Are Boards' Risk Management Committees associated with Firms' Environmental Performance?

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Abstract

We examine the relationship between board of director committees tasked with risk management and environmental performance, based on a sample of 1,466 firm-year observations from 2007 to 2015. We find that the presence of board committees dedicated only to risk management is associated with better environmental performance. The human capital of risk committees (measured by board tenure, committee tenure, experience, and qualifications) is also positively related to environmental performance. Our findings suggest that the benefits of risk management committees extend to non-financial matters, such as environmental performance. Our findings further suggest that environmental performance is now managed through the regular governance mechanisms within firms. This supports the notion that environmental performance is managed for economic reasons and for the benefit of investors, rather than for the aggrandisement of individual managers. Our findings should be of interest to boards, CEOs, and CFOs who are interested in risk management, as well as to investors, lenders, and auditors who are interested in assessing risk.

Key Words
Environmental Performance; Risk Management Committee

1. Introduction

Environmental issues are increasingly seen as important by society, making it more likely that poor firm environmental performance could lead to adverse financial consequences. For example, after the 2010 Deepwater Horizon oil spill, BP took a charge of $40.9 billion (BP, 2010) and paid record-breaking EPA fines ($5.5 billion) and damages ($8.8 billion)[1], while the 2015 emissions scandal has cost Volkswagen more than $25 billion in fines in the US alone (Parloff, 2019). In other words, firms' environmental performance affects risk. Blackstone, the world's largest investment management firm, now regards environmental performance as a key issue and they encourage the firms they invest in to manage environmental performance.[2] Practitioners have responded and AICPA (2015) found that US practitioners' focus on environmental performance closely relates to a desire to improve risk management. Research has also shown that firms with poor environmental performance or corporate social responsibility performance face significantly higher idiosyncratic risk (El Ghoul, Guedhami, Kwok, & Mishra, 2011; Attig, El Ghoul, & Guedhami, 2013; Alrazi, De Villiers, & Van Staden, 2015). However, the view that the pursuit of enhanced environmental performance could be a way for individual managers to burnish their reputation, rather than for economic reasons, and thus at the cost of shareholder returns, continues to be expressed. For example, SEC Commissioner Hester M. Peirce recently wrote: "Although sustainability standards at times may touch on economics, they are not fundamentally about economic decision-making" (Peirce, 2021)[3].

Recommended corporate risk management procedures include establishing a board of directors' risk management committee (RMC), with the aim to reduce risk, which may include environmental risk. The existence and characteristics of the board's RMC evidence the internal risk management procedures and should be indicative of their effectiveness in managing risks, including environmental risks, which are inversely related to firms' environmental performance. However, while RMCs can be expected to address firms' environmental risk/performance, if environmental performance is seen as a relatively small or marginal

[1] More information about the BP and Deepwater Horizon can be found at https://www.epa.gov/enforcement/deepwater-horizon-bp-gulf-mexico-oil-spill, and access date is 16 May 2019.
[2] As a global investment business, Blackstone pays particular attention to firms' environmental performance and actively encourages the firms in their portfolios to improve environmental performance. More information in this regard can be found at https://www.blackstone.com/our-impact/corporate-social-responsibility/, https://www.blackstone.com/docs/default-source/black-papers/bx-responsible-investing-policy.pdf?sfvrsn=cef0a3ad_2, and https://www.blackstone.com/wp-content/uploads/sites/2/2020/07/sustainability-myth-madness-and-magic.pdf (access date is 31 January 2021).
[3] Peirce explains in this same public statement that sustainability includes environmental matters.

concern, there may be no association between RMCs and environmental performance, and if RMCs are more likely to be established in firms with pre-existing environmental concerns and the RMCs are ineffective in reducing risk (thereby improving performance), the relationship could be negative. Therefore, it is not possible to predict the direction of this relationship, and the prior literature provides no indication.

Various stakeholders, including boards of directors, CEOs, CFOs, investors, lenders, and auditors, would benefit from a better understanding of the relationship between RMC characteristics and firms' environmental performance. If RMCs and their characteristics are positively related to environmental performance, this provides evidence that environmental performance is managed for economic reasons (i.e. for the benefit of investors), rather than to enhance the reputation of certain individual managers, which would represent a serious agency problem. Boards, CEOs, and CFOs could potentially use knowledge of the relationship between RMCs and environmental matters to manage environmental performance through establishing RMCs and choosing appropriate members to serve on these committees, while investors, lenders, and auditors could use this information to better assess the potential environmental risk of an investment or a client. Specifically, understanding the relationship between RMCs and corporate environmental performance will help investors to assess appropriate risk premiums relating to future cash flows, and in determining the likelihood that a firm will face reduced market share and the availability of financing.

De Villiers, Naiker & Van Staden (2011) and Walls, Berrone & Phan (2012) argue that boards are concerned with environmental performance and provide evidence that several board characteristics are associated with environmental performance. Regarding the question of whether certain board committees are associated with environmental performance, Walls *et al*. (2012) find a significant positive relationship (at the 1% level) between "environmental committee" and environmental strengths (consistent with an argument that such committees positively affect environmental performance), as well as between "environmental committee" and environmental concerns (consistent with the view that firms with environmental concerns are more likely to establish such committees). In addition, "environmental committee" (or corporate social responsibility committee) is also found to be related to corporate carbon disclosures (Bui *et al.*, 2020; Liao *et al.*, 2015). Endrikat, De Villiers, Guenther & Guenther (2020) provide similar evidence in the form of a meta-analysis, which can be expected for committees with the specific purpose of environmental governance. However, as far as we could ascertain, no prior study investigates the association between committees tasked with managing risk (RMCs) and environmental performance.

Therefore, we examine the relationship between the presence/characteristics of RMCs and firms' environmental performance. We examine the presence and two sets of characteristics of RMCs, namely their structure (i.e., dedicated RMCs or cases where another board committee is tasked with risk management (combined)), and the human capital of their members. Human capital refers to the skills, knowledge, and expertise that committee members hold that allow them to perform risk management more effectively (Baron, 2007; Becker, 1993; Dakhli & De Clercq, 2004), and it can be divided into two types, namely generic and firm-specific (Becker, 1962). Generic skills and knowledge can be deployed at any firm (Becker, 1962; Becker, 1993; Kor & Sundaramurthy, 2009), whereas firm-specific human capital is the skills and knowledge acquired by holding a position in a particular firm (Abdel-Khalik, 2003; Donaldson & Eaton, 1976; Wulf & Singh, 2011). Consistent with the prior literature, we measure generic human capital of RMCs as the work experience and qualification of members, and firm-specific human capital as members' committee tenure and board tenure (Gimeno, Folta, Cooper & Woo, 1997; Carpenter & Westphal, 2001; Hillman & Dalziel, 2003; Dimov & Shepherd, 2005; McDonald, Westphal & Graebner, 2008; Crook, Todd, Combs, Woehr & Ketchen, 2011).

Our Australian dataset is uniquely suited to examining these matters, as corporate environmental performance has attracted regulatory interest in Australia, for example, the Australian Securities and Investments Commission issued Regulatory Guide 65 – Section 1013DA Disclosure Guidelines in 2011 to elaborate how social and environmental risks about investment products ought to be presented and Regulatory Guide 247 – Operating and Financial Review in 2013 to explain how firms should disclose social and environmental risk information. More importantly, in 2007, the Australian Securities Exchange's Corporate Governance Principles and Recommendations stated "when establishing and implementing its approach to risk management, a company should consider all material business risks, these risks may include …… environmental …… risk" (Australian Securities Exchange, 2007, p. 32). In addition, Australia has one of the worst environmental and greenhouse gas records among OECD countries and therefore Australian firms face increasing pressure regarding environmental matters. For example, an emissions reduction fund and increasing regulation, including the National Greenhouse and Energy Reporting (NGER) scheme and the Safeguard Mechanism, exert additional pressure on Australian firms.

Analysing a sample of 1,466 firm-year observations between 2007 and 2015, we find that the presence of a board committee tasked with risk management is not related to environmental performance. However, the presence of a committee exclusively tasked with risk management, which we label a dedicated RMC, is positively and significantly related to firms' environmental performance. These results are consistent with the view that dedicated RMCs manage environmental risks and promote better environmental performance. Moreover, we find that RMCs whose members have higher levels of human capital are associated with better environmental performance, suggesting more effective environmental risk management.

We perform several additional analyses to address possible endogeneity concerns[4]. First, following Huang *et al.* (2018), we use instrumental variables-generalised method of moments (IV-GMM) estimations to address possible concerns regarding reverse causality and omitted variables. Second, following Liang and Renneboog (2017) and Dyck *et al.* (2019), we use the Deepwater Horizon oil spill in 2010 as an exogenous environmental shock to mitigate endogeneity concerns. Third, we perform propensity score matching (PSM) analyses to reduce bias from functional form misspecification by decreasing reliance on the specification of the relationship between variables (Rosenbaum and Rubin, 1983). All of these tests yield consistent results, supporting our main findings and hypotheses. We also provide evidence that our findings hold in both environmentally sensitive and non-sensitive industries. In addition, we show that our results are robust to an alternative measure of environmental performance.

