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Corporate carbon performance and cost of debt: Evidence from Asia-Pacific countries

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ABSTRACT

This study examines the relationship between corporate carbon performance (CCP) and corporate cost of debt (COD) in Asia-Pacific countries. Using a sample of 3666 firm-year observations from 14 countries over the period 2003–2018, COD is found to be lower when a firm has higher carbon performance (CCP). We also find that CCP produces greater reductions in COD for firms in countries with weak governance quality. Thus, a country-level governance mechanism and debt markets are substitutes in addressing corporate carbon performance (CCP). The main results are robust after controlling for sample selection bias and endogeneity problems using alternative model specifications. The results are also robust after controlling for heterogeneity problems using sub-samples, accounting for the Global Financial Crisis (GFC), using an alternative COD measure, and controlling for potential simultaneous causality and for corporate governance variables.

1. Introduction

Climate change, resulting from greenhouse gas (GHG) emissions, has attracted widespread global attention in the past few decades. Extreme weather events, such as floods and droughts, resulting from climate change are causing adverse impacts on ecological systems, unprecedented damage to people's health and a serious threat to economic activities (Busch & Lewandowski, 2018). As part of worldwide efforts to reduce global warming, in 1992, countries joined an international treaty to form the United Nations Framework Convention on Climate Change (UNFCCC). In 1997, participating countries adopted the Kyoto Protocol to reduce GHG emissions and mitigate climate change and global warming problems. In response to the Kyoto Protocol, legislation has been enacted and policies have been adopted by many countries to not only reduce and monitor the environmental effects of firms' operations, but also to form a target for reduced GHG emissions (Lee, Min, & Yook, 2015).

The complexity of the process of moving to a low carbon economy necessitates collaborative efforts by different market players. With increasing calls for companies to assume their environmental responsibilities, financial markets are becoming more aware of the potential financial implications resulting from carbon-related concerns (Jung, Herbohn, & Clarkson, 2018; Lee & Choi, 2019). This study argues that financial markets can play an essential role in encouraging or penalising companies based on their carbon performance. This study adds to the existing literature by examining whether, and in what ways, corporate carbon performance (CCP) or carbon risk could affect cost of debt (COD) and whether this relationship is different with different country-level governance characteristics.

The relationship between CCP and COD is unclear. To date, no agreed position about this relationship is found in the literature (Trinks, Mulder, & Scholtens, 2020). In line with neoclassical economics (Friedman, 1970), the unnecessary increase in costs from green projects would be viewed as placing the firm at a competitive disadvantage (Aupperle, Carroll, & Hatfield, 1985), with these projects possibly perceived as a costly diversion of the firm's resources. To the extent that carbon-related costs negatively affect Corporate Financial Performance (CFP), thereby increasing the financial distress risk, CCP will increase the cost of debt (Damert, Paul, & Baumgartner, 2017; Wang, Li, & Gao, 2014).

Despite the above view, we argue that CCP is negatively correlated with COD for several reasons. Firstly, firms can rely on corporate environmental performance (CEP), as strategic tools, to create tangible and intangible value and achieve sustainable economic success. According to stakeholder theory (Donaldson & Preston, 1995; Jones, 1995), building a better relationship with key stakeholders will lead a firm to gain a better reputation, and consequently achieve greater economic success; thus, COD will decrease. Secondly, firms with higher carbon risk are

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more vulnerable to potential changes in environmental regulations and obligations, increasing the uncertainty of current and future business conditions and increasing their financial distress risk, resulting in higher interest rates. Finally, lending institutions are more likely to require a higher premium when they finance a carbon-intensive project as compensation for their potential reputational losses. Against the backdrop of these opposing arguments, we empirically examine the CCP–COD relationship.

The study sample consists of 3666 firm-year observations from 14 countries over the period 2003–2018. Our data analysis shows that COD is lower when firms have higher carbon performance (CCP). We also find that a country-level governance mechanism and debt markets are substitutes in addressing carbon performance (CCP). Specifically, CCP produces greater reduction in COD for firms from countries with weak governance quality. Next, we run a battery of robustness checks to reinforce our main finding. In general, we provide evidence that lending institutions are likely to consider CCP in their lending decisions.

The Asia-Pacific countries provide a useful setting in which to examine the research questions for three reasons. Firstly, as many of these countries are among the largest industrial countries in the world, they significantly contribute to global GHG emissions and exacerbate the climate change problem. For example, Fig. 1 shows the percentage of emissions from these countries that were included in the sample of global carbon dioxide (CO_2) emissions over the period 1962–2018. In 2018, these countries emitted approximately 48% of the world's CO_2, while in 1962, they only emitted around 11% of global CO_2, even though their percentage of the world population slightly decreased over the same period (World-Bank, 2019). Secondly, as most of these countries ratified the Kyoto Protocol, many are adopting stringent carbon-related legislation and policies with which firms must comply (Shyu, 2014). This will increase firms' exposure to carbon risks. Finally, to the best of our knowledge, no study has examined the CCP–COD relationship using a comprehensive sample from the Asia-Pacific region.

This study contributes to the literature in several ways. Firstly, this study responds to recent calls for further research on this relationship (Busch & Lewandowski, 2018; Lee et al., 2015; Wang et al., 2014). Secondly, in contrast to previous studies (e.g. Fujii, Iwata, Kaneko, & Managi, 2013; Ganda, 2018), we investigate the CCP–COD relationship using data that cover a relatively longer time span (2003–2018). Given CEP is considered a strategic investment, studying this relationship in the long run will be more meaningful. Thirdly, as this is a contemporary issue, studies that investigate the CCP–COD relationship in a multi-country setting are rare (Caragnano, Mariani, Pizzutilo, & Zito, 2020). To the best of our knowledge, this study is the first in Asia-Pacific region. Finally, the current study shed light on a possible reason for the mixed findings in the CEP and CCP literature. It examines whether the lenders' evaluation of the firm's carbon risk is different with different country-level governance characteristics. This paper not only evaluates the influences of debt market exerting environmental-related pressure on firms, but also depicts how country-level governance moderate or intensify this pressure.

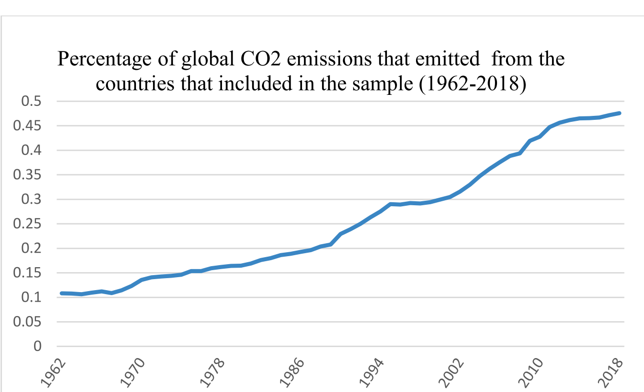

Fig. 1. Percentage of global CO_2 emissions from countries included in the sample (1962–2018).
Source: developed by authors (the researchers) based on data from World Bank databases (World-Bank, 2019).

The remainder of this paper is organised as follows. Section 2 reviews the related literature on corporate environmental and carbon performance and presents the hypotheses development, while Section 3 discusses the research design and data. Section 4 presents our study's findings, with Section 5 drawing conclusions and presenting the implications.

2. Literature review and hypotheses development

2.1. Literature review

For several decades, the impact of CEP on CFP has been a widely discussed issue and a worthwhile topic and subject for theoretical and empirical research. Some studies have examined the association between CEP and CFP (e.g. Iwata & Okada, 2011; Lannelongue, Gonzalez-Benito, & Gonzalez-Benito, 2015; Misani & Pogutz, 2015); firm risk (Cai, Cui, & Jo, 2016; Muhammad, Scrimgeour, Reddy, & Abidin, 2015a); dividend policies (Balachandran & Nguyen, 2018); and the cost of financing (El Ghoul, Guedhami, Kim, & Park, 2018; Fonseka, Rajapakse, & Richardson, 2019; Sharfman & Fernando, 2008). Studies on this topic have yielded mixed results. For instance, some studies found a negative relationship between CEP and CFP (e.g. Hatakeda, Kokubu, Kajiwara, & Nishitani, 2012; Wang et al., 2014), while many others have shown a positive CEP–CFP relationship and that better CEP leads to benefits for both society and firms (e.g. Cai et al., 2016; Chakrabarty & Wang, 2013; El Ghoul et al., 2018).

