise, Martin and Herrero (2020), find no relationship between CEO duality and CO2 emissions, and evidence of a weak association between board independence and CO2 emissions. Similarly, Cong and Freedman (2011) show that there is no relationship between good corporate governance and good pollution performance. Finally, Fakoya and Nakeng (2019) conclude that female board members do not influence energy usage performance. To account for the potential relationship between corporate governance mechanisms and greenhouse gas emissions, we control for board size (natural logarithm of number of board directors), gender diversity (% female board members), board independence and CEO duality.

Zailani et al. (2012) and Miroshnychenko et al. (2019) suggest that external governance forces (institutional and regulatory environments) also influence a firm's environmental performance, that is in general consistent with of the literature on institutional theory and environmental management practices (Delmas and Toffel, 2004; Daddi et al., 2016; Wang et al., 2018). Therefore, we also control for the level of institutional development. As in past studies (Li et al., 2006; Lensink et al., 2008), we use information from the Worldwide Governance indicators. To construct an overall index, we take the first principal component's scores (explaining ~86% of the total variation) of the following six indicators: (i) voice and accountability, (ii) political instability and violence, (iii) government effectiveness, (iv) regulatory quality, (v) rule of law, (vi) and control of corruption.

3.2. Methodology

To examine the impact of managerial ability on greenhouse gas emissions, we estimate a model of the following form:

$$Y_{it} = f(Managerial\ Ability_{it},\ Firm_{it}, Country_{it}, FE_{it}; \beta),$$

[14] As acknowledge by Demerjian et al. (2012), their indicator has some limitations that relate to potential measurement errors in the inputs and outputs used in DEA and the set of variables used in the second stage regressions. Nonetheless, Demerjian et al. (2012) validate the proposed managerial ability measure by showing that: (i) it has an economically significant association with manager fixed effects, suggesting that it reflects manager characteristics, not just firm characteristics omitted from their Tobit regressions (Demerjian et al., 2013), (ii) it is negatively associated with the price reactions to CEO turnover announcements, and (iii) it is positively associated with the subsequent performance at CEOs' new appointments (where the score is measured in their prior firms). Additionally, the proposed managerial ability measure outperforms alternative ability measures on each of these dimensions. Taken together, these tests provide support to the earlier-mentioned argument that this managerial ability indicator reflects managerial talent that is distinct from the firm (Demerjian et al., 2013).

Table 1
. Descriptive statistics.

VARIABLES	(1) N	(2) Mean	(3) Std.	(4) Min	(5) Max
Total GHG to Revenue	2329	267.1	483.1	0.0500	3104
Managerial ability	2329	0.0178	0.175	−0.254	0.535
ROA	2328	4.804	4.554	−9.783	19.09
Leverage	2329	0.589	0.204	0.152	0.922
Size (Ln)	2329	23.58	2.224	19.78	31.55
Market to book	2329	3.002	5.008	0.013	32.73
Capital intensity	2329	2.071	1.440	0.447	7.888
R&D to sales (%)	2329	2.75	5.630	0	25.51
Board size	2329	10.679	3.274	2	51
Board independence	2329	0.8388	0.1324	0	0.9804
Board gender diversity (%)	2329	17.80	12.49	0	57.14
CEO Duality	2329	0.374	0.484	0	1
GDP growth (%)	2329	1.274	2.766	−5.286	8.256
Inflation (%)	2329	2.047	1.727	−0.726	9.030
Institutional index (PC1)	2329	−0.388	2.508	−6.961	2.105

Where *Y* is our dependent variable, ***Firm*, and *Country*** are vectors of firm, and country control variables discussed in Section 3.1.3, and we include industry × year fixed effects (***FE***). The model is estimated via OLS with robust standard errors clustered by firms, as in Alam et al. (2019) .[15]

3.3. Data

Our starting point for the construction of the sample is the updated dataset by Demerjian et al. (2012) .[16] We merge this dataset with information on greenhouse gas emissions and financial data from EIKON (formerly DataStream's 'ASSET4') database. This merging process substantially reduces the sample. However, as mentioned in the outset of the study, we are interested in the actual environmental outcomes rather than environmental ratings by ASSET4 and KLD. The reason is that these ratings mainly reflect environmental strengths, environmental concerns, and the adoption of environmental protection policies rather than actual outcomes. We also eliminate firms whose financial and corporate governance information is not available in EIKON, or only report Scope 1 or 2 emissions (that is to keep sample balanced for when performing additional analyses). This results in a baseline sample of 407 firms for the period 2003–2020, corresponding to 2329 firm-year observations. Information on the country governance indicators is from the Worldwide Governance Indicators project. Data on GDP growth and inflation are obtained from the World Bank. To facilitate the interpretation of the results, all the variables are standardised (with a mean of 0 and standard deviation of 1), whilst, to eliminate the impact of outliers, all the variables are winsorised at their 1st and 99th percentiles (e.g. Alam et al., 2019).