We contribute to the literature in at least three ways. First, we are the first to examine the association between RMCs and environmental performance. Differentiating from environmental/ corporate social responsibility (CSR) committees that are established to engage in environmental performance and disclosure, RMCs are not necessarily involved in environmental performance. Our findings provide evidence consistent with the view that environmental issues are being managed by board committees not specifically tasked with environmental concerns and therefore that environmental performance is now managed through the general governance mechanisms within firms. Therefore, we contribute to the literature on corporate governance and CSR (Jain and Jamali, 2016; Walls *et al.*, 2012; De Villiers *et al.*, 2011) and specifically on an under-researched matter, namely RMCs. As corporate governance is expected to protect investors' interests, our research contributes insights to better understand whether risk management governance mechanisms can protect

[4] We argue that reverse causality is unlikely to be a major concern here, because if bad environmental performance causes the establishment of RMCs (and/or the enhancement of the human capital of RMCs) and these RMCs are not successful at enhancing environmental performance, the association between these constructs would be negative, i.e. any instances of reverse causality would serve to weaken our findings of positive associations. However, we acknowledge that some firms may be progressive in their stance towards environmental performance, which may lead to both the establishment of board committees and better environmental performance. We include the existence of a CSR committee, an indicator of progressiveness, as a control variable throughout and our association between RMCs and environmental performance persists. In an additional test, the (untabulated) results show that our findings persist when we include an interaction term between our CSR committee and RMC variables, the coefficient of which is not significant, indicating that our findings are similar for progressive and non-progressive firms.

investors from environmental risks. Differentiating from Krishnamurti and Velayutham (2017) who examine the presence of RMCs and the disclosure (not the performance/risk) of greenhouse gas emissions (a minor component of overall environmental concerns), we provide richer evidence of the role played by RMCs in managing environmental performance/risk. Moreover, we use instrumental variables-generalised method of moments (IV-GMM) estimations and an exogenous environmental shock to mitigate endogeneity concerns, and propensity score matching (PSM) analyses to reduce bias from functional form misspecification. Thus, this convincing evidence adds weight to our interpretation of the results.

Second, we use a range of committee characteristics to explore the features associated with effective RMCs. Extending the literature on RMCs (e.g., Brancato *et al.*, 2009; Mongiardino and Plath, 2010), we evidence that RMCs' structure (dedicated or combined) and human capital matter in environmental performance. Therefore, we provide further evidence consistent with resource dependency theory, i.e. that boards provide firms with resources, such as knowledge and networks (Pfeffer and Salancik, 2003).

Third, in terms of practical contributions, our findings will be of interest to boards of directors, CEOs and CFOs in their quest to reduce risk, especially environmental risks. The results are relevant to investors, lenders, and auditors, who will be interested in the potential of our results to provide input into their risk assessment procedures.

The rest of the paper consists of Section 2, which reviews the prior literature and develops hypotheses, followed by the research design in Section 3, the findings (Section 4), and the conclusion (Section 5).

2. Literature Review and Hypotheses Development

De Villiers *et al*. (2011) and Walls *et al*. (2012) argue that boards are concerned with environmental performance, and relying on US data, evidence that certain board characteristics are related to environmental performance. Regarding the question of whether board committees are related to environmental performance, De Villiers *et al*. (2011) identified that "governance committee" is positively and marginally significantly related (i.e. at the 10% level) to firms' environmental performance. Walls *et al*. (2012) found a significant positive relationship (at the 1% level) between "environmental committee" and environmental strengths (consistent with an argument that such committees are positively related to environmental performance), as well as between "environmental committee" and environmental concerns (consistent with a view that firms with environmental concerns are more likely to set up such committees).

Krishnamurti and Velayutham (2017) investigated the influence of RMCs on the disclosure of greenhouse gas emissions, providing evidence that combined RMCs are negatively related to disclosures, while dedicated committees are not related. However, although such disclosure is a subset of firms' environmental practices, it is a different construct, because managers' decision regarding disclosure is different from the decisions that influence and lead to environmental performance (Delmas & Burbano, 2011). Note also that while managers' environmental disclosure decisions relate to environmental performance (De Villiers, Venter & Hsiao, 2017), Krishnamurti and Velayutham (2017) do not control for performance in their model. The prior literature report both positive and negative relationships between environmental performance and environmental disclosure, therefore it is not possible to assume what form the relationship takes, and thus essential to control for environmental performance in any environmental disclosure study (De Villiers *et al*., 2017). Extending Krishnamurti and Velayutham (2017), our study further investigates the relationship between RMCs and environmental performance, and following their research, we also distinguish between dedicated and combined RMCs. As far as we could ascertain, no prior study examines the association between RMCs and environmental performance.

According to agency theory, boards of directors' main function relates to the monitoring of management's management and strategic direction (Hillman & Dalziel, 2003). Board committees are established to enhance the monitoring by directors (Hillman & Dalziel, 2003), and to ensure directors provide good stewardship over the varied resources entrusted to them (Daily, Dalton, & Cannella, 2003; Kiel & Nicholson, 2003; Nicholson & Kiel, 2007). As RMCs are tasked with the management of all corporate risks, including environmental risk (refer to Australian Securities Exchange (Corporate Governance Principles and Recommendations, 2007), agency theory based arguments would lead to an expectation that the presence of RMCs is associated with lower environmental risks, i.e. better environmental performance.

The prior literature has documented an insurance effect of superior corporate environmental performance, e.g. Godfrey (2005), Godfrey, Merrill, and Hansen (2009), Lee and Faff (2009), and Minor and Morgan (2011), found firms' environmental performance is an effective risk management strategy that protects firms from the risk of adverse political, regulatory and social sanctions. Cognisant of this insurance effect, boards of directors are likely to pursue enhanced environmental performance to insure against (or mitigate) future risks. The establishment of RMCs could support the improvement of environmental performance. When RMCs report back to boards, directors discuss and monitor risk management processes, including environmental performance/risk. Thus, firms with RMCs are more likely to recognize the (insurance) benefit(s) of enhanced environmental performance, leading to better environmental performance.

However, it is also possible that the establishment of RMCs are driven by pre-existing environmental performance concerns, and if these RMCs are not effective in improving environmental performance, then there would be a negative association between RMCs and environmental performance. Nevertheless, the weight of the arguments appears to be behind the expectation of a positive association, therefore, we state our first hypothesis as:

H1. *The existence of a RMC is positively associated with corporate environmental performance.*

Boards of directors can establish dedicated RMCs or can delegate risk management along with other tasks to a single board committee (combined committee). A number of studies discuss the merits of the two structures (dedicated or combined). Combined committees offer the advantage that different issues, including environmental performance and risks, can be considered in an integrated fashion and this environment facilitates information flows for directors, i.e. positive information spill-over effects (DeZoort, Hermanson, Archambearlt & Reed, 2002). On the other hand, in combined RMCs, members could be distracted by other agendas and could be less focused on the task of risk management, including the management of environmental performance and risks. A dedicated RMC could harness specialized risk management expertise, allowing firms to make effective and timely risk management decisions (Karamanou and Vafeas, 2005; Pirson and Turnbull, 2011). Time constraints, fatigue, and prioritisation of other responsibilities could dilute combined committees' effectiveness (Daly and Bocchino, 2006).

Prior research has suggested delegating risk management responsibility to a dedicated RMC instead of a combined committee is more effective (Aebi, Sabato & Schmid, 2012; Brancato, Tonello, Hexter & Newman, 2009; Kirkpatrick, 2009; Mongiardino and Plath, 2010). The ability of a combined committee to perform risk management activities is questioned (Kirkpatrick, 2009; Mongiardino and Plath, 2010). Therefore, we expect dedicated RMCs to be more effective at managing risks, including environmental risks (Brancato *et al.*, 2009). This leads to our second hypothesis:

H2. *Dedicated RMCs are associated with stronger corporate environmental performance than combined RMCs.*

More experienced individuals are generally more effective at performing their duties (Bailey and Helfat, 2003). According to Baron (2007), human capital is a type of firm resource that can deliver economic outcomes and strengthen competitive advantage (Coff, 1997; Dakhli & De Clercq, 2004). Supporting Baron's (2007) argument, Crook *et al*. (2011) provide meta-analytic evidence that more human capital translates into better firm performance. Regarding boards of directors, resource dependence theory suggests that a major function of boards of directors is to enhance resource provision to the firm, including facilitating access to knowledge and networks (Hillman, Cannella, & Paetzold, 2000). Resource-rich directors are more knowledgeable and have access to more important and effective networks (Hillman & Dalziel, 2003). Prior research shows that boards' human capital is significantly related to the ability to effectively advise senior management teams (Carpenter and Westphal, 2001; Kor and Sundaramurthy, 2009). In other words, there is a link between the human capital of directors and the effectiveness of boards (Pfeffer & Salancik, 2003). Therefore, more knowledgeable and experienced RMC members will be better placed to reduce environment related risks, which should be reflected in better environmental performance.