Cheng, Ioannou, and Serafeim (2014) investigated the relationship of the corporate social responsibility (CSR) index, and its three pillars: environmental, social and corporate governance, with financial constraints. They found that companies with superior CSR performance within the three pillars had lower capital constraints and, therefore, were more able to access finance. In a similar study, Sharfman and Fernando (2008) found a negative relationship between environmental risk management and both weighted average cost of capital (WACC) and Cost of Equity (COE), but they unexpectedly found a positive relationship between environmental risk management and cost of debt (COD). In addition, they found that superior environmental risk management was associated with more leverage and more tax advantage from debt financing.

Previously, data on carbon emissions at firm level were limited to United States (US) data, where the Toxics Release Inventory (TRI) program is one of the most available sources of data used for measuring CEP (K.-H. Lee et al., 2015). At the current time, as environmental issues have become a global concern, a new field of study has arisen, known as carbon accounting, with carbon data now available for many companies in countries worldwide. In light of the increased focus on carbon emissions, numerous studies have investigated the CCP–CFP relationship. Fujii et al. (2013) found a statistically significant positive relationship between CEP, including CO_2 emissions, and return on assets (ROA). Balachandran and Nguyen (2018) reported that carbon risk has a negative impact on the stability of earnings, affecting dividend payments. The authors used a difference-in-differences (DiD) model to examine the exogenous effect of adopting the Kyoto Protocol on dividend policy. The results showed that the payout ratio and the propensity of paying dividends decreased among firms classified as high emissions firms after ratification of the Kyoto Protocol. From a sample of US firms, Delmas, Nairn-Birch, and Lim (2015) found that improved CCP caused a decrease in CFP (Return on Assets [ROA]) in the short term. Conversely, they found that it increased long-term financial performance (Tobin's Q), suggesting that investors saw the potential benefits of CEP in the long run.

It is noteworthy that some studies have, in particular, examined the CCP–COD relationship (e.g. Caragnano et al., 2020; Lee & Choi, 2019; Li, Eddie, & Liu, 2014; Maaloul, 2018; Zhou, Zhang, Wen, Zeng, & Chen, 2018). However, the questions of whether and how carbon performance affects firm financial policies have not been satisfactorily answered for some reasons. Firstly, as differences are found between the previous studies (Busch & Lewandowski, 2018), it is important to examine whether the debt markets' assessment of carbon risk differs with differences in governance mechanisms between developed and developing countries. To the best of our knowledge, this study is the first to explore this aspect. Secondly, previous studies have mainly used carbon intensity and industry-adjusted carbon intensity as proxies for corporate carbon performance (CCP). However, in the current research, in addition to these proxies, we apply additional proxies for carbon performance (*CCP3* and *CCP4*). Finally, in addition to the endogeneity problem, we extensively address many empirical challenges that could potentially affect our results, such as sample selection bias and the heterogeneity and simultaneous causality problems.

For instance, using a sample of Canadian firms over the period 2012–2015, Maaloul (2018) found that COD were positively related to total carbon emissions and carbon intensity. Jung et al. (2018) used a sample of 78 Australian firms during the period 2009–2013 and found a positive association between COD and carbon risk. They also found this relationship was negated for firms with high carbon risk awareness. In a similar study, Li et al. (2014) investigated the influence of the Australian carbon emissions reduction plan on the cost of capital. They found a positive relationship between high carbon risk and cost of debt (COD). Zhou et al. (2018) found a significant U-shaped relationship between COD and carbon risk. In a sub-sample of privately-owned firms, they found this relationship was more pronounced when a firm had higher media attention. Otherwise, the U-shaped relationship was flatter, indicating the importance of public opinion and a country-level governance mechanism in the CCP–COD relationship. Finally, very few studies have examined the relationship between a firm's carbon risk and COD in a multi-country context. In one example, Caragnano et al. (2020) found carbon risk to be positively related to COD using a multi-country sample from the region of Europe over the period 2010–2017.

In conclusion, as previously discussed, several studies have examined the influence of CEP and CSR on cost of debt (COD). As carbon performance is an essential component of corporate social and environmental responsibility, the question of which dimensions of environmental responsibility might impact on COD is left open and subject to further investigations (Nguyen & Phan, 2020). Therefore, the current study provides significant international insights about long-term business responses to the effectiveness of corporate environmental actions, in the case of carbon emissions, and the role of country-level governance in this relationship.

2.2. Impact of corporate carbon performance (CCP) on cost of debt (COD)

Given that CCP is an important part of CEP, we begin by reviewing the CEP literature. As discussed in Section 2.1, several scholars have emphasised the importance of environmental responsibility not only for society, but also for firms themselves. For example, previous studies found that better environmental management and performance are associated with higher profitability and better economic performance (Al-Tuwaijri, Christensen, & Hughes, 2004; Chava, 2014; Muhammad, Scrimgeour, Reddy, & Abidin, 2015b; Sharfman & Fernando, 2008); lower idiosyncratic risk (Cai et al., 2016; Goss & Roberts, 2011; Muhammad et al., 2015a); lower cost of equity capital (Gupta, 2018; Kim, An, & Kim, 2015; Ng & Rezaee, 2015); higher payout ratio (Balachandran & Nguyen, 2018); and better access to finance (Cheng et al., 2014; El Ghoul et al., 2018; Muhammad et al., 2015b).

Environmentally friendly projects may be a double-edged sword. They can bring benefits through three main paths: (i) decreasing the direct effect of environmental regulation and environmental protection activities, consequently decreasing the probability of fines or liabilities for environmental violations (Hatakeda et al., 2012); (ii) increasing demand for environmentally friendly products and then increasing sales (Subramaniam, Wahyuni, Cooper, Leung, & Wines, 2015); and (iii) decreasing production costs by enhancing production efficiency through reductions in resources use, improvements in production operation and optimum utilisation of wastes and recycling (Busch & Lewandowski, 2018; Kuo, Kevin Huang, Jim, & Y.-C., 2010). Conversely, these projects may require initial investment costs, such as the installation of energy-efficient plants, which may affect the firm's profitability and cash flow. They may also increase agency costs if these activities are accompanied by information asymmetry between stakeholders and conflicts of interest (Hatakeda et al., 2012). Companies, therefore, may incur additional costs without observing direct profits.

As it is not possible to fully observe the indirect costs and benefits of environmental investment, the relationship between CCP and COD is regarded as unclear *ex ante*. In line with neoclassical economics (Friedman, 1970), the unnecessary increase in costs from green projects places the firm at a competitive disadvantage (Aupperle et al., 1985), with these projects possibly viewed as a costly diversion of the firm's resources. To the extent that CCP negatively affects CFP, thereby increasing the financial distress risk, the firm's ability to pay off debt is jeopardised (Damert et al., 2017; Wang et al., 2014). To bear this risk, lenders may demand more compensation by charging a higher interest rate.

In contrast, other scholars have argued that higher carbon-related risk (lower CCP) leads to higher interest rates for several reasons. Firstly, firms can count on CEP and CCP, as strategic tools, to create tangible and intangible value and achieve sustainable economic success. According to stakeholder theory (Donaldson & Preston, 1995; Jones, 1995), when a firm effectively manages a better relationship with its key stakeholders, thereby building a better reputation, it is more likely to achieve economic success (Brammer & Millington, 2008). Conversely, if they do not respond to mounting environmental pressure from diverse stakeholders, such as the media, public opinion, regulators and environmental activists, they may experience a loss in their reputation, clients may boycott their products and they may face costly environmental fines. Accordingly, their CFP will be negatively affected and, in turn, their COD will increase.

Secondly, firms with lower carbon performance are more vulnerable to carbon risk, making them more vulnerable to potential changes in environmental regulations and obligations. This increases the uncertainty of current and future business conditions and increases firms' financial distress risk, resulting in higher interest rates (Attig, El Ghoul, Guedhami, & Suh, 2013; Chava, 2014; Sharfman & Fernando, 2008). Finally, financing a high carbon intensity project which has a negative impact on the environment may create an agency problem between borrowers and lenders (Jung et al., 2018; Maaloul, 2018). It may cause an unequal pay-off. If the project is economically successful, the borrower would receive most of the benefits/gains, while the lender would not receive any excess as they would have a fixed claim. However, the lender would still face a reputational risk if the borrower was responsible for a negative environmental performance. If a lending project was unsuccessful, the lender might be subject to "the risk-shifting effect", obviously bearing most of the costs, especially if they take over mortgaged assets that have lost their market value for environment-related reasons.