Tables 1 and 2 present descriptive statistics (raw data) and the correlation coefficients of (standardised and winsorised) co-variates used throughout our subsequent analysis. The full description of our data and further descriptives about the sample distribution are available in Tables 1 and 2 of the Appendix.

4. Empirical results

4.1. Baseline results

Column 1 of Table 3 presents the baseline specification that includes the indicator of managerial ability and the controls for the financial characteristics of the firms. In Column 2 we augment the baseline specification with corporate governance attributes. Column 3 presents the results of the baseline regression with the addition of country-level control variables, whilst Column 4 provides the most comprehensive specification that includes all the control variables.

Our indicator of managerial ability enters the regressions with a negative and statistically significant (at the 5% level) coefficient in all the models of Table 3. 8. These results suggest that firms with more able managers have lower greenhouse gas emissions after controlling for financial, governance, and county characteristics. Based on the estimates of the comprehensive model (i.e. with all the variables; see Column 4 of Table 3), a standard-deviation increase in managerial ability is associated, on average, with a 0.022 standard deviations reduction in GHG emissions (=10.2) per million dollar of sale for a firm, ceteris paribus. Thus, our results support our hypothesis that managerial ability is associated with less environmental pollution.

[15] The authors include year and industry fixed effects to capture time-invariant fixed effects on industries and business cycles across the entire sample from year fixed effects, accordingly. Whilst we do find qualitatively similar results with their specification, we use industry *x* year fixed effects instead, to sharpen our estimations for potentially different needs in energy intensities across different industries in each year.

[16] Data (version 'through 2020') provided by Peter Demerjian, available at the time of writing this study at: https://peterdemerjian.weebly.com/managerialability.html

Table 2
. Correlation coefficients.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Total GHG to revenues	1.000												
(2) Managerial ability	−0.120***	1.000											
(3) ROA (%)	−0.215***	0.287***	1.000										
(4) Leverage	−0.013	−0.056***	−0.020	1.000									
(5) Size (Ln)	−0.189***	0.293***	0.100***	0.010	1.000								
(6) Market to book	0.035*	−0.005	−0.022	0.036*	−0.008	1.000							
(7) Capital intensity	0.169***	−0.117***	−0.270***	−0.132***	−0.080***	−0.004	1.000						
(8) R&D to revenues	−0.054***	−0.009	−0.098***	−0.081***	−0.048**	−0.003	0.799***	1.000					
(9) Board size (Ln)	−0.129***	0.098***	0.080***	0.091***	0.366***	0.005	−0.086***	−0.001	1.000				
(10) Board gender diversity (%)	−0.095***	−0.011	0.084***	0.073***	−0.137***	−0.030	−0.023	0.028	0.125***	1.000			
(11) CEO duality	−0.064***	0.040*	0.131***	−0.010	0.003	−0.017	−0.034*	0.005	0.072***	−0.016	1.000		
(12) GDP growth (%)	−0.045**	0.088***	0.158***	−0.081***	0.138***	0.015	−0.058***	−0.015	0.007	−0.191***	0.012	1.000	
(13) Inflation (%)	−0.038*	0.097***	0.061***	−0.010	0.213***	0.017	−0.033*	−0.040*	−0.017	−0.245***	−0.063***	0.156***	1.000
(14) Institutional index	0.056***	−0.171***	−0.035*	−0.064***	−0.399***	−0.045**	0.049**	0.013	−0.081***	0.237***	−0.035*	−0.054***	−0.626***

* $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 3
. Baseline results.