From an agency theory perspective, bad environmental performance can be seen as an agency cost, where managers do not effectively manage environmental performance (Christensen, 2016; Ferrell, Liang & Renneboog, 2016). Experienced directors are better placed to monitor managerial decisions, mitigating agency costs, and improving firms' environmental performance. Therefore, RMCs composed of more experienced directors, i.e. with more human capital, can be expected to better monitor managerial decisions and mitigate agency costs.

Thus, our third hypothesis is:

H3. *Higher levels of human capital of RMCs are associated with better corporate environmental performance.*

3. Research Design

3.1 Sample Selection

The sample consists of ASX300 firms between 2007 and 2015, a period after the adoption of IFRS, to mitigate changes in financial accounting (Chalmers, Clinch, & Godfrey, 2011; Loyeung, Matolcsy, Weber, & Wells, 2016). Environmental performance data are from Thomson Reuters Asset4. We hand collect RMC data from annual reports, including presence, structure and human capital. Financial and other data are from the Morningstar and SIRCA databases. After merging datasets and removing firm-year observations with missing data, we have a final sample of 1,466 firm-year observations. Following Beck, Frost, and Jones (2018), we use the Global Industry Classification Standard to classify our sample firms into different industries. Table 1, Panel A presents the sample distribution by industry, as industry often drives environmental concerns (De Villiers and Lubbe, 2001), while Panel B presents the sample distribution by year. Our sample is similar to the sample used by Nguyen, Agbola, and Choi (2018), who also use Thomson Reuters Asset4 data.

Table 1 Sample Selection

Panel A presents sample distribution by industry, and Panel B presents sample distribution by year.

Panel A Distribution of observations by Industry

Industrial Affiliation	**N**	**Percent%**
Materials	335	22.85
Financials	278	18.96
Industrials	224	15.28
Consumer Discretionary	209	14.26
Energy	161	10.98
Consumer Staples	76	5.18
Health Care	68	4.64
Utilities	56	3.82
Information Technology	34	2.32
Telecommunication Services	25	1.71
Total	1466	100%

Panel B Distribution of observations by Year

Year	**N**	**Percent%**
2007	81	5.53
2008	89	6.07
2009	175	11.94
2010	204	13.92
2011	212	14.46
2012	207	14.12
2013	193	13.17
2014	159	10.85
2015	146	9.96
Total	1466	100%

3.2 Econometric Models

Three equations listed below are developed to test the three hypotheses. The first equation aims to analyse the relationship between the presence of a RMC and environmental performance. The second equation examines the relationship between the structure of the RMC and environmental performance. The third equation examines the relationship between the human capital of the RMC and corporate environmental performance. Note that only firms with RMCs are eligible to be included in the regression analysis using the third equation.

Analyses of the first and the second equations are based on the full sample of 1,466 firm-year observations, and analysis of the third equation is based on the RMC-subsample that consists of 788 firm-year observations. Panel regressions are used for the analysis. Standard errors are clustered by firm[5].

(1) $CEP_{i,t} = b_0 + b_1 RMC_{i,t} + \text{Control Variables}_{i,t} + \text{Year} + \text{Industry} + \varepsilon_{i,t}$

(2) $CEP_{i,t} = b_0 + b_1 COMBINED\_RMC_{i,t} + b_2 DEDICATED\_RMC_{i,t} + \text{Control Variables}_{i,t} + \text{Year} + \text{Industry} + \varepsilon_{i,t}$

(3) $CEP_{i,t} = b_0 + b_1 HC\_RMC_{i,t} + +b_2 DEDICATED\_RMC_{i,t} + \text{Control Variables}_{i,t} + \text{Year} + \text{Industry} + \varepsilon_{i,t}$

3.3 Variables and Their Measurements

3.3.1 Corporate Environmental Performance (CEP)

We follow Ioannou and Serafeim (2010), Eccles, Ioannou, and Serafeim (2014), Cheng, Ioannou, and Serafeim (2014), Michelon, Pilonato, and Ricceri (2015), Lys, Naughton, and Wang (2015) and Liang and Renneboog (2017), by measuring environmental performance based on the ESG ratings assigned by the Thomson Reuters Asset4[6] database (i.e. Asset4). Asset4 has a multilevel structure with more than 750 data points for each firm-year, aggregated into more than 250 performance indicators, aggregated into categories, which make up the four pillars of environmental performance, social performance, financial/ economic performance and governance performance. Our study adopts environmental performance which consists of resource reduction, emission reduction and product innovation. Although Asset4 considers corporate disclosure in its rating process, its ratings also take into account information gathered directly from NGOs and the news media (De Villiers *et al.*, 2017). Thus, Asset4's ESG data measure underlying performance rather than firms' disclosure (De Villiers *et al.*, 2017). More detail regarding Asset4 data are provided in Appendix A.

3.3.2 Risk Management Committee: Presence (RMC), Structure (DEDICATED_RMC and COMBINED_RMC), and Human Capital (HC_RMC)

We examine three aspects of RMC, namely presence, structure, and human capital. Regarding the existence of RMCs, firms with a RMC are coded with the value of one and zero

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[5] Our results remain unchanged when we cluster by firm and year.
[6] More information about the Thomson Reuters Asset4 can be found at https://libguides.mit.edu/sustainablebusiness/asset4 and https://www.sri-connect.com/index.php?option=com_comprofiler&Itemid=4&task=userProfile&user=1007283, and access date is 24 January 2019.

otherwise. In relation to the structure of committee, we distinguish between RMCs that are dedicated to risk management (dedicated RMCs) and where risk management activities are undertaken by a committee that is also tasked with other activities (combined RMC). With respect to human capital of RMCs, we operationalize human capital of RMCs as firm-specific and generic human capital. Following Hogan and McPheters (1980), Bilimoria and Piderit (1994), Vafeas (2003), and Wulf and Singh (2011), committee tenure and board tenure of RMC members represent firm-specific RMC human capital. By devoting more time and attention to a firm, committee members are perceived to better manage the issues of the firm. Qualification and work experience of RMC members represent generic RMC human capital. By holding more qualifications and richer work experience, committee members tend to better comprehend risk management in general. Following Kennedy (2008) and Wooldridge (2010), we use principal component analysis that effectively extracts a latent component with an eigenvalue greater than one from the four variables mentioned. This principal component measures the collective ability of a RMC, namely the human capital of the RMC (HC_RMC).

Following Tetlock (2007) and Ellul and Yerramilli (2013), HC_RMC is constructed on a year-by-year basis using information from the current year. This approach avoids possible look-ahead bias due to incorporating future information. By synthesizing the four different variables, measurement error is minimized, the power of the analysis is increased, and multicollinearity is avoided (Custódio, Ferreira, & Matos, 2013; Jolliffe, 2002). We perform several additional tests to check for the appropriateness of principal component analysis – the Kaiser-Meyer-Olkin test of sampling adequacy is moderate with a value of 0.70, and the Cronbach's alpha is 0.60. We also find that the result of the Bartlett's test of sphericity is significant ($p<0.000$). Thus, our principal component analysis is appropriate.

3.3.3 Control Variables

Following Clarkson, Overell, and Chapple (2011) and Khan, Serafeim, and Yoon (2016), we use six control variables: firm size (SIZE), leverage (LEV), return on assets (ROA), capital expenditure (CAPEXP), market-to-book ratio (MTB), shareholding structure (SHARECON), and newness of property, plant and equipment (NEW). Larger firms are expected to generate better corporate environmental performance (Gallo & Christensen, 2011). Firms with the latest property, plant and equipment can generate better environmental performance (Clarkson, Li, Richardson, & Vasvari, 2008). High leverage firms or incur more capital expenditure may invest less on environmental performance, as they do not have slack resources (Arora & Dharwadkar, 2011). Those with high market-to-book ratios are likely to invest less on environmental performance, as they have more profitable projects awaiting investment. Following Rankin, Windsor, and Wahyuni (2011) and Jain and Jamali (2016), we also control for the presence of a corporate social responsibility committee (CSR_COM) and corporate governance (CG). The presence of a CSR committee and better corporate governance are likely to be positively related to environmental performance.

We control for other RMC characteristics, namely independence, shareholding of members, committee size and meeting frequency, to shed light on whether the human capital of RMCs is related to environmental performance.

To control for the undesirable effect of outliers, all continuous variables are winsorized at 1 and 99 percent. Appendix B tabulates the variable definitions and their measurement.