An agency problem, in the case of carbon emissions, may occur when lenders' expectations are not aligned with those of borrowers. As carbon risk may be transferable to creditors, they would expect the adoption of more steps and actions by borrowers to mitigate the carbon-related risk, with this possibly not aligned with management's prospects. The fundamental assumption is that lenders normally demand higher interest rates as compensation for agency costs resulting from the manager's involvement in environmentally irresponsible actions that may benefit shareholders at the expense of lenders (Fonseka et al., 2019; La Rosa, Liberatore, Mazzi, & Terzani, 2018). According to agency theory, information asymmetry (to benefit shareholders at the cost of debtholders) increases agency costs which then increase capital constraints and cost of debt (COD). Even when information asymmetry is at a minimal level, a higher COD is likely to be charged when current and future business conditions are uncertain.

Based on the previous discussion and in line with the theoretical arguments and empirical evidence, the premise in this paper is that CCP, as an essential component of CEP, is negatively associated with cost of debt (COD). Thus, we propose the following hypothesis:

H1. A negative relationship exists between corporate carbon performance (CCP) and cost of debt (COD).

2.3. Role of country-level governance

The prior literature has addressed the effect of country-level governance on firm performance in different contexts. For example, Gupta (2018) found that the negative relationship between better CEP and implied COE is stronger in countries where country-level governance is weak. Qi, Roth, and Wald (2010) found that greater political rights, in general, and better freedom of the press are negatively associated with cost of debt (COD). They also found that this relationship is more pronounced in countries with weaker creditor rights. Ernstberger and Grüning (2013) found that the positive relationship between corporate governance and firm disclosure is more pronounced in weak legal environments. They argued that, for firms to legitimise their activities, they respond to weak country-level governance by improving their level of disclosure. Chen, Chen, and Wei (2009) found that the negative effect of corporate governance on COE is more pronounced in emerging markets where the legal protection of investors is weak. In the current study, we attempt to fill a gap in the literature when we examine the effect of country-level governance on the CCP–COD relationship.

Country-level determinants, such as legal, social and economic factors, are known to influence a firm's actions towards environmental responsibility (Gupta, 2018). The following two arguments lead to different impacts of country-level governance on the CCP–COD relationship. The first argument states that financial institutions penalise firms with high carbon risk and charge a higher interest rate; thus, the CCP–COD relationship is more pronounced in countries with strong governance for the following two main reasons. Firstly, when firms operate in a country with stringent environmental regulations which has greater ability to enforce the law and effective government, they are more susceptible to expensive environmental costs (carbon-related costs), leading to increased sensitivity to future changes in environmental regulations, as well as increased uncertainty of future cash flows. Thus, financial institutions are more likely to overprice environmental risk in these settings. Secondly, stringent environmental regulations are more likely to be accompanied by more attention given to environmental issues in the media, and from public opinion and environmental activists. The failure to respond to local community pressure leads to a steeper reputational loss for firms with high carbon risk, compared to what firms face in countries with weak environmental regulations. Thus, as compensation for potential reputational losses, financial institutions charge a higher interest rate to firms with a high level of carbon risk if they operate in countries with strong governance, compared to firms with a similar high level of carbon risk operating in countries with weak governance.

The second argument states that financial institutions penalise firms with high carbon risk by charging a higher interest rate in countries with weak governance for two main reasons. Firstly, as countries with weak governance quality tend to have poor environmental regulations, a firm in this setting gives less priority and concern to carbon performance. Nevertheless, the globalisation of financial markets increases the awareness of environmental issues in such countries. For example, Cole, Elliott, and Shimamoto (2006) found that growth in international trade and foreign direct investment (FDI) increases firms' focus on corporate environmental performance (CEP). Therefore, the increased interest of global financial institutions on environmental issues and including CEP as a criterion in their financing decisions (Chava, 2014) has stimulated firms in countries with weak environmental regulation to improve their carbon performance (Gupta, 2018). Thus, they can access debt financing at a lower interest rate compared with their competitors. This might widen the gap between low-performing firms and their high-performing peers in weak country-level governance settings, which makes the relationship between CCP and COD more pronounced in this setting.

Secondly, as financial institutions are less confident about firms' abilities to mitigate carbon risks in countries with a weak governance mechanism, firms with lower CCP usually suffer from high interest rates (Schmidt, 2014). Thus, carbon risks could receive greater consideration in countries with a weak governance mechanism. Based on the above discussion, we investigate the following hypotheses:

H2. Ceteris paribus, the effect of corporate carbon performance (CCP) on cost of debt (COD) is stronger in countries with weak country-level governance.

3. Research design and data

3.1. Sample construction and data

The initial sample comprises all publicly listed firms in 14 countries in the Asia-Pacific region. We extracted data from the different database sources as described in Appendix A. The final sample consists of 3666 firm-year observations over the 2003–2018 period. Table 1, Panel A provides details of the sample selection process. We exclude financial firms from the sample as they are subject to industry-specific regulations, which make their capital structure decisions and debt financing substantially different in comparison with non-financial firms (La Rosa

Table 1
Sample selection and distribution.

Panel A – Sample selection	
Details	Obs.
Firm-year observations in Thomson-Reuters databases for carbon data	6535
Less: Firm-year observations with insufficient financial data	(1954)
Less: Financial firms	(915)
Firm-year observations in final sample	**3666**

Panel B – Sample breakdown by industry and year					
ICB industry classification	Obs.	% of sample	Year	Obs.	% of sample
Oil and Gas	103	2.81	2003	11	0.30
Basic Materials	598	16.31	2004	15	0.41
Industrials	911	24.85	2005	55	1.50
Consumer Goods	711	19.39	2006	94	2.56
Health Care	241	6.57	2007	112	3.06
Consumer Services	307	8.37	2008	152	4.15
Telecommunications	147	4.01	2009	184	5.02
Utilities	244	6.66	2010	213	5.81
Technology	404	11.02	2011	283	7.72
Total	3666	100%	2012	294	8.02
			2013	317	0.30
			2014	351	0.41
			2015	381	1.50
			2016	407	2.56
			2017	419	3.06
			2018	378	4.15
			Total	3666	100

Notes: This table presents the sample selection process (Panel A), and the sample distribution by industry based on the Industrial Classification Benchmark (ICB) and by year (Panel B).

et al., 2018; Nguyen & Phan, 2020). Table 1, Panel B shows the sample distribution by industry and year. The continuous variables were winsorised at the 5th and 95th percentiles to reduce the potential misleading caused by outliers.

3.2. Empirical model

To test our first hypothesis (H1), we used the following regression model:

$$COD_{it} = \alpha + \beta_1 CCP_{it} + \sum_{j=2}^{n} \beta_j CONTROL_{jit} + \text{year and industry FE} + \varepsilon_{it} \quad (1)$$

where *i* denotes firms; *t* denotes time; *COD* is the cost of debt; *CCP* is corporate carbon performance, calculated based on four proxies (*CCP1–CCP4*); and $CONTROL_{jit}$ is the control variable *j* of firm *i* at year *t*. Based on Hypothesis 1 (H1), we expect $\beta_1$in Eq. (1) to be negative. The firm-level and country-level variables are discussed in Section 3.3.

To test Hypothesis 2, we estimate the following regression model, where GI denotes country-level governance indicators. Based on H2, we expect $\beta_3$in Eq. (2) to be positive:

$$COD_{it} = \alpha + \beta_1 CCP_{it} + \beta_2\, GI_{it} + \beta_3\, GI_{it}{*}CCP_{it} + \sum_{j=4}^{n} \beta_j CONTROL_{jit} + \text{year and industry FE} + \varepsilon_{it} \quad (2)$$

3.3. Definition of variables

3.3.1. Corporate carbon performance (CCP)

In the literature, carbon risk or carbon performance is measured by the absolute or relative value of carbon emissions. The absolute measure is the amount of emitted GHG in tonnes of CO_2 and CO_2-equivalent per year which indicates the firm's individual contribution to climate change. The relative measure (or emissions intensity) links the absolute measure to sales, revenue or any other business metric. In the current study, we use the relative measure of carbon emissions. This helps us to control for any sudden events that may change total emissions, such as mergers and acquisitions (M&As) or any changes in the overall economy (Busch & Lewandowski, 2018). In addition, given the variation between firms in economic output, size and industry, the relative measure makes an applicable comparison between firms.