VARIABLES	(1) Baseline	(2) Corporate Governance	(3) Country	(4) All	(5) All lagged	(6) IV
Managerial ability	−0.0217**	−0.0215**	−0.0218**	−0.0216**	−0.0309**	−0.0453***
	(0.0108)	(0.0107)	(0.0107)	(0.0106)	(0.0128)	(0.0149)
ROA	−79.77*	−52.60	−79.69*	−53.87	−6.894	−24.74
	(43.68)	(41.09)	(44.46)	(42.07)	(48.25)	(41.54)
Leverage	0.0530	0.0488	0.0570	0.0534	0.0999	0.0449
	(0.0464)	(0.0441)	(0.0467)	(0.0446)	(0.0739)	(0.0419)
Size (Ln)	−0.0552**	−0.0796***	−0.0614**	−0.0833***	−0.0745***	−0.0726***
	(0.0229)	(0.0227)	(0.0246)	(0.0248)	(0.0265)	(0.0239)
Market to Book	32.10**	32.06***	32.88***	32.80***	44.86***	33.24***
	(12.41)	(11.27)	(12.13)	(11.11)	(13.20)	(10.23)
Capital Intensity	36.63***	36.81***	37.17***	37.20***	28.96**	35.15***
	(11.62)	(11.81)	(11.75)	(11.98)	(12.33)	(11.49)
R&D to Revenues	−66.60***	−67.33***	−67.69***	−68.18***	−51.93**	−65.07***
	(20.54)	(20.88)	(20.79)	(21.21)	(20.90)	(20.30)
GDP growth (%)			−2.92e-05	0.00154	0.00233	0.00264
			(0.00583)	(0.00559)	(0.00548)	(0.00547)
Inflation (%)			−0.0103	−0.00949	−0.00847	−0.00898
			(0.00673)	(0.00606)	(0.00686)	(0.00595)
Institutional index (PC1)			−0.00713	−0.00547	−0.00390	−0.00585
			(0.00815)	(0.00854)	0.00233	(0.00819)
Board size (Ln)		0.1091*		0.105	0.116*	0.101
		(0.0657)		(0.0664)	(0.0690)	(0.0647)
Board independence		0.01448		0.00747	0.0126	−0.00935
		(0.1012)		(0.105)	(0.105)	(0.106)
Board gender diversity (%)		−0.00187		−0.00179	−0.00180	−0.00166
		(0.00134)		(0.00135)	(0.00140)	(0.00132)
CEO duality		−0.0277		−0.0309	−0.0261	−0.0313
		(0.0282)		(0.0279)	(0.0323)	(0.0273)
Industry-Year FE	YES	YES	YES	YES	YES	YES
Observations	2329	2329	2329	2329	2165	2329
No. of firms	407	407	407	407	392	407
T-bar	5.7	5.7	5.7	5.7	5.6	5.7
Adj.R-squared	0.335	0.342	0.336	0.343	0.325	0.336
Managerial ability (industry-year median)						0.8729***
Kleibergen-Paap rk LM statistic						56.189
Cragg-Donald Wald F statistic						945.759
Kleibergen-Paap rk Wald F statistic						267.410

Robust standard errors clustered by firm in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Variables defined in Appendix I.

One could claim that the results presented so far are clouded by endogeneity concerns. We have attempted to address the omitted variable issue with firm- and country-level controls and the addition of fixed effects to saturate our specification. However, the proxy for managerial ability that we employ could still suffer from endogeneity concerns related to: (i) other factors that we have not accounted for, driving both the key variable of interest and our dependent variable; (ii) managerial ability being the response to needs in improving GHG performance and thus suffering from reverse causality. To lessen such concerns, we first lag all independent variables by a fiscal year to mitigate the reverse causality issue. The results with the use of the lagged variables in Column 5 of Table 3 remain qualitatively similar to the ones discussed so far. Going a step further in tackling both aforementioned issues we employ a Two-Stage Least Squared (2SLS) estimation approach. In this case, we instrument the assumed endogenous variable, managerial ability, with the supply of managerial ability in a firm's country within industry and year. This is captured by the average country-industry-year value of managerial ability accordingly, similarly to Demerjian et al. (2020).[17] The diagnostics validate the employed specification (Kleibergen-Paap rk LM p-value = 0.000; Cragg-Donald Wald F statistic = 945.759; Kleibergen-Paap rk Wald F statistic = 267.410) while the obtained results (column 6,Table 3), confirm our previous findings.

4.2. Further analysis

In this section we present the results of further analysis. First, in Table 4 we present the re-estimation of the comprehensive specification of Column 4 of Table 3, while distinguishing between Scope 1 and Scope 2 emissions. In both cases,

[17] Demerjian et al. (2020) assume that the pool of talent (average value calculated for instrument) varies per state and time period, not specifying the industry as we do on this occasion, potentially assuming that a firm can employ talent from different industries. If we make the same assumption, thereby dropping the industry filter in the average ability calculation, we find qualitatively similar results. We additionally test the assumption that talent is borderless when it comes to managerial ability as firms may employ CEOs from different countries; hence the pool, proxied by the average managerial ability value, should vary per year, or per industry and year, essentially confirming that our results remain qualitatively similar.