4. Results and Discussion

4.1 Descriptive Statistics

Descriptive statistics are shown in Table 2. The descriptive statistics about the full sample of 1,466 firm-year observations are presented in Panel A of Table 2. Panel B shows information about the presence of corporate social responsibility committee and RMC. Panel C displays the descriptive statistics about the RMC-subsample of 788 firm-year observations. According to panel A of Table 2, CEP exhibits a wide variation in distribution with a minimum score of 8.9 and a maximum score of 94.95. Panel B of Table 2 presents that greater than half of the full sample firms formed RMC, and almost a tenth of them formed a dedicated RMC. 15% of them also formed corporate social responsibility committee. Panel C of Table 2 shows: on average, committee members have board tenure of 5.50 years and committee tenure of 3.32 years. They hold an average of 1.39 education qualifications and performed 2.86 functions. The four variables show a great deal of variance. With respect to other committee characteristics, most of the committee members are independent, committee size ranges from two to 11, and there are, on average, 1.4 meetings per year. Panel D of Table 2 shows the distribution by year of corporate environmental performance, the number of firms with a dedicated, combined and no RMC and the number of firms that establish a RMC for the first time, showing the changes in our variables of interest.

Appendix C presents the Pearson correlation coefficients among the key variables. As expected, there is a high correlation between dedicated RMC and corporate environmental performance (CEP). CSR committee (CSR_COM) and corporate governance (CG) also exhibit positive associations with corporate environmental performance (CEP).

Table 2 Descriptive Statistics

Panel A presents descriptive statistics about important variables in sample. Panel B shows the number of risk management committees and the number of corporate-social-responsibility committees. Note that audit committees are compulsory for public firms in Australia. Panel C reports different characteristics of risk management committees. Variables in this table are defined in Appendix B.

Panel A Important Variables	N	MEAN	STD.DEV	MIN	MAX
CEP	1466	43.74	29.18	8.9	94.95
LEV	1466	0.45	0.24	0.00	1.62
ROA	1466	0.06	0.11	-0.93	0.97
MTB	1466	2.85	6.20	-29.55	53.63
Market Capitalization (in Billions)	1466	20.40	2.47	10.60	26.22
CG	1466	67.40	55.50	5.95	97.51
NEW	1466	0.86	0.16	0.00	1.00
CAPEXP	1466	0.07	0.10	0.00	1.00
SHARECON	1466	36.01	27.54	0.00	99.96
Panel B Board Committees				**TOTAL**	**PERCENTAGE**
CSR_COM				227	15.48%
COMBINED_RMC				655	44.68%
DEDICATED_RMC				133	9.07%
First time Combined RMC				134	9.14%
First time Dedicated RMC				48	3.27%
Panel C Characteristics of Risk Management Committee	**N**	**MEAN**	**STD.DEV**	**MIN**	**MAX**
QUALI	788	1.39	0.73	0	4.00
EXPERIENCE	788	2.86	2.70	0	4.89
BOD_ TENURE	788	5.50	3.06	0	24.67
RMC_ TENURE	788	3.32	1.80	0	11
RMC_SIZE	788	3.61	1.15	2	11
RMC_INDEP	788	0.87	0.21	0	1
RMC_MEET	788	1.40	0.46	1	3.18
RMC_SHARE	788	0.01	0.03	0	0.55

Panel D Variables by year

	CEP		Dedicated RMC		Combined RMC		NRMC		Total no. of firms	No. of first-time Dedicated RMC establishers	No. of first-time Combined RMC establishers
	Mean	STDDEV		%		%		%			
2007	49.64	30.10	7	8.64	29	35.80	45	55.56	81	0	0
2008	54.75	29.57	9	10.11	37	41.57	43	48.31	89	1	3
2009	41.47	28.60	13	7.43	72	41.14	90	51.43	175	0	0
2010	40.23	29.30	19	9.31	77	37.75	108	52.94	204	11	18
2011	40.15	28.25	23	10.85	83	39.15	106	50	212	10	17
2012	39.58	28.27	16	7.73	96	46.38	95	45.89	207	4	30
2013	42.24	29.75	16	8.29	96	49.74	81	41.97	193	9	19
2014	45.48	28.77	13	8.18	89	55.97	57	35.85	159	6	27
2015	50.78	28.55	17	11.64	76	52.05	53	36.30	146	7	20
Total			133		655		678		1466	48	134

Table 3 Presence and Structure of Risk Management Committee and Environmental Performance (H1 and H2)

This table has two columns, one for environmental performance and existence of risk management committee, and the other for environmental performance and structure of risk management committee. Structure of risk management committee has two types, dedicated (DEDICATED_RMC) and combined (COMBINED_RMC). Other variables are defined in Appendix B.

	(1) DV: CEP *Coeff.* *(t-stat)*	(2) DV: CEP *Coeff.* *(t-stat)*
RMC	0.49 (0.45)	-
DEDICATED_RMC	-	3.81 (2.37)**
COMBINED_RMC	-	0.79 (0.97)
SIZE	3.42 (1.99)**	4.51 (2.67)***
LEV	3.30 (3.57)**	9.75 (2.87)***
ROA	5.45 (1.19)	2.70 (1.25)
MTB	-0.06 (-1.25)	-0.06 (-1.27)
NEW	-1.18 (-0.35)	-0.12 (-0.04)
CSR_COM	10.91 (6.69)***	11.16 (6.93)***
CAP_EXP	-9.85 (-1.70)*	-8.13 (-1.44)
CG	0.02 (3.81)***	0.02 (3.66)***
SHARE_CON	0.04 (2.36)**	0.03 (2.37)**
Constant	29.13 (4.15)***	15.09 (2.92)***
Year FE	YES	YES
Industry FE	YES	YES
Observations	1466	1466
Adjusted R-square	0.24	0.15
Test of coefficient equality (p-value shown below)		
DEDICATED_RMC vs COMBINED_RMC		0.01

***, **, * indicate significance at the 0.01, 0.05, 0.1 levels respectively

4.2 Presence and Structure of RMC and Environmental Performance

Findings related to H1 and H2 are shown in columns 1 and 2 of Table 3. Column 1 of Table 3 presents the finding regarding the relationship between RMCs and environment performance (H1). We report that the presence of an RMC is not significantly related to environmental performance. Column 2 of Table 3 presents the finding regarding the relationship between committee structure and environment performance (H2). We find that firms with a dedicated RMC have better environmental performance, $\beta = 3.81$ ($p<0.05$). On average, dedicated RMCs are positively relates to environmental performance by more than 3%. But combined RMCs are not significantly related to environmental performance. In addition, we test the coefficient equality between DEDICATED_RMC and COMBINED_RMC. As shown in Table 3, the coefficient of DEDICATED_RMC is significantly greater than that of COMBINED_RMC. Firms with dedicated RMCs are associated with better environmental performance than those with combined RMCs. Thus, H1 is not substantiated, while H2 is supported. Our findings align with prior studies, including Brancato *et al.* (2009) and Mongiardino and Plath (2010), which indicate RMCs in independent structures to be a more effective mechanism to monitor risk management and advise directors about relevant issues.

4.3 Human Capital of Risk Management Committee and Environmental Performance

Findings of H3 are presented in Table 4. As discussed in Section 3.2.2, principal component analysis on the four variables, namely board tenure, committee tenure, qualifications and work experience, is used to extract the overall human capital of RMC (HC_RMC). As indicated by Column 1 of Table 4, HC_RMC is positively related to environmental performance (CEP), $\beta = 1.67$ ($p<0.05$). On average, a unit of increase in HC_RMC is related to 1.67% of increase in CEP. Performing as an alternative check, we split RMCs in the sample (788 firm-year observations) into two groups according to the industry-year sample mean of HC_RMC. A dummy variable HC_RMC_DUMMY is introduced. RMCs with human capital greater than the sample mean are coded as one, and zero otherwise. As shown by Column 2 of Table 4, HC_RMC_DUMMY is positively related to CEP, $\beta = 4.73$ ($p<0.05$). On average, the CEP of RMCs with human capital greater than the sample mean is 4.73% higher than RMCs with human capital below the sample mean. Thus, H3 is substantiated. In terms of the literature, the findings support Pfeffer and Salancik (2003) that a committee with richer human capital contributes more to firm performance. Regarding control variables, we find that dedicated RMC is positively related to CEP, and members' shareholding is positively related to CEP. An inference is that committee members with more stakes at a firm on which they serve put efforts on risk management, leading to stronger performance. Others, including newness of property, plant and equipment (NEW), corporate social responsibility committee (CSR_COM) and corporate governance (CG), behave in the ways expected. A number of additional analyses, namely endogeneity, alternative performance measurement, and sectoral environment, are performed in the following sections.

Table 4 Human Capital of Risk Management Committee and Environmental Performance (H3)

Four characteristics of committee members, namely board tenure, committee tenure, qualification and work experience, are synthesized into one variable, human capital of risk management committee (HC_RMC). A dummy variable, HC_RMC_DUMMY, is introduced, according to whether human capital of risk management committee is greater than or less than industry-year sample mean. Other variables are defined in Appendix B.