Four proxies for CCP are used in this study: *CCP1, CCP2, CCP3* and *CCP4*. *CCP1* is carbon emissions intensity, measured by the ratio of total carbon emissions (Scopes 1 and 2)[1] to total sales multiplied by −1. Following Luo and Tang (2014) and Jung et al. (2018), *CCP2* refers to carbon emissions intensity minus the country–industry mean, as per the following formula:

$$CCP2_i = CCP1_i - \frac{1}{n}\sum_{k=0}^{Nk} CCP1_i,$$

where *Nk* is the number of firms *i* in sector *k* and *CCP3* is an index used to measure the firm's performance in mitigating its carbon risk. The index is calculated as follows: 3 points are awarded if the firm's *CCP1* value is higher than the previous year ($CCP1_{it} > CCP1_{i(t-1)}$); 2 points are awarded if the firm's *CCP1* value is higher than the country–sector median; 1 point is awarded if the firm has an environment management team; 1 point is added if the firm has a policy to improve its energy efficiency; 1 point is added if the firm sets targets or objectives to be achieved on emissions reduction; 1 point is added if the firm is aware that climate change could represent commercial risks and/or opportunities; 1 point is added if the firm makes use of renewable energy; 1 point is added if the firm reports on initiatives to reduce, reuse, recycle, substitute or phase out sulphur oxides (SO_x) or nitrogen oxides (NO_x) emissions; and 1 point is added if the firm reports on its environmentally friendly or green sites or offices. *CCP4* is the equally weighted score of *CCP3*. Higher values of *CCP1*, *CCP2*, *CCP3* and *CCP4* mean that the firm has better carbon performance (CCP).

3.3.2. Cost of debt (COD)

We use the weighted average cost of debt calculated by the Bloomberg Professional database as the measure of cost of debt (COD). According to Bloomberg (2013), this is calculated as follows:

$$COD = \left(\frac{SD{*}CS}{TD} + \frac{LD{*}CL}{TD}\right) AF\ (1 - TR)$$

where *SD* is short-term debt; *TD* is total debt; *CS* is the pre-tax cost of short-term debt; *AF* is the debt adjustment factor[2]; *LD* is long-term debt; *CL* is the pre-tax cost of long-term debt; and *TR* is the effective tax rate.

Use of the Bloomberg database enables us to utilise the benefit of having COD calculated by a data specialist company. The Bloomberg Professional database has been adopted in the literature as a credible source of data (e.g. Desender, LópezPuertas-Lamy, Pattitoni, & Petracci, 2020; Huang & Shang, 2019; Maaloul, 2018; Sharfman & Fernando, 2008). It is also widely used by firm stakeholders and market participants and has gained high credibility among its users internationally.

3.3.3. Country-level governance variables

We use three indicators for governance mechanisms from World Bank databases (World-Bank, 2019), government effectiveness (GE), regulatory quality (RQ) and rule of law (RL). All variables are defined in Appendix A.

3.3.4. Control variables

The actual interest rate may not be significantly associated with CCP activities in the presence of other important factors, such as any potential business or financial risk/opportunity, which are most likely to dominate lending decisions. To be able to test whether CCP, as distinct from other factors, is associated with COD, we control for the major factors identified as determinants of COD in the literature in our multivariate regression models. Following previous studies (Al-Tuwaijri et al., 2004; Attig et al., 2013; La Rosa et al., 2018), we add the following control variables: *LOG_SIZE*, the natural logarithm of total assets recorded in billions of US dollars; *LOG_COV*, the natural logarithm of the coverage ratio; *ROA*, return on assets; *LEVERAGE*, the ratio of total liabilities to total assets; *CAPINT*, the capital intensity ratio; *BETA*, the systematic risk beta; *LIQUIDITY*, the current ratio which is equal to current assets divided by current liabilities; *GROWTH*, the sales growth rate; *LOSS*, a dummy variable equal to 1 if the firm reports losses in the last two years, and 0 otherwise; and *MARGIN*, the operating income divided by net sales. Finally, we include a set of country-level variables to control for potential cross-country differences: *LOG_GDPC* is the natural logarithm of gross domestic product (GDP) per capita in US dollars to control for differences in economic development between countries (El Ghoul et al., 2018; Luo & Tang, 2016), while

[1] The Greenhouse Gas Protocol is one of the carbon accounting tools that is widely applied internationally. This protocol defines three scopes of carbon emissions according to their sources. Scope 1 refers to direct emissions of GHGs caused by the company, such as fuel combustion or emissions from operational processes owned or controlled by the company. Scope 2 refers to emissions caused by purchasing electricity. Scope 3 refers to emissions from sources not owned or controlled by the company (see Busch & Lewandowski, 2018).

[2] According to Bloomberg (2013),[t]he debt adjustment factor represents the average yield above government bonds for a given rating class. The lower the rating, the higher the adjustment factor. The debt adjustment factor (AF) is only used when a company does not have a fair market curve (FMC). When a company does not have a credit rating, an assumed rate of 1.38 (the equivalent rate of a BBB+ Standard and Poor's long term currency issuer rating) is used. (p. 18).

COMMONLAW is an indicator variable equal to 1 if the company is based in a common-law country, and 0 otherwise (Djankov, La Porta, Lopez-de-Silanes, & Shleifer, 2008; Gallego-Álvarez, Segura, & Martinez-Ferrero, 2015). As documented by La Porta, Lopez-de-Silanes, and Shleifer (2008), the legal origin of countries is highly correlated with economic outcomes such as financial development, unemployment, investment and international trade. Following Krishnamurti, Shams, and Velayutham (2018) and Espenlaub, Goyal, and Mohamed (2020), we use the revised Anti-Director Rights Index (*ADR*) from Djankov et al. (2008) to control for country-level governance, with a higher value for *ADR* indicating a higher level of shareholder protection. The variable *LOG_MCAP* is the natural logarithm of country-level stock market capitalisation. We use this variable to control for country-level stock market development. All variables are defined in more detail in Appendix A.

4. Results and discussion

4.1. Descriptive statistics and univariate analysis

Table 2 presents the descriptive statistics for the independent variables and dependent variables employed in this study, as well as univariate analysis. Table 2, Panel A shows the variables' means, standard deviations, minimums, 25th percentiles, medians, 75th percentiles and maximum values for the full sample, comprising 3666 firm-year observations from 2003 to 2018. For *COD*, the mean and median values are 1.128% and 0.678%, respectively, ranging from a minimum of −0.053% to a maximum of 7.83%. The reason for the negative *COD* value is that Bloomberg uses the 10-year government bond rate in *COD* calculations which was negative in Japan in some years (specifically in 2016 and 2019) as the central bank of Japan introduced negative interest rates. As presented in Table 3, the *COD* for Japanese firms was, on average, 0.399% which is relatively lower than that of other countries. In general, *COD* figures in Japan in the current study are relatively similar to the values reported in related studies (e.g. Shuto & Kitagawa, 2011; Suto & Takehara, 2017). The mean value of the first measure of corporate carbon performance (*CCP1*) is −0.42, which means that firms in the sample emit, on average, 0.42 t of GHG emissions (Scopes 1 and 2) per US$1000 of sales.[3]

To provide initial evidence on the CCP–COD relationship, as shown in Table 2, Panel B, we compare the mean and median values of the firm-level variables for sub-samples divided into firms with low carbon performance and firms with high carbon performance. The sub-samples are separated based on the industry–country mean value of carbon intensity (*CCP1*), where low and high carbon performance firms are those below and above the mean value of *CCP1*, respectively. The last two columns present the results of the Mann–Whitney test and *t*-test to examine differences in mean and median values. We find that the mean value of *COD* for firms with low carbon performance is 1.434%, while it is 0.993% for those with high carbon performance. The difference is statistically significant at the 1% level. The results also show statistically significant mean differences between high and low *CCP* for most variables, except for *BETA*, *LIQUIDITY* and *MARGIN*. Firms with low carbon performance (higher emissions intensity), on average, have higher cost of debt, lower size, lower coverage ratio, lower return on assets, higher leverage, higher capital intensity, lower sales growth and are more likely to report losses. When we examine the median differences between the two sub-samples, we find similar results.