Table 4
Additional results.

VARIABLES	(1) Scope 1	(2) Scope 2	(3) Business confidence	(4) Consumer confidence	(5) Market volatility	(6) National culture
Managerial ability	−0.0145**	−0.0362**	−0.0227**	−0.0228**	−0.0214**	−0.0213**
	(0.00636)	(0.0153)	(0.0110)	(0.0109)	(0.0106)	(0.0105)
ROA	−25.72	−138.2**	−55.81	−57.07	−62.65	−60.29
	(31.74)	(57.687)	(43.83)	(43.43)	(42.71)	(43.26)
Leverage	0.0847	−0.123	0.0472	0.0449	0.0508	0.0540
	(0.0565)	(0.120)	(0.0452)	(0.0448)	(0.0450)	(0.0472)
Size (Ln)	−0.0483***	−0.145***	−0.0845***	−0.0830***	−0.0823***	−0.0831***
	(0.0144)	(0.0416)	(0.0249)	(0.0246)	(0.0247)	(0.0297)
Market to Book	33.56***	2.752	33.97***	33.46***	33.35***	32.13***
	(6.397)	(7.105)	(11.17)	(11.15)	(11.25)	(11.01)
Capital Intensity	35.30***	22.89***	37.71***	36.95***	37.07***	37.22***
	(3.757)	(4.583)	(12.09)	(11.85)	(11.92)	(11.92)
R&D to Revenues	−63.59***	−44.82***	−69.05***	−67.57***	−67.76***	−68.11***
	(7.795)	(9.508)	(21.48)	(21.00)	(21.13)	(21.13)
GDP growth (%)	−0.00372	0.0126**	0.000469	0.000553	−5.70e-05	0.000929
	(0.00412)	(0.00503)	(0.00574)	(0.00581)	(0.00600)	(0.00539)
Inflation (%)	−0.00456	−0.0253**	−0.00895	−0.00930	−0.00944	−0.00943
	(0.00527)	(0.0122)	(0.00662)	(0.00709)	(0.00677)	(0.00601)
Institutional index (PC1)	−0.00240	−0.0105	−0.00518	−0.00536	−0.00586	−0.00466
	(0.00413)	(0.0135)	(0.00860)	(0.00859)	(0.00932)	(0.00893)
Board size (Ln)	0.0891***	0.125***	0.121**	0.118**	0.116**	0.114**
	(0.0299)	(0.0365)	(0.0591)	(0.0573)	(0.0589)	(0.0574)
Board gender diversity (%)	−0.00164	−0.000497	−0.00191	−0.00183	−0.00183	−0.00183
	(0.001259)	(0.000752)	(0.00129)	(0.00127)	(0.00127)	(0.00137)
CEO duality	−0.0289	0.00689	−0.0217	−0.0205	−0.0237	−0.0251
	(0.0253)	(0.0170)	(0.0291)	(0.0284)	(0.0276)	(0.0280)
Business confidence index			0.00166			
			(0.0132)			
Consumer confidence index				−0.00165		
				(0.0117)		
Stock market volatility					−0.00127	
					(0.00272)	
National culture						−0.00236
						(0.0273)
Industry-Year FE	YES	YES	YES	YES	YES	YES
Observations	2329	2329	2260	2296	2329	2329
No. of firms	407	407	401	402	405	407
T-bar	5.7	5.7	5.6	5.6	5.7	5.7
Adj.R-squared	0.289	0.290	0.345	0.345	0.343	0.343

Robust standard errors clustered by firm in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Variables defined in Appendix I.

managerial ability enters the regressions with a negative and statistically significant coefficient. Thus, it appears that firms with more able managers not only release lower levels of emissions from the activities under their direct control, but they also operate with lower emissions from purchased or acquired electricity, steam, heat, and cooling.