	(1) DV: CEP *Coeff.* *(t-stat)*	(2) DV: CEP *Coeff.* *(t-stat)*
HC_RMC	1.67 (1.98)**	-
HC_RMC_DUMMY	-	4.73 (2.09)**
RMC_SIZE	0.23 (0.21)	0.46 (0.38)
RMC_INDEP	7.99 (1.06)	7.78 (1.03)
RMC_MEET	1.04 (1.57)	0.75 (1.10)
RMC_SHARE	21.14 (2.14)**	21.80 (2.19)**
SIZE	0.81 (1.45)	0.84 (1.49)
LEV	-1.16 (-0.17)	-1.17 (-0.17)
ROA	3.69 (0.31)	4.29 (0.35)
MTB	-0.39 (-0.95)	-0.49 (-1.18)
NEW	31.20 (2.96)***	30.00 (2.83)***
CSR_COM	7.34 (2.19)**	7.46 (2.22)**
CAP_EXP	-17.84 (-1.19)	-16.04 (-1.05)
CG	0.30 (6.48)***	0.28 (6.08)***
SHARE_CON	0.003 (0.07)	0.001 (0.02)
Constant	19.60 (0.55)	21.04 (0.58)***
Year FE	YES	YES
Industry FE	YES	YES
Observations	788	788
Adjusted R- square	0.32	0.31

***, **, * indicate significance at the 0.01, 0.05, 0.1 levels respectively

4.4 Additional Analyses

We employ several additional analyses[7] to address possible endogeneity and construct validity concerns. Aligning with Nguyen *et al*. (2018), we use propensity score matching

[7] We also use a lag model by including lagged CEP as a regressor to check the robustness of our results. We find after including lagged CEP in our models, the results are qualitatively similar to the main results. In addition, self-selection bias may be considered an issue, as firms with (dedicated) risk management committees may be

(PSM) to reduce functional form misspecification bias. We use IV-GMM estimations to re-test H2 and H3 to address the potential endogeneity threat of reverse causality and/or omitted variables. To support a causal interpretation[8], following Liang and Renneboog (2017) and Dyck *et al.* (2019), we use the Deepwater Horizon oil spill in 2010 as an exogenous environmental shock. This costly environmental shock demonstrates the immense scale of potential financial consequences of bad environmental performance (Dyck *et al.*, 2019). Although this environmental shock occurred in the US, it was a high-profile event globally and raised awareness of environmental risks in other countries, especially among firms in the energy sector. Liang and Renneboog (2017) also suggest that the Deepwater Horizon oil spill was an environmental shock to all energy firms in terms of the environmental consequences of their operations and productions. If dedicated RMCs and RMCs' human capital drive changes in environmental performance, energy firms can be expected to react more strongly after the exogenous environmental shock of the large financial consequences of the Deepwater Horizon oil spill. Lastly, we perform analyses focused on the first-time appointment of a RMC. In terms of construct validity, we use alternative measures of CEP. Following De Villiers *et al.* (2011) and Eccles *et al*. (2014), the effects of sectoral environment on the findings are also considered.

4.4.1 Endogeneity Tests on H2

Propensity Score Matching on H2

Following Mishra (2014) and Michelon *et al.* (2015), we perform propensity score matching (PSM)[9] to reduce bias from functional form misspecification by decreasing reliance on the specification of the relation between variables (Rosenbaum and Rubin, 1983). PSM forms treatment and control groups that are similar across observable factors, relaxing the assumption about the functional form of variable relations and reducing bias from functional form misspecification. H2 is re-tested by a matched-sample design. A propensity score is calculated from the first-stage model[10] to predict a firm with a dedicated RMC. The prediction model considers control variables from Equation (1). Then, we match each firm-year observation where DEDICATED_RMC = 1 with an observation where DEDICATED_RMC

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systematically different from other firms. To address this potential concern, we conduct Heckman two-stage tests for H1, H2, and H3. The untabulated Heckman results are qualitatively similar for H1, H2, and H3.

[8] This expression is used in Dyck *et al.* (2019, p. 694).

[9] We employ one to one matching to create the propensity-matched sample. To ensure that matched observations are similar, we use a calliper of 0.25 times the standard deviation of the logit of the propensity scores. Specifically, we use the "psmatch2" command in STATA to construct our matches

[10] As evidenced by the area under ROC curve of 76.5%, the result shows our first-stage logistic regression model is well specified.

= 0. Panel A of Table 5 shows that the matching procedure is valid, as all matched variables are statistically indistinguishable. As presented by Panel B of Table 5, the findings of H2 remain qualitatively similar: dedicated RMCs are positively related to corporate environmental performance.

IV-GMM Regression on H2

In addition to PSM regression, we use an IV-GMM regression to re-test H2 to address possible reverse causality and omitted variable concerns. We prefer the GMM method to the two-stage least squares (2SLS) as GMM provides reliable estimates for inferences from different types of datasets (Hansen, 1982) and the predicted values under 2SLS may not be efficient even if they are consistent (Greene, 2012; Huang *et al.*, 2018).

The introduction of the *Corporate Governance Principles and Recommendations* and the mean of dedicated RMC in the same industry and year are used as instrumental variables[11]. In 2007, the Exchange released the second version of *Corporate Governance Principles and Recommendations*. Being effective from 2009, this document has emphasised the importance of having a RMC. In the second version, ASX highlights the importance of RMCs, stating "A board committee is an efficient mechanism for focusing the company on appropriate risk oversight, risk management and internal control (CGPR, 2007, p33)". Thus, we expect the effectiveness of the *2007 Corporate Governance Principles and Recommendations* is positively related to the presence of a dedicated RMC, yet it is not directly related to environmental performance. Accordingly, a dummy variable, CGPR, is created to account for the effects of *2007 Corporate Governance Principles and Recommendations*. It is coded with the value of one, if firm-year observations are after 2009, and zero otherwise. Following Wang, Duan and Liu (2021) and Banker, Huang & Natarajan (2011), we select the mean of dedicated RMC in the same industry and year (INDUS_SRMC) as another instrumental variable. This is because the likelihood of having a dedicated RMC at the firm level tends to converge around the industry-year average (Lev & Sougiannis, 1996). If the likelihood of having a dedicated RMC is high in an industry, then it is expected that firms operating in the industry are more likely to have a dedicated RMC.

[11] We acknowledge that it is often difficult to find a valid and suitable instrumental variable in accounting research (Ittonen, Johnstone, & Myllymäki, 2015, p. 629).

Table 5 Endogeneity Tests on H2

This table presents endogeneity test results regarding the relationship between dedicated risk management committees and environmental performance. Starting with propensity score matching (PSM), Panel A shows comparisons of variables of the propensity-matched firm-years (dependent variable is environmental performance). Panel B presents PSM regression results regarding the relationship between dedicated risk management committees and environmental performance based on this matched sample. In relation to IV-GMM, Panel C shows the results of the first stage, and Panel D shows the results of the second stage. Panel E presents the exogenous environmental shock results. A dummy, *POST2010*, is created to reflect that the Deepwater Horizon oil spill occurred in 2010. As the oil spill event is directly related to energy firms, we create a dummy, *ENERGY*, equals to one for firms operating in the energy industry and zero otherwise. Panel F shows the results for the first-time risk management committee establishment. The results when using the full sample are reported on Column 1, and the results of using a reduced sample including only firms that established a risk management committee during our sample period are shown in Column 2. Variables are defined in Appendix B.

Propensity Score Matching (PSM)

Panel A Propensity-matched Variables

	Treated (DEDICATED_RMC)	Controlled (No DEDICATED_RMC)	t-stat	p-value
SIZE	20.88	20.81	0.53	0.595
LEV	0.46	0.46	0.21	0.836
ROA	0.07	0.07	-0.46	0.647
MTB	2.65	2.83	-0.93	0.355
NEW	0.87	0.87	-0.25	0.803
CSR_COM	0.25	0.26	-0.85	0.396
CAP_EXP	0.08	0.09	-1.33	0.183
CG	70.68	66.68	1.32	0.176
SHARE_CON	65.59	68.20	-2.01	0.045

Panel B PSM Regression

	DV: CEP *Coeff.* *(t-stat)*
DEDICATED_RMC	4.67
	(2.63)***
Controls Included	YES
Year FE	YES
Industry FE	YES
Observations	1130
Adjusted R- square	0.20

IV-GMM Regression

Panel C Stage One

	DEDICATED_RMC *Coeff.* *(t-stat)*
CGPR	0.05
	(1.97)**
INDUS_SRMC	0.96
	(17.84)***
Controls Included	YES
Year FE	YES
Industry FE	YES

Panel D Stage Two

	DV: CEP *Coeff.* *(t-stat)*
DEDICATED_RMC	10.054
	(2.38)**
Controls Included	YES
Industry FE	YES
Observations	1466

Adjusted R-square	0.30	
Hansen J-statistic (p value)	0.424	
GMM C statistic (p value)	0.280	
F-statistic for weak instrument (p value)	0.000	
Exogenous Environmental Shock		
Panel E		
	CEP *Coeff.* *(t-stat)*	
DEDICATED_RMC × POST2010 × ENERGY	30.204** (2.45)	
Controls Included	YES	
Other Interactions and Individual Variables Included	YES	
Year FE	YES	
Industry FE	YES	
Observations	1466	
Adjusted R-square	0.87	
First Time RMC Establishment and Reduced Sample		
Panel F	First time RMC establishment	Only firms that establish a RMC
	DV: CEP *Coeff.* *(t-stat)*	DV: CEP *Coeff.* *(t-stat)*
$DEDICATED\_RMC_t$	2.130 (5.95)***	7.00 (2.30)**
$COMBINED\_RMC_t$	-0.41 (-1.54)	-2.76 (-1.49)
Controls Included	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	1466	585
Adjusted R-square	0.45	0.48

***, **, * indicate significance at the 0.01, 0.05, 0.1 levels respectively

Table 5, Panel C and D show the coefficient estimates using IV-GMM. We rely on the following three model specification tests for instrument validity: (1) the Hansen *J* statistic to test for over-identifying restrictions; (2) the Hayashi *C* statistic for endogeneity and (3) the *F*-statistics to test the correlation between instrument variables and the endogenous variable (i.e. weak instrument test). The results are reported at the bottom of Table 5, Panel D. We find that the p values of the Hansen *J* statistic and the Hayashi *C* statistic are larger than 0.1. The *F*-statistic has a p-value of less than 0.1. These tests provide us confidence in our estimations.