Table 3 reports the sample distribution by country, as well as the mean values of the key variables by country. Most of the sample's observations (more than 61%) are from Japan. The reason is that Japan is one of the countries that responded early to the Kyoto Protocol. In addition to the voluntary disclosure of carbon emissions, the mandatory GHG accounting and reporting system obligates Japanese firms that exceed a specific level of emissions to report these amounts annually to the government. Therefore, Japan's carbon-related data are more available than data from other countries in our sample. In contrast, Chinese firms are underrepresented in the sample at only 0.35% of the entire sample, as these only number of observations were reported by DataStream Database.[4] This disparity may raise the problem of sample selection bias in our study. To deal with this concern, we use Heckman's (1979) two-stage model analysis[5] and the propensity score matching (PSM) model as robustness tests.

Table 4 reports Pearson's correlation coefficients between the regression variables. The table shows the absence of high correlation coefficients between the firm-level control variables, this suggests that multicollinearity between the explanatory variables is unlikely to drive our multivariate regression results. For more investigation of this potential problem, we use variance inflation factor (VIF) values when we estimate the regression models and find that all VIF values are below 6 (un-tabulated); if the value is more than 10, this would indicate the presence of a multicollinearity problem (Rashid, 2013).

4.2. Multivariate regression analysis

In this section, we empirically examine the effect of CCP on COD in a multivariate setting after controlling for the factors most likely to influence cost of debt (COD). We regress COD on CCP and a set of control variables. All models include year and industry dummies and a list of country-level control variables to control for unobserved variations or macroeconomic factors that could drive CCP and/or COD across country, industry or over years.

Table 5 reports the results for ordinary least squares (OLS) regressions for the full sample of 3666 firm-years from 14 countries. The results show that *COD* is negatively associated with *CCP1* (−0.240), *CCP2* (−0.238), *CCP3* (−0.022) and *CCP4* (−0.024), with statistical significance at 5% (10%) level for *CCP1*, *CCP2* and *CCP3* (*CCP4*).[6] This result implies that the higher the level of CCP, the lower the company's cost of debt (COD). The estimated coefficients for the CCP indices suggest that an increase of one standard deviation in *CCP1, CCP2, CCP3* and *CCP4* leads to a decrease in *COD* by 22, 15, 6 and 5 basis points, respectively. These estimates are also economically significant, as they equal approximately 17%, 11%, 5% and 4% of one standard deviation of the COD index, respectively.

As shown in Table 6, we examine whether the CCP–COD relationship is different with different country-level governance settings. We employ three country-level governance characteristics, as developed by World Bank databases, namely, government effectiveness (GE), regulatory quality (RQ) and rule of law (RL), which is reported in Panel A, Panel B and Panel C, respectively. We find that most of the coefficients of the interaction term between country-level governance indicators and each of *CCP1, CCP2, CCP3* and *CCP4* are positive and statistically significant at the 10% level or better. The results suggest that CCP have, ceteris paribus, a great impact on COD in countries with weak governance quality than in countries with strong government effectiveness (and having a smaller impact on COD in firms from countries with a strong governance mechanism). This suggests a substitution effect between a country-level governance mechanism and debt markets in addressing

[3] *CCP1* is carbon emissions intensity, with this value multiplied by −1 so higher values represent better carbon performance.

[4] The initial sample contains 148 firm-year observations from China where carbon data are available. Next, we excluded observations that do not have COD variables. Thus, only 58 firm-year observations from China remained. Then, we ruled out observations with missing control variables and those from financial sectors, leaving 13 firm-year observations.

[5] See Appendix B.

[6] We also run a simple OLS regression excluding year and industry dummies and country-level control variables. We find that the coefficients on CCP1, CCP2, CCP3 and CCP4 are qualitatively similar (See Table B7 in Appendix B).

Table 2
Descriptive statistics for full sample and mean and median differences tests between two sub-samples.

Panel A – Descriptive statistics

	Mean	Std. Dev.	Min	P25	Median	P75	Max
COD	1.128	1.362	−0.053	0.201	0.678	1.520	7.830
CCP1	−0.420	0.910	−5.856	−0.319	−0.070	−0.027	−0.002
CCP2	0.026	0.610	−3.431	−0.019	0.035	0.129	2.251
CCP3	6.623	2.439	1.000	5.000	7.000	8.000	12.000
CCP4	5.063	1.777	1.000	4.000	5.000	6.000	9.000
LOG_SIZE	9.660	10.563	0.934	2.570	5.471	11.866	40.266
LOG_COV	4.010	0.550	3.477	3.660	3.786	4.126	5.585
ROA	0.045	0.038	−0.022	0.020	0.039	0.066	0.128
LEVERAGE	0.248	0.156	0.007	0.126	0.238	0.358	0.557
CAPINT	0.371	0.194	0.100	0.217	0.337	0.484	0.800
BETA	1.002	0.423	0.250	0.673	1.000	1.300	1.790
LIQUIDITY	1.616	0.787	0.580	1.080	1.430	1.950	3.650
MARGIN	0.088	0.073	−0.002	0.036	0.067	0.118	0.277
GROWTH	0.044	0.103	−0.149	−0.017	0.039	0.100	0.268
LOSS	0.044	0.205	0.000	0.000	0.000	0.000	1.000
LOG_GDPC	10.431	0.557	7.022	10.417	10.582	10.698	11.134
COMMNLAW	0.183	0.387	0.000	0.000	0.000	0.000	1.000
ADR	4.301	0.478	3.000	4.500	4.500	4.500	5.000
LOG_MCAP	7.77	0.921	2.746	7.118	8.154	8.428	9.072

Panel B – Sub-samples separated based on the industry–country median of carbon intensity (*CCP1*)

	Low *CCP1*		High *CCP2*		Mean test (*p*-value)	MW test (*p*-value)
	Mean	Median	Mean	Median		
COD	1.434	0.861	0.993	0.628	0.000	0.000
LOG_SIZE	10.260	6.167	8.298	4.331	0.000	0.000
LOG_COV	3.943	3.732	4.039	3.820	0.000	0.000
ROA	0.043	0.039	0.046	0.040	0.020	0.028
LEVERAGE	0.278	0.273	0.234	0.225	0.000	0.000
CAPINT	0.454	0.435	0.334	0.298	0.000	0.000
BETA	1.018	1.010	0.995	1.000	0.143	0.212
LIQUIDITY	1.602	1.410	1.622	1.430	0.495	0.123
MARGIN	0.091	0.072	0.087	0.065	0.130	0.050
GROWTH	0.039	0.035	0.047	0.041	0.033	0.029
LOSS	0.062	0.000	0.036	0.000	0.002	0.001

Notes: In this table, Panel A presents descriptive statistics for the variables in the full sample. In this table, Panel B presents the univariate analysis results. The Mann–Whitney (MW) test and *t*-test have been used to examine the median and mean differences, respectively, between high and low carbon performance based on the industry–country median of *CCP1* (*p*-values are two-tailed). *LOG_SIZE* is reported in billions of US dollars. All variables are defined in Appendix A.

Table 3
Descriptive statistics of key variables across countries.

Country	N	% of sample	*CCP1*	*CCP2*	*CCP3*	*CCP4*	*COD*
Australia	360	9.82	−0.629	0.323	5.672	4.069	3.438
China	13	0.35	−0.434	0.232	4.769	3.538	2.239
India	29	0.79	−3.681	−1.397	5.207	4.586	7.305
Indonesia	8	0.22	−0.893	−0.442	6.375	4.250	7.128
Japan	2237	61.02	−0.323	0.013	6.733	5.164	0.399
Malaysia	34	0.93	−1.937	−0.681	6.000	4.765	3.280
New Zealand	58	1.58	−0.420	−0.044	5.672	4.034	3.212
Philippines	35	0.95	−0.458	0.099	5.943	4.457	2.093
Singapore	12	0.33	−0.090	0.301	7.417	5.417	2.118
South Korea	358	9.77	−0.240	−0.008	7.313	5.721	1.445
Sri Lanka	5	0.14	−1.151	−0.175	7.200	5.600	2.179
Taiwan	344	9.38	−0.377	−0.010	6.709	5.250	1.014
Thailand	84	2.29	−0.841	−0.100	7.369	5.821	2.660
Hong Kong	89	2.43	−0.825	0.291	5.640	3.865	2.374
Total sample	3666	100.00	−0.420	0.026	6.623	5.063	1.128

Notes: This table presents the number of observations, percentage of the full sample and the mean value of the key variables by country. Cost of debt (*COD*) is reported by percentage. All variables are defined in Appendix A.

carbon performance.