In columns 3–6, we include in the regressions some additional country-level control variables to mitigate further potential concerns about omitted variable bias. The global financial stability report of the International Monetary Fund (2020) suggests that adverse economic conditions are likely to reduce the ability of firms to invest in green projects and cut greenhouse gas emissions, and therefore being detrimental to firms' environmental performance.[18] To account for such conditions, we include in the regressions in columns 3 to 5, the following country-specific control variables: consumer confidence, business confidence, stock market volatility index.[19] All three variables are insignificant, and their inclusion in the regressions does not change our main findings. To control for deep-rooted informal institutions, in Column 6, we include the principal component score from the six cultural dimensions of Hofstede et al. (2010). These national dimensions account for: (i) uncertainty avoidance, (ii) power distance, (iii) individualism versus collectivism, (iv) masculinity versus femininity, (v) long-term versus short-term normative orientation, and (vi) indulgence versus restraint.[20] We account for national culture because the literature suggests that it may influence various firm-level environmental management practices (Song et al.,

[18] As discussed in Seles et al. (2019), another strand of the literature suggests that environmental and social practices are not reduced during periods of economic crisis because they may, in fact, as survival factors during such difficult times.

[19] The confidence indices are obtained from Passport (Global Market Information Database). The consumer confidence index measures consumer optimism or pessimism about their current and future situations. Business confidence index measures the amount of optimism or pessimism that business managers have with regard to current situation and the prospects of their organizations. The stock volatility index is from the World Bank's Global Financial Development Database and it is being calculated as the average of the 360-day volatility of the national stock market index.

[20] Data for the national culture dimensions are obtained from the 'Hofstede Insights' website.

2018) as well as it can have a direct or moderating role in affecting the country-level environmental performance (Park et al., 2007; Dangelico et al., 2020). Given that culture is time invariant, in this case we resort to a random effects specification. The inclusions of this variable in the analysis does not alter our results.

In additional analysis, we sharpen our specification as follows.[21] First, following research by Altunbas et al. (2022), showing that gender diversity among executive managers has important implications for reducing firms' carbon emissions, we control for the percentage of females in executive managerial positions.[22] Furthermore, we re-run this specification with the inclusion of an interaction term (% female executive mangers *x* managerial ability) to examine whether the effect of managerial ability on emissions varies across different levels of female representation in executive positions. In both cases, the percentage of female executive managers enters the regression with an insignificant coefficient. The interaction term is also insignificant. At the same time, managerial ability remains statistically significant at the 5% level in both regressions. Finally, Muttakin et al. (2022) find that firms operating in countries with strong democratic institutions are negatively associated with carbon emission intensity. Therefore, we add a control variable for the quality of democratic institutions (through POLITY's project proxies). Furthermore, we re-run this specification while interacting our indicator of democratic institutions with managerial ability. These additional variables enter the regressions with statistically insignificant coefficients and have no impact on the main results.

5. Conclusions

The success of a company depends to a large extent on the quality of decisions made by its management (Goldfarb and Xiao, 2011). In more detail, managers are responsible for the coordination of decisions and for accessing resources, and hence their ability is more likely to lead to effective practice across numerous dimensions. Consistent with this view, prior research has shown that managerial ability is an important corporate asset that is beneficial to the firm in various respects, like innovative output, lower credit risk, more favourable loan terms, higher profitability and market share growth. We hypothesize that the same efficiency attributes that enable high-ability managers to achieve these superior outcomes will also lead to better environment performance in terms of lower greenhouse gas emissions.

Controlling for financial and corporate governance firm-specific potential drivers of environmental performance, we find empirical evidence that is consistent with our prediction. When we disaggregate total greenhouse gas emissions into Scope 1 emissions and Scope 2 emissions, we find that managerial ability is negatively associated with both components. The results hold while controlling for various country-level characteristics that account for the economic environment, formal and informal institutions.

Overall, the findings of our study suggest that managerial ability is a crucial dimension of firm quality and performance. It is important to note that our results show that managerial ability appears to be more effective in reducing greenhouse gas emissions than standard corporate governance mechanisms. Our findings should be of interest to board members when considering the costs and benefits of hiring top managers, as well as to policy makers, corporate stakeholders, and academics interested in understanding how top management decision making affect corporate environmental performance.

As most empirical studies, our work is not without its limitations that could be addressed in future research. For example, our analysis decomposes total greenhouse gas emissions into Scope 1 and 2 emissions; however, it was not possible to consider Scope 3 emissions. This because firms do not have to disclose Scope 3 emissions, and their efficient measurement requires them to dive deeper into their value chain. We hope that as more companies realize the importance of Scope 3 emissions, more data will become available, allowing researchers to consider this component in future research. Second, the managerial ability that we use reflects, by construction, the ability of the entire management team. Hence, it is not possible to examine if the ability of certain top management roles (e.g. CFO, CEO, CGO, etc.) matters more than others.

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Declaration of Competing Interest

None.

Data availability

The authors do not have permission to share data.

[21] To conserve space, these results are not reported in Tables; however, they are available from the authors upon request.