The results of the first stage and the second stage IV-GMM are presented in Panel C and Pane D of Table 5, respectively. We find that our instrumental variables, CGPR and INDUS_SRMC, are positively and significantly related to the presence of a dedicated RMC. As shown in Panel D of Table 5, the findings regarding H2 remain qualitatively similar to our main analysis, i.e. the presence of a dedicated RMC is positively related to environmental performance.

To further ensure our results are unbiased by endogeneity, we conduct an alternative instrumental regression, namely the Lewbel method (Lewbel, 2012), which uses internally generated instruments to address potential endogeneity (Emran & Shilpi, 2012; Mishra & Smyt, 2015; Churchill, Valenzuela & Sablah, 2017). The Lewbel method utilizes a heteroscedastic covariance restriction to construct internal instruments when the conventional instruments are potentially weak or there are no conventional instruments available. This method has been used in various settings, including agriculture (Emran & Shilpi, 2012), education (Mishra & Smyt, 2015), and microfinance (Mallick, 2012). The results are shown in Column (1) of Appendix D. We conduct several post estimation tests. The Anderson LM test (under identification test) shows that the model is identified. The Sargan statistic (over-identification test) is insignificant, indicating the null hypothesis, i.e. the instruments being exogenous (unrelated with the error terms). The two tests show that the internally generated instruments satisfy the conditions of exogeneity and relevance. Thus, our results can be relied on.

Exogenous Environmental Shock on H2

We follow Liang and Renneboog (2017) and Dyck et al. (2019) and use the Deepwater Horizon oil spill in 2010 as an exogenous environmental shock and conduct a difference-in-differences analysis. We compare the environmental performance of energy firms with non-energy firms with dedicated RMC, before and after the Deepwater Horizon oil spill. The oil spill event occurred in 2010, thus we create a dummy, *POST2010*. Also, as the oil spill event directly relates to all energy firms, we create a dummy, *ENERGY*, coded one for energy industry firms and zero otherwise. Our variable of interest is the coefficient of *DEDICATED_RMC×POST2010×ENERGY*. Table 5 Panel E shows that this coefficient is positive and statistically significant. This indicates that, as expected, in responding to the environmental shock, the relationship between dedicated RMCs and higher levels of environmental performance was stronger for energy firms than for non-energy firms. This reinforces our findings of H2 and mitigates endogeneity concerns.

First Time RMC Establishment and Reduced Sample Including Only Firm-Years with Changes in RMC for H2

In order to address endogeneity concerns, we re-estimate our main regression (shown in Table 3), but coding our variables of interest as defined only in the firm-year in which a RMC was first established in our sample, zero otherwise. Table 2, Panel B shows 134 (9.14% of firm-years) combined RMCs and 48 (3.27% of firm-years) dedicated RMCs were established in our sample. The regression results are shown in Table 5, Panel F, Column 1. Our results are qualitatively similar to our main results, i.e. when first established, dedicated RMCs are associated with better environmental performance.

In addition, we re-test H2 using only firms that established a RMC during our sample period (including the years before and after the first-time establishment of an RMC), i.e. we eliminated from our sample firms that never had a RMC or had a RMC in each firm-year during the sample period. The results are shown in Table 5, Panel F, Column 2. These results are again qualitatively similar to our main results, i.e. when first established, dedicated RMCs are associated with better environmental performance.

4.4.2 Endogeneity Tests on H3

Propensity Score Matching on H3

Again, PSM regression is used to reduce bias from functional form misspecification (H3). H3 is re-tested by a matched-sample design. A propensity score is calculated from a first-stage model[12] to predict a firm with high human capital of RMC. The prediction model includes all control variables from Equation (3). Sample committees are discriminated into two groups, committees with human capital greater than the industry-year sample mean are labelled with the value of one (HC_RMC_DUMMY = 1) and zero otherwise (HC_RMC_DUMMY = 0). Next, we match each firm-year observation whose HC_RMC_DUMMY = 1 with another observation whose HC_RMC_DUMMY = 0. As presented by Panel A of Table 6, the matching procedure is valid, as all matched variables are statistically indistinguishable. As presented by Panel B of Table 6, human capital of committee also is positively related to environmental performance. Thus, findings of H3 remain qualitatively unchanged.

[12] As evidenced by the area under ROC curve of 77.8%, the result shows our first-stage logistic regression model is well specified.

Table 6 Endogeneity Tests on H3

This table presents endogeneity tests' results regarding the relationship between human capital of risk management committee and environmental performance. Starting with propensity score matching (PSM), we introduce a dummy variable, *HC_RMC_DUMMY*, by discriminating sample committees into two groups, committees with human capital greater than industry-year sample mean (*HC_RMC_DUMMY* = 1) and committees with human capital less than industry-year sample mean (*HC_RMC_DUMMY* = 0). Panel A shows comparisons of variables of the propensity-matched firm-years (dependent variable is environmental performance). Panel B presents PSM regression results regarding the relationship between human capital of risk management committees and environmental performance based on this matched sample. In relation to IV-GMM, Panel C shows the results of the first stage, and Panel D shows the results of the second stage. Panel E presents the exogenous environmental shock results. A dummy, *POST2010*, is created to reflect that the Deepwater Horizon oil spill occurred in 2010. As the oil spill event is directly related to energy firms, we create a dummy, *ENERGY*, equals to one for firms operating in the energy industry and zero otherwise. Panel F shows the results for the first-time risk management committee establishment. The results when using the full sample are reported on Column 1, and the results when using a reduced sample including only firms that established a risk management committee during our sample period are shown in Column 2. Variables are defined in Appendix B.

Propensity Score Matching (PSM)

Panel A Propensity-matched Variables

	Treated (HC_RMC_DUMMY=1)	Controlled (HC_RMC_DUMMY=0)	t-stat	p-value
RMC_SIZE	3.70	3.64	1.52	0.544
RMC_INDEP	0.89	0.86	1.27	0.203
RMC_SHARE	0.004	0.005	-0.42	0.674
RMC_MEET	4.40	4.41	-0.06	0.952
SIZE	20.88	20.81	0.53	0.595
LEV	0.46	0.46	0.21	0.836
ROA	0.07	0.07	-0.46	0.647
MTB	2.65	2.83	-0.93	0.355
NEW	0.87	0.87	-0.25	0.803
CSR_COM	0.25	0.26	-0.85	0.396
CAP_EXP	0.08	0.09	-1.33	0.183
CG	70.68	66.68	1.32	0.176
SHARE_CON	65.59	68.20	-2.01	0.045

Panel B PSM Regression

	DV: CEP *Coeff.* *(t-stat)*
HC_RMC_DUMMY	4.54 (2.00)**
Controls Included	YES
Year FE	YES
Industry FE	YES
Observations	610
Adjusted R- square	0.31

IV-GMM Regression

Panel C First Stage	DV: HC_RMC *Coeff.* *(t-stat)*
INDUS_HCRMC	0.62 (2.96)***
SQUARE_RMCHC	0.163 (6.65)***
Controls Included	YES
Year FE	YES
Industry FE	YES

Panel D Second Stage

	DV: CEP *Coeff.* *(t-stat)*
HC_RMC	4.18 (1.97)**

Controls Included	YES
Year FE	YES
Industry FE	YES
Observations	788
Adjusted R- square	0.33
Hansen J-statistic (p value)	0.408

Exogenous Environmental Shock	
Panel E	
	CEP *Coeff.* *(t-stat)*
HC_RMC × POST2010 × ENERGY	15.977***
	(4.73)
Controls Included	YES
Other Interactions and Individual Variables Included	YES
Year FE	YES
Industry FE	YES
Observations	788
Adjusted R-square	0.32

First Time RMC Establishment and Reduced Sample		
Panel F	First time RMC establishment	Only firms that establish a RMC
	DV: CEP *Coeff.* *(t-stat)*	DV: CEP *Coeff.* *(t-stat)*
HC_RMC_t	1.73	2.24
	(1.98)**	(1.88)*
Controls Included	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	788	247
Adjusted R-square	0.35	0.49

IV-GMM Regression on H3

To mitigate against any possible concerns regarding reverse causality and omitted variables, we use an IV-GMM regression (Huang *et al.*, 2018). Following Wang, Duan and Liu (2021) and Banker, Huang & Natarajan (2011), we select the mean of human capital of RMC in the same industry and year as the instrumental variable (INDUS_HCRMC), as the human capital of RMCs at the firm level tends to converge around the industry average (Lev & Sougiannis, 1996). Following Greiner, Patelli, and Pedrini (2020), we use the square of human capital of RMC (SQUARE_RMCHC) as another instrument.