To visualise the results and better interpretation for the results, we developed Fig. 2. The graph shows predictive margins for the interaction terms in Panel A, Table 6. Fig. 2a and b show that the slope of the relationship between CCP and COD is more dramatic when the country-level governance is low. Although there is a cross-over interaction in Fig. 2b, the large overlap in confidence intervals suggests that the slope of CCP2 is not different between countries with high and low governance quality. Fig. 2c and d show that the slope of the relationship between CCP and COD is negative (positive) when the country-level governance is low (high). As the interaction coefficients (un-tabulated) for countries with high governance are statistically insignificant, again

Table 4
Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
(1) *COD*	1.00																				
(2) *CCP1*	−0.30	1.00																			
(3) *CCP2*	−0.08	0.64	1.00																		
(4) *CCP3*	−0.12	0.12	0.12	1.00																	
(5) *CCP4*	−0.15	0.06	0.02	0.90	1.00																
(6) *LOG_SIZE*	−0.01	0.04	0.00	0.26	0.31	1.00															
(7) *LOG_COV*	−0.25	0.20	0.06	0.05	0.02	0.21	1.00														
(8) *ROA*	0.18	0.10	0.09	0.06	−0.02	0.32	0.52	1.00													
(9) *LEVERAGE*	0.16	−0.36	−0.17	−0.02	0.02	−0.08	−0.63	−0.31	1.00												
(10) *CAPINT*	0.31	−0.45	−0.09	−0.15	−0.12	−0.04	−0.30	−0.08	0.47	1.00											
(11) *BETA*	0.00	0.04	−0.01	0.00	0.02	−0.23	−0.22	−0.22	0.04	−0.07	1.00										
(12) *LIQUIDITY*	−0.15	0.18	0.09	−0.06	−0.07	−0.02	0.51	0.22	−0.57	−0.35	−0.02	1.00									
(13) *MARGIN*	0.26	−0.05	0.08	−0.02	−0.07	0.30	0.35	0.67	−0.13	0.18	−0.25	0.25	1.00								
(14) *GROWTH*	0.11	−0.00	0.04	0.13	0.00	0.12	0.12	0.36	−0.02	−0.01	−0.04	−0.03	0.25	1.00							
(15) *LOSS*	0.08	−0.07	−0.02	−0.04	−0.03	−0.13	−0.19	−0.32	0.14	0.11	0.13	−0.08	−0.21	−0.07	1.00						
(16) *LOG_GDPC*	−0.34	−0.23	−0.20	0.02	−0.02	−0.04	0.04	−0.18	−0.09	−0.05	0.02	0.08	−0.13	−0.09	0.02	1.00					
(17) *COMMNLAW*	0.76	−0.23	0.06	−0.14	−0.19	−0.07	−0.18	0.21	0.09	0.26	−0.02	−0.06	0.12	0.12	0.02	−0.09	1.00				
(18) *ADR*	−0.15	−0.03	−0.05	0.02	0.02	0.19	0.04	−0.09	0.03	−0.07	−0.03	0.04	0.02	0.02	−0.03	0.23	−0.06	1.00			
(19) *LOG_MCAP*	−0.59	0.11	0.02	0.02	0.03	0.15	0.20	−0.20	−0.10	−0.21	−0.01	0.13	−0.07	−0.07	−0.02	0.49	−0.50	0.53	1.00		
(20) GE	−0.37	0.16	0.13	−0.06	−0.09	−0.05	0.13	−0.12	−0.11	−0.07	−0.00	0.11	−0.08	−0.04	−0.00	0.39	−0.08	0.24	0.53	1.00	
(21) RQ	−0.20	0.14	0.16	−0.07	−0.11	−0.07	0.07	−0.10	−0.10	0.00	0.00	0.08	−0.03	−0.03	0.02	0.30	0.08	0.18	0.41	0.93	1.00
(22) RL	0.01	0.10	0.20	−0.08	−0.15	−0.13	0.01	0.01	−0.06	0.07	0.00	0.04	0.10	0.00	0.03	−0.11	0.34	−0.04	0.10	0.77	0.86

Notes: This table presents Pearson's correlation between the variables. All variables are defined in Appendix A. Correlation coefficients reported in bold font are significant at the 1% level.

Table 5
Ordinary least squares (OLS) regression results of CCP–COD association.

Panel A – OLS regression models				
	DV=*COD*	DV=*COD*	DV=*COD*	DV=*COD*
CCP1	−0.240**			
	(−2.42)			
CCP2		−0.238**		
		(−2.39)		
CCP3			−0.022**	
			(−2.45)	
CCP4				−0.024*
				(−1.84)
LOG_SIZE	0.070***	0.077***	0.092***	0.094***
	(2.69)	(2.94)	(3.14)	(3.06)
LOG_COV	−0.240***	−0.231***	−0.189***	−0.189***
	(−3.85)	(−3.66)	(−3.10)	(−3.11)
ROA	3.899***	3.744***	3.549***	3.523***
	(3.42)	(3.36)	(3.23)	(3.21)
LEVERAGE	−0.102	−0.088	0.138	0.147
	(−0.44)	(−0.38)	(0.63)	(0.66)
CAPINT	0.439**	0.534***	0.569***	0.593***
	(2.39)	(2.87)	(3.04)	(3.15)
BETA	0.073	0.067	0.086	0.087
	(1.25)	(1.15)	(1.41)	(1.41)
LIQUIDITY	0.000	0.004	0.002	0.004
	(0.00)	(0.12)	(0.06)	(0.10)
MARGIN	−0.869	−0.924	−1.167*	−1.177*
	(−1.32)	(−1.45)	(−1.89)	(−1.89)
GROWTH	0.332**	0.358**	0.394**	0.329**
	(2.08)	(2.22)	(2.37)	(2.03)
LOSS	0.403***	0.401***	0.380***	0.379***
	(3.82)	(3.85)	(3.57)	(3.56)
LOG_GDPC	−0.549***	−0.568***	−0.604***	−0.606***
	(−3.98)	(−4.05)	(−4.00)	(−4.02)
COMMNLAW	2.083***	2.207***	2.158***	2.155***
	(15.52)	(14.08)	(13.85)	(13.72)
ADR	0.027	−0.009	0.026	0.028
	(0.29)	(−0.10)	(0.28)	(0.30)
LOG_MCAP	−1.024***	−0.907***	−1.010***	−1.010***
	(−4.97)	(−4.43)	(−4.74)	(−4.73)
Intercept	12.634***	12.200***	12.845***	12.815***
	(8.30)	(7.65)	(8.35)	(8.23)
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.716	0.712	0.703	0.702
Observations	3666	3666	3666	3666

Notes: This table presents the OLS regression results of the CCP–COD association. All regressions are estimated with clustered robust standard errors by firm and include year and industry fixed-effects, with *t*-statistics reported in parentheses. Superscript *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively. DV = dependent variable. All variables are defined in Appendix A.

we can say that the CCP-COD relationship is more pronounced in countries with low governance quality. In the next section, we document results of the robustness tests that we use to verify the study's main results for the negative relationship between CCP and cost of debt (COD) (Table 5).

4.3. Robustness tests and additional analyses

This section investigates whether the results are robust after controlling for the sample selection bias problem, endogeneity concerns, the heterogeneity problem, sensitivity to alternative estimation for COD, potential simultaneous causality between COD and CCP, and the influence of the GFC years. In general, these investigations support our main finding regarding the negative association between CCP and cost of debt (COD).

4.3.1. Sample selection bias

One of the issues in our study is sample selection bias which occurs when the outcome of interest is only observed for a sample that is non-randomly selected. In our context, firms that chose to disclose their

Table 6
Role of country-level governance indicators in CCP–COD association.