[22] Please note that in earlier regressions we controlled for gender diversity in the board as a total (i.e. considering both executive and non-executive positions).

Appendix I. Variables' definition

Acronym	Definition	Source
Total GGE to Revenues	Greenhouse gas emissions, defined as carbon dioxide (CO_2) and CO_2 equivalents emissions of methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PCFs), sulfur hexafluoride (SF6) and nitrogen trifluoride (NF3), divided by firm's total revenues	EIKON
Managerial ability	Managerial ability reflects the ability of managers, relative to their peers, in transforming corporate resources to firm revenues.	Demerjian et al. (2012)
ROA (%)	Indicator of profitability calculated as profits to total assets	EIKON
Size (Ln)	Natural logarithm of a firm's total revenues.	EIKON
Leverage	Total liabilities to total assets.	EIKON
Market to book	Market capitalization to net book value.	EIKON
Capital intensity	Total assets to total revenues.	EIKON
R&D to total revenues	R&D expenses to total revenues.	EIKON
Board size	Natural logarithm of the total number of board directors.	EIKON
Board independence	Ratio of independent directors to total number of directors.	EIKON
Board gender diversity	Percentage of female board members.	EIKON
CEO duality	Dummy variable that takes the value of '1′ when the CEO is also the Chair of the board of directors and '0′ otherwise.	EIKON
GDP growth (%)	Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars.	World Bank (World Development Indicators)
Institutional index	First principal component (cumulative variation explained ∼86%) of the following indicators: (i) voice and accountability, (ii) political instability and violence, (iii) government effectiveness, (iv) regulatory quality, (v) rule of law, (vi) and control of corruption. Each indicator takes values between approximately −2.5 and +2.5, with higher figures denoting better institutions.	World Bank (Worldwide Governance Indicators)
Inflation (%)	Inflation as measured by the consumer price index.	World Bank (World Development Indicators)
National culture	Principal component scores of the first component (cumulative variation explained ∼90%) from the six cultural dimensions: (i) uncertainty avoidance, (ii) power distance, (iii) individualism versus collectivism, (iv) masculinity versus femininity, (v) long-term versus short-term normative orientation, and (vi) indulgence versus restraint	Hofstede insights
Consumer confidence index	Measures consumer optimism or pessimism about their current and future situations.	Passport (Global Market Information Database)
Business confidence	Measures the amount of optimism or pessimism that business managers have with regard to current situation and the prospects of their organizations.	Passport (Global Market Information Database)
Stock market volatility	Average of the 360-day volatility of the national stock market index	World Bank (Global Financial Development Database)

Appendix II. Sample description and tabulation

(Tables A1,A2,A3 and Fig. A1)

Table A1
Sample distribution (obs.) per year.

Year	Freq.	Percent	Cum.
2003	4	0.17	0.17
2004	6	0.26	0.43
2005	15	0.64	1.07
2006	32	1.37	2.45
2007	44	1.89	4.34
2008	51	2.19	6.53
2009	91	3.91	10.43
2010	114	4.89	15.33
2011	130	5.58	20.91
2012	134	5.75	26.66
2013	129	5.54	32.2
2014	150	6.44	38.64
2015	173	7.43	46.07
2016	195	8.37	54.44
2017	215	9.23	63.68
2018	236	10.13	73.81
2019	291	12.49	86.3
2020	319	13.7	100
Total	2329	100	

Table A2
Sample distribution (obs.) by region.

Region	Freq.	Percent	Cum.
East Asia & Pacific	192	8.24	8.24
Europe & Central Asia	768	32.98	41.22
Latin America & Caribbean	211	9.06	50.28
Middle East & North Africa	11	0.47	50.75
North America	1053	45.21	95.96
South Asia	41	1.76	97.72
Sub-Saharan Africa	53	2.28	100
Total	2329	100	

Table A3
Sample distribution by industry.

Industry	Freq.	Percent	Cum.
Communication Services	328	14.08	14.08
Consumer Discretionary	245	10.52	24.6
Consumer Staples	193	8.29	32.89
Energy	312	13.4	46.29
Health Care	164	7.04	53.33
Industrials	329	14.13	67.45
Information Technology	283	12.15	79.6
Materials	467	20.05	99.66
Utilities	8	0.34	100
Total	2329	100	

Fig. A1. Time series evolution of key variables
The figure illustrates the time series evolution of the (average) Emissions intensity (Greenhouse gasses to revenues in millions $) and managerial ability in our sample.

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