Table 6, Panel C and D show the coefficient estimates using IV-GMM. We rely on the following three model specification tests for instrument validity: (1) the Hansen *J* statistic to test for over-identifying restrictions; (2) the Hayashi *C* statistic for endogeneity and (3) the *F*-statistics to test the correlation between instrument variables and the endogenous variable (i.e. weak instrument test). The results are reported at the bottom of Table 6, Panel D. We find that the p values of the Hansen *J* statistic and the Hayashi *C* statistic are larger than 0.1. The *F*-statistic has a p-value of less than 0.1. These tests provide confidence in our estimations.

Panel C of Table 6 shows the instrumental variables, INDUS_HCRMC and SQUARE_RMCHC, are positively and significantly ($p<0.01$) related to the human capital of RMCs at the firm level. Panel D of Table 6 shows the human capital of the committee is positively related to environmental performance, i.e., the IV-GMM findings regarding H3 are qualitatively similar to the results in our main analysis.

To further ensure our results are unbiased by endogeneity concerns, we conduct an alternative instrumental regression, namely the Lewbel method, which uses internally generated instruments to address potential endogeneity (Emran & Shilpi, 2012; Mishra & Smyt, 2015; Churchill *et al*., 2017). The results are shown in Column (2) of Appendix D. We conduct two post estimation tests. The Anderson LM test (under-identification test) shows that the model is identified. The Sargan statistic (over-identification test) is insignificant, indicating that the null hypothesis holds, i.e. the instruments are exogenous (unrelated with the error terms). The two tests show that the internally generated instruments satisfy the conditions of exogeneity and relevance. Thus, our results are valid. The findings regarding H3 are qualitatively similar to the results in our main analysis.

Exogenous Environmental Shock on H3

We use the Deepwater Horizon oil spill in 2010 as an exogenous environmental shock to draw casual interpretation regarding the relationship between the human capital of RMC members and environmental performance. We analyse how environmental performance changes for energy firms versus non-energy firms with a high-human-capital RMC after the oil spill event. The oil spill event occurred in 2010, thus we create a dummy, *POST2010*. Also, as the oil spill event directly relates to energy firms, we create a dummy, *ENERGY*, coded one for energy industry firms and zero otherwise. Our variable of interest is the coefficient of *HC_RMC ×POST2010×ENERGY*. Table 6 Panel E shows that the coefficient is positive and statistically significant. This indicates that, as expected, the positive relationship between the human capital of RMC members and environmental performance is stronger among energy firms than non-energy firms after the exogenous energy shock. This result reinforces our H3 findings and suggests that RMC plays a significant role in responding to the exogenous environmental shock.

First Time RMC Establishment and Reduced Sample Including Only Firm-Years with Changes in RMC for H3

Again, we focus on the first time RMC establishment to address endogeneity concerns for H3. We re-estimate our main regression (shown in Table 4), but coding our variables of interest as defined only in the firm-year in which a RMC was first established in our sample, zero otherwise. The regression results are shown in Table 6, Panel F, Column 1. Our results are qualitatively similar to our main results for H3.

In addition, we re-test our hypotheses using only firms that established a RMC during our sample period (including the years before and after the first-time establishment of an RMC), i.e. we eliminated from our sample firms that never had a RMC or had a RMC in each firm-year during the sample period. The results are shown in Table 6, Panel F, Column 2. These results are again qualitatively similar to our main results, i.e. RMCs with higher levels of human capital are associated with better environmental performance.

4.4.3 Alternative Measurement on CEP

Our main measure of CEP is the overall environmental score provided by the Thomson Reuters Asset4 database. Apart from the overall environmental score, Asset4 provides a second level of three environmental measures that together make up the overall score. These measures are resource reduction, emission reduction and product innovation. Asset4 does not declare exactly how the three second-level measures are aggregated to form the overall environmental performance measure. Therefore, we use principal component analysis to extract the latent component(s) from the three second-level measures as an alternative measurement of CEP. The findings are tabulated in Table 7. Panel A presents the principal component analysis, showing only one principal component with an Eigenvalue over 1, which we use as an alternative CEP measure in Panel B. The findings regarding H1, H2 and H3 remain qualitatively similar to our main analyses.

In order to shed light on which sub-categories of environmental performance is related to RMC, we specify each of the three environmental performance sub-categories as the dependent variable in the model. The results are shown in Panel C of Table 7. We find that dedicated RMC is positively and significantly related to firms' emission reduction performance. In terms of RMC human capital, we find RMC human capital to be positively related to all three categories of corporate environmental performance.

Table 7 Alternative Measurement of Environmental Performance

This table presents results as to alternative measurement on environmental performance. Panel A presents alternative measurement on environmental performance based on principal component analysis. Panel B shows results of three hypotheses. Environmental performance is calculated by extracting a latent component from the three categories composed of it. Other variables are defined in Appendix B.

Panel A: Principal Component Analysis on Three Categories of Environmental Performance

	Eigenvalue	Difference	Proportion	Cumulative
Resource Reduction (ENRR)	2.33	1.83	0.78	0.77
Emission Reduction (ENER)	0.50	0.32	0.17	0.95
Product Innovation (ENPI)	0.17	-	0.05	1.00

Panel B: Panel Regression

	(1) DV: CEP *Coeff.* *(t-stat)*	(2) DV: CEP *Coeff.* *(t-stat)*	(3) DV: CEP *Coeff.* *(t-stat)*
RMC	0.02	-	-
	(0.39)		
DEDICATED_RMC	-	0.15	-
		(2.25)**	
COMBINED_RMC	-	0.06	-
		(0.05)	
HC_RMC	-		0.18
			(5.95)***
Controls Included	YES	YES	YES
Year FE	YES	YES	YES
Industry FE	YES	YES	YES
Observations	1414	1414	727
Adjusted R-square	0.20	0.20	0.30

Panel C: sub-CEP categories

	(1) DV: ENRR *Coeff.* *(t-stat)*	(2) DV: ENER *Coeff.* *(t-stat)*	(3) DV: ENPI *Coeff.* *(t-stat)*	(4) DV: ENRR *Coeff.* *(t-stat)*	(5) DV: ENER *Coeff.* *(t-stat)*	(6) DV: ENPI *Coeff.* *(t-stat)*
DEDICATED_RMC	2.711	4.775	1.340	-	-	-
	(1.42)	(2.55)**	(0.77)			
HC_RMC	-	-	-	2.805	3.187	1.874
				(3.92)***	(4.54)***	(2.45)**
Controls Included	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	1414	1414	1414	727	727	727
Adjusted R-square	0.16	0.13	0.08	0.22	0.29	0.26

***, **, * indicate significance at the 0.01, 0.05, 0.1 levels respectively

4.4.4 Sectoral Environment

Following Cho and Patten (2007) and Eccles *et al*. (2014), we classify industries into two pairs of categories, dirty versus non-dirty and business-to-consumer (B2C) versus others. Regarding the first pair, we code as one for industries deemed to be environmentally sensitive and zero otherwise (De Villiers *et al*., 2011)[13]. Firms in dirty industries are subject to more

[13] To be specific, dirty industries are forestry, metal mining, coal mining, oil and gas exploration, paper and pulp mills, chemicals, pharmaceutical, plastics manufacturing, iron and steel manufacturing, electricity, gas and waste water (De Villiers *et al*., 2011).

environmental pressures (Cho, Laine, Roberts, & Rodrigue, 2015), leading us to expect a stranger relationship between RMC and environmental performance.

In terms of the second pair, we code as one B2C sector, and otherwise zero. Following Eccles *et al*. (2014), firms in B2C sectors are more visible as they directly interact with consumers. Thus, firms in B2C sectors tend to care more about image and reputation than their peers in other sectors. The relationship between RMC and environmental performance may be influenced by such concern. The (untabulated) findings show that neither dirty industries nor B2C industries influence the relationship between RMC and CEP. Therefore, our findings regarding H1, H2 and H3 are consistent across sectors and industries.

4.4.5 Individual Human Capital Characteristics

In the main results, we constructed HC_RMC using principal component analysis of the four human capital characteristics, namely board tenure, RMC tenure, qualification and experience. In order to shed light on which of the individual measures contribute to the main result, we place each of the four individual human capital characteristics in the model. The results, presented in Table 8, show that RMC members' board tenure, committee tenure and qualifications are positively and significantly associated with corporate environmental performance, while experience is not significant. Directors' power and legitimacy may drive our results, as much as our explanations based on expertise.