	DV=*COD*	DV=*COD*	DV=*COD*	DV=*COD*
Panel A – Government effectiveness (*GE*)				
*GE*CCP1*	0.250*** (2.76)			
*GE*CCP2*		0.367*** (2.69)		
*GE*CCP3*			0.121*** (2.90)	
*GE*CCP4*				0.168** (2.47)
CCP1	−0.456*** (−3.07)			
CCP2		−0.688*** (−3.12)		
CCP3			−0.195*** (−2.99)	−0.148*** (−3.10)
CCP4				−0.274** (−2.54)
GE	−0.573*** (−2.90)	−0.787*** (−4.21)	−1.691*** (−4.23)	−1.768*** (−3.82)
Intercept	7.144*** (4.81)	6.438*** (4.14)	7.614*** (4.66)	7.727*** (4.40)
Country-level control variables	Yes	Yes	Yes	Yes
Firm-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.754	0.753	0.745	0.745
Observations	3666	3666	3666	3666
Panel B – Regulatory quality (*RQ*)				
*RQ*CCP1*	**0.215*** **(1.95)**			
*RQ*CCP2*		**0.253** **(1.47)**		
*RQ*CCP3*			**0.105***** **(2.80)**	
*RQ*CCP4*				**0.162***** **(2.72)**
CCP1	−0.397** (−2.40)			
CCP2		−0.509* (−1.92)		
CCP3			−0.157*** (−2.94)	
CCP4				−0.241*** (−2.80)
RQ	−0.325* (−1.88)	−0.526*** (−3.14)	−1.268*** (−3.51)	−1.400*** (−3.46)
Intercept	8.430*** (5.35)	7.741*** (4.65)	8.883*** (5.23)	9.187*** (5.13)
Country-level control variables	Yes	Yes	Yes	Yes
Firm-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.740	0.736	0.731	0.732
Observations	3666	3666	3666	3666
Panel C – Rule of law (*RL*)				
*RL*CCP1*	**0.220***** **(2.66)**			
*RL*CCP2*		**0.250*** **(1.88)**		
*RL*CCP3*			**0.108***** **(2.96)**	
*RL*CCP4*				**0.166***** **(3.00)**
CCP1	−0.392*** (−3.00)			
CCP2		−0.486** (−2.34)		

Table 6 (*continued*)

	DV=*COD*	DV=*COD*	DV=*COD*	DV=*COD*
Panel A – Government effectiveness (*GE*)				
CCP3			−0.148*** (−3.10)	
CCP4				−0.228*** (−3.07)
RL	−0.334* (−1.79)	−0.567*** (−3.11)	−1.341*** (−3.67)	−1.471*** (−3.75)
Intercept	10.149*** (7.21)	9.769*** (6.77)	10.865*** (7.48)	11.048*** (7.25)
Country-level control variables	Yes	Yes	Yes	Yes
Firm-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.744	0.739	0.734	0.734
Observations	3666	3666	3666	3666

Notes: This table presents the results of the country-level governance role in the CCP–COD association. We include the interaction terms between government effectiveness (*GE*), regulatory quality (*RQ*) and rule of law (*RL*) and the four proxies for CCP in the baseline model, with the results reported in Panels A, B and C, respectively. The *t*-statistics are reported in parentheses. Superscript *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively. DV = dependent variable. All variables are defined in Appendix A.

carbon emissions may have unobserved common characteristics that influence our findings; thus, the sample may not then correctly represent the population. To deal with this concern, we follow Krishnamurti et al. (2018) and Goss and Roberts (2011) and employ Heckman's (1979) two-stage model (reported in Table 7). In the first stage (Column 1), we use the probit regression model as a selection equation where the dependent variable (*DISC*) is a dummy variable equal to 1 if carbon data are available, and 0 otherwise. Next, we calculate the inverse Mills ratio (IMR) from the selection equation and include it as an additional control variable in the second stage. To conduct this test, we add 3475 firm-year observations to our sample for firms that have all other variables but did not disclose their carbon data. The observation must have all other variables to enter this test, with the final sample in the first stage having 7141 firm-year observations.

The results show significant positive coefficients of *IMR*, thus indicating the presence of upward-sample selection bias in our baseline model (Table 5). However, selection bias-corrected estimates, in Table 7, Columns 2–5, suggest that our baseline results are slightly upward-biased and that sample selection bias is a minor concern. Therefore, our main finding remains robust after controlling for potential sample selection bias, with the CCP variables having a statistically significant negative relationship with cost of debt (COD).

4.3.2. Robustness across sub-samples

In Table 8, we estimate the baseline regression model for a set of sub-samples separated by country to control for heterogeneity problems and to check the robustness of our results across countries. Firstly, we separately run the baseline regression model for the top four countries (with the highest number of observations) and report the results in the first four panels. In Panel A, we use a sub-sample from Japan. The results suggest that *CCP1* and *CCP2* indices are negatively associated with *COD*. However, the coefficients of *CCP3* and *CCP4* are statistically insignificant. Similarly, the results of a sub-sample from Australia suggest that our main results for *CCP1* and *CCP2* are robust and remain the same. However, the coefficients of *CCP3* and *CCP4* are statistically insignificant. In Panel C, we report the results for a sub-sample from Taiwan. The coefficient is negative and statistically significant at the 5% level for *CCP1*, while it is statistically insignificant for *CCP2*. More interestingly, the coefficients for *CCP3* and *CCP4* are positive and statistically significant, which indicates that the results in this sub-sample and for these

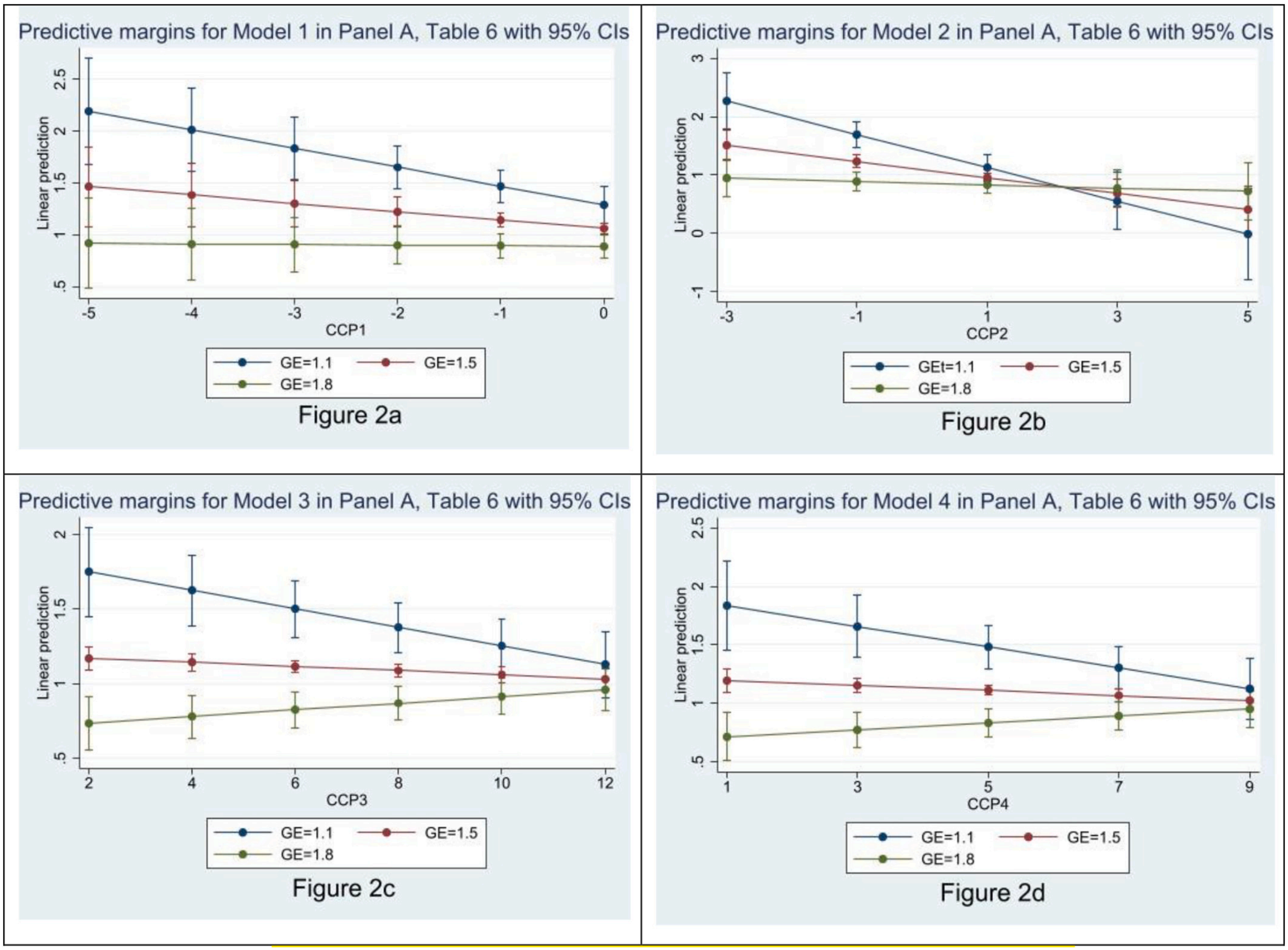

Fig. 2. Predictive margins for the interaction terms in Panel A, Table 6.
Source: developed by authors (the researchers) based on the results of Panel A, Table 6.

proxies are in the opposite direction to our main finding. The reason is probably that Taiwan is one of the countries that has not ratified the United Nations Framework Convention on Climate Change (UNFCCC) or the Kyoto Protocol (Shyu, 2014), suggesting that firms' exposure to carbon risk in Taiwan is relatively minimal. Next, we run the regression for a sub-sample from South Korea, with the results reported in Panel D. The coefficients are negative for *CCP2, CCP3* and *CCP4*, which are statistically significant. However, the coefficient of *CCP1* is statistically insignificant.