Table 8 Human Capital Characteristics and Environmental Performance

Four characteristics of committee members, namely board tenure, committee tenure, qualification and work experience are tested individually. Other variables are defined in Appendix B.

	(1) DV: CEP *Coeff.* *(t-stat)*
BRD_Tenure	1.30 (2.48)**
RMC_Tenure	1.57 (2.45)**
Qualification	1.71 (1.88)*
Experience	-0.25 (-0.50)
Controls Included	YES
Year FE	YES
Industry FE	YES
Observations	788
Adjusted R- square	0.34

***, **, * indicate significance at the 0.01, 0.05, 0.1 levels respectively

5. Conclusion

We investigate the previously unexamined relationship between RMCs and environmental performance, based on the analysis of 1,466 firm-year observations from 2007 to 2015. We find that dedicated RMCs are positively related to environmental performance, while combined RMCs are not related to environmental performance. Therefore, our results suggest that dedicated RMCs are more effective than combined RMCs at enhancing environmental performance. These findings are consistent with prior studies that find that dedicated board committees are more effective (Brancato *et al*., 2009; Mongiardino and Plath, 2010; *Aebi et al*., 2012). We also find that RMCs with greater human capital are associated with better environmental performance. The finding that high-calibre directors contribute more to firm performance is consistent with resources dependency theory. We perform several additional analyses, including (1) using an exogenous environmental shock to draw casual interpretations; (2) IV-GMM to address the potential endogeneity threats of reverse causality and/or omitted variables; (3) propensity score matching to reduce bias from functional form misspecification; (4) a focus on first time appointment of RMCs, (5) an alternative measure of environmental performance, and (6) whether our results hold in both environmentally sensitive and non-sensitive industries. These additional analyses provide consistent evidence in support of our main results.

Our findings have several practical implications. First, we are the first to reveal that the benefits of RMCs are not limited to financial issues. It also contributes to non-financial issues, including environmental performance. Second, whether a board committee is dedicated to risk management or whether this task is combined with other responsibilities for the same committee matters, as does the experience level of the RMC's members. These findings will interest those who are tasked with risk management, as well as investors, lenders, and auditors who need to assess risk, not to mention regulators, such as securities exchange commissions, as well as stock exchanges.

We contribute to the literature in several ways. First, aligning with studies that examine corporate governance and corporate social responsibility (De Villiers et al., 2011), we shed light on the effectiveness of board committees in relation to corporate social responsibility (the aspect of environmental performance/risk). Specifically, extending the research scope of Krishnamurti and Velayutham (2017), we analyse different characteristics of RMCs, rather than only the presence/absence of RMCs. In terms of theoretical contributions, we provide evidence in support of resource dependency theory (Pfeffer & Salancik, 2003), namely that the experience level of directors and board committee members influence their effectiveness in tasks such as risk management activities. Second, extending the scope of prior studies (Bui *et al.*, 2020; Liao *et al.*, 2015), which examine other board committees, our study sheds light on RMCs. The prior literature provides little evidence in this regard. Third, our study contributes to knowledge regarding how general governance mechanisms relate to environmental performance. Differentiating from Rankin *et al.* (2011) who examine the relationship between the presence of CSR committees and environmental matters, which can be expected, we focus on a committee that do not necessarily relate to environmental matters, but relate to risk and therefore may involve environmental risk/performance management, namely RMCs, and instead of their mere existence, we also take account of their structure and the human capital of their members.

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Appendix A Description of Asset4's Environmental Performance/Score

Asset4's environmental performance pillar consists of three categories whose details are tabulated below.

Categories	Asset4 Code	Description
Emission Reduction	ENER	The emission reduction category measures a firm's management commitment and effectiveness towards reducing environmental emission in the production and operational processes. It reflects a firm's capacity to reduce air emissions (greenhouse gases, F-gases, ozone-depleting substances, NOx and SOx, etc.), waste, hazardous waste, water discharges, spills or its impacts on biodiversity and to partner with environmental organisations to reduce the environmental impact of the firm in the local or broader community.
Product Innovation	ENPI	The product innovation category measures a firm's management commitment and effectiveness towards supporting the research and development of eco-efficient products or services. It reflects a firm's capacity to reduce the environmental costs and burdens for its customers, and thereby creating new market opportunities through new environmental technologies and processes or eco-designed, dematerialized products with extended durability.
Resource Reduction	ENRR	The resource reduction category measures a firm's management commitment and effectiveness towards achieving an efficient use of natural resources in the production process. It reflects a firm's capacity to reduce the use of materials, energy or water, and to find more eco-efficient solutions by improving supply chain management.

Appendix B Definitions of variables

Variable	Abbr.	Expected Sign	Measurement	Sources
Set 1 – Corporate Environmental Performance				
Corporate Environmental Performance	CEP		Environmental scores assigned by Thomson Reuters Asset4 on a scale of 1 – 100.	Asset4
Set 2 – Risk Management Committee				
Presence of Risk Management Committee	RMC	+	One for presence of a risk management committee, zero otherwise	Hand-collected
Existence of Combined Committee	COMBINED_RMC	+	One for existence of a risk management committee combined with other board committees, zero otherwise	Hand-collected
Existence of Standalone Committee	DEDICATED_RMC	+	One for existence of a standalone risk management committee, zero otherwise	Hand-collected
Board Tenure of Committee Members	BOD_ Tenure	+	Average number of years that committee members serve on board	Hand-collected
Committee Tenure of Committee Members	RMC_ Tenure	+	Average number of years that committee members serve on risk management committee	Hand-collected
Qualification	QUALI	+	Average number of qualifications (diploma, bachelor, honours, master, doctor and CPA/CA) that committee members hold	Hand-collected
Work Experience	EXPERIENCE	+	Average number of functions (e.g. industry, accounting, finance, management, tax and risk management) that committee members held	Hand-collected
Committee Independence	RMC_INDEP	+	Percentage of independent directors on committee	Hand-collected
Meeting Frequency	RMC_MEET	+	Number of meetings that a committee holds in a year	Hand-collected
Shareholding of Committee Members	RMC_SHARE	+	Average shareholding of committee members	Hand-collected
Committee Size	RMC_SIZE	+	Number of committee members	Hand-collected
Set 3 – Control Variables				
Leverage	LEV	-	Total liabilities over Total assets	Morningstar
Return on Assets	ROA	+	$\frac{\text{Reported Net Profit After Tax}}{\text{Total Assets}}$	Morningstar
Market-to-book Ratio	MTB	-	$\frac{\text{Market Capitalization}}{\text{Book Value}}$	Morningstar
Firm Size	SIZE	+	$\ln$ Market Capitalization	Morningstar
Governance Index	CG	+	Corporate governance scores assigned by Thomson Reuters Asset4	Asset4
Newness of Property, Plant and Equipment	NEW	+	$\frac{\text{Net Property, Plant and Equipment}}{\text{Gross Property, Plant and Equipmen}}$	Morningstar
Capital Expenditure	CAPEXP	-	Capital expenditure over Total assets	Morningstar
Shareholding Concentration	SHARE_CON	?	Percentage of ordinary shares owned by Top 20 shareholders	SIRCA
Corporate Sustainability Committee	CSR_COM	+	Existence of a board committee devoted to corporate sustainability	Asset4

Appendix C Correlations among continuous variables estimated using Pearson Correlation

Appendix C presents the Pearson correlation coefficients among the key variables.

	CEP	SIZE	LEV	ROA	MTB	NEW	CAP_EXP	CG
CEP	1							
SIZE	0.012	1						
LEV	0.273^{***}	0.203^{***}	1					
ROA	0.007	0.125^{***}	0.003	1				
MTB	-0.172^{***}	0.065^{**}	0.009	0.270^{***}	1			
NEW	0.148^{***}	0.117^{***}	-0.092^{***}	-0.080^{***}	-0.150^{***}	1		
CAP_EXP	-0.129^{***}	-0.035	-0.136^{***}	-0.046^{*}	-0.097^{***}	0.206^{***}	1	
CG	0.230^{***}	0.004	0.092^{***}	0.001	-0.052^{**}	-0.068^{**}	-0.017	1
SHARE_CON	0.102^{***}	-0.070^{***}	-0.075^{***}	-0.010	0.047^{**}	0.026	0.046^{*}	0.004

***, **, * indicate significance at the 0.01, 0.05, 0.1 levels respectively

Appendix D. RMC and RMC human capital using Lewbel method

	(1) DV: CEP *Coeff.* *(t-stat)*	(2) DV: CEP *Coeff.* *(t-stat)*
DEDICATED_RMC	4.308 (1.65)*	-
RMC_HC	-	5.841 (2.66)***
Controls Included	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	1466	788
Under-identification test		
Anderson canon. Corr. LM statistic (P-value)	0.000	0.000
Over-identification test		
Sargan statistic (p-value)	0.226	0.172

***, **, * indicate significance at the 0.01, 0.05, 0.1 levels respectively