Secondly, as most observations (more than 61%) are from Japan, we re-run the regression after excluding Japanese firms. The results are reported in Panel E, with the coefficients remaining negative and statistically significant. Next, in Panel F, we exclude the top three countries (those with the highest number of observations) from our sample and estimate the baseline model. The coefficients are negative and statistically significant. Finally, we exclude the bottom five countries, those with the lowest number of observations, namely, Indonesia, Sri Lanka, Singapore, China and India. The results in Panel G indicate that our main results are robust to using another sub-sample.

4.3.3. Alternative measure of cost of debt (COD)

In this test, we re-run the baseline regression model using credit rating (CR) as an alternative measurement for cost of debt (COD). We regress *CR* on *CCP* and a set of control variables and employ robust standard errors clustered by firm and include year and industry fixed-effects. Table 9 reports the results of OLS regressions for a sample of 870 firm-years from 12 countries where the *CR* variable is available. The results show that the coefficients of *CCP* indices are positive and statistically significant. This result implies that the higher the level of CCP, the higher the company's credit rating (CR). Thus, our main results continue to hold and are robust when we use an alternative measure for cost of debt (COD). The estimated coefficients for CCP indices suggest that an increase of one standard deviation in *CCP1, CCP2, CCP3* and *CCP4* leads to an increase in *CR* by 0.38, 0.35, 0.29 and 0.39 units (*CR* measurement units), respectively. These estimates are also economically significant, as they are equal to approximately 15%, 14%, 12% and 16% of one standard deviation of the CR index, respectively.

4.3.4. Additional analyses

In this subsection, we report on the additional analyses used to support our main finding. Slack resource theory suggests that an increase in access to a debt at a lower cost may also increase CCP and that the exact direction of the relationship is uncertain. To alleviate potential simultaneous causality between COD and CCP, we follow previous studies (Busch & Hoffmann, 2011; Lewandowski, 2017; Trumpp & Guenther, 2017) and lag the independent variables one and two years behind cost of debt (COD). This also helps to control for any delay in carbon performance disclosure and the fact that CEP can achieve financial benefits in the long run. The results[7] reinforce our main results

[7] See Table B5 in Appendix B.

Table 7
Heckman's (1979) two-stage model analysis.

	First stage	Second stage			
	DV=*DISC*	DV=*COD*	DV=*COD*	DV=*COD*	DV=*COD*
CCP1		−0.134**			
		(−2.21)			
CCP2			−0.150**		
			(−2.44)		
CCP3				−0.012**	
				(−2.32)	
CCP4					−0.018**
					(−2.47)
LOG_SIZE	0.596***	0.172***	0.168***	0.177***	0.182***
	[13.37]	(2.88)	(2.85)	(5.04)	(5.19)
LOG_COV	−0.193***	−0.278***	−0.275***	−0.250***	−0.250***
	[−2.59]	(−4.41)	(−4.35)	(−6.59)	(−6.60)
ROA	−1.195**	2.713**	2.646**	2.461***	2.423***
	[−2.03]	(2.49)	(2.43)	(3.51)	(3.46)
LEVERAGE	−0.867***	−0.441*	−0.442*	−0.321**	−0.314**
	[−2.60]	(−1.91)	(−1.96)	(−2.58)	(−2.53)
CAPINT	0.571**	0.801***	0.840***	0.878***	0.886***
	[2.07]	(4.28)	(4.42)	(7.82)	(8.02)
BETA	0.071	0.082	0.077	0.088**	0.090**
	[0.90]	(1.45)	(1.36)	(2.46)	(2.50)
LIQUIDITY	−0.066	−0.013	−0.011	−0.012	−0.012
	[−1.35]	(−0.41)	(−0.34)	(−0.57)	(−0.55)
MARGIN	−0.913	−1.155*	−1.139*	−1.287***	−1.297***
	[−1.44]	(−1.76)	(−1.75)	(−3.32)	(−3.35)
GROWTH	−1.585***	−0.108	−0.073	−0.069	−0.106
	[−9.59]	(−0.44)	(−0.30)	(−0.40)	(−0.62)
LOSS	0.037	0.392***	0.393***	0.380***	0.379***
	[0.27]	(3.76)	(3.81)	(4.87)	(4.84)
LOG_GDPC	0.518***	−0.420**	−0.446***	−0.480***	−0.482***
	[6.45]	(−2.55)	(−2.70)	(−5.80)	(−5.84)
COMMNLAW	−0.598***	2.207***	2.303***	2.283***	2.279***
	[−4.53]	(13.22)	(13.32)	(26.63)	(26.49)
ADR	0.232***	−0.003	−0.036	−0.017	−0.017
	[3.31]	(−0.04)	(−0.47)	(−0.41)	(−0.41)
LOG_MCAP	−0.281**	−0.415**	−0.354**	−0.366***	−0.369***
	[−2.10]	(−2.41)	(−2.01)	(−4.12)	(−4.14)
IMR		0.541*	0.513*	0.521*	0.523*
		(1.88)	(1.81)	(1.81)	(1.82)
Intercept	−1.317	10.118***	9.817***	10.163***	10.184***
	[−0.91]	(6.02)	(5.76)	(10.03)	(9.96)
Year fixed-effects	Yes	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes	Yes
Adjusted/ Pseudo R^2 R^2	0.443	0.746	0.746	0.743	0.743
Observations	7141	3666	3666	3666	3666

Notes: This table presents the results from Heckman's (1979) two-stage model. The first stage is the probit regression model with a dependent variable that equals 1 if the firm discloses its carbon data (*DISC*), and 0 otherwise. The second stage is the baseline regression model which includes the inverse Mills ratio (*IMR*) to control for selection bias. All regressions are estimated with clustered robust standard errors by firm and include year and industry fixed-effects, with *t*-statistics (z-statistics) reported in parentheses (brackets). Superscript *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively. DV = dependent variable. All variables are defined in Appendix A.

as we find that the lagged value of the four proxies for CCP at both *t-1* and *t-2* are negatively and significantly associated with COD, suggesting that endogeneity stemming from simultaneous causality is not influencing our main finding.

During the GFC, firms experienced instability in their profitability and were required to cope with financial distress, higher interest rates and credit constraints (La Rosa et al., 2018). Therefore, it may have been necessary to reduce their investment in environmental protection activities to reduce costs and increase financial performance. Consequently, the relationship between CCP and COD may be unstable during the GFC years (2007–2008). To address this concern, we re-estimate the baseline regression model after excluding the GFC years. The results reinforce our main finding.[8]

5. Discussion and conclusion

In this study, we empirically examine the debt markets' response to corporate carbon performance (CCP). Specifically, we examine the influence of CCP on COD for a comprehensive sample of 3666 firm-year observations from 14 countries in the Asia-Pacific region over the 2003–2018 period. We find that COD is lower when a firm has higher carbon performance (CCP) (H1). We also find that CCP produces greater reductions in COD for firms from countries with countries with weak governance quality (H2). Thus, a country-level governance mechanism and debt markets are substitutes in addressing corporate carbon performance (CCP).

Firstly, we conduct a univariate analysis and then multivariate analysis using OLS regression models, while controlling for a set of firm-level and country-level variables. Secondly, to address potential sample

[8] See Table B6 in Appendix B.

Table 8
Ordinary least squares (OLS) regression results for sub-samples.

	DV=*COD*	DV=*COD*	DV=*COD*	DV=*COD*
Panel A – Japan				
CCP1	−0.012* (−1.90)			
CCP2		−0.015** (−2.15)		
CCP3			0.003 (1.38)	
CCP4				0.003 (1.12)
Firm-level control variables	Yes	Yes	Yes	Yes
Country-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted *R*-squared	0.759	0.749	0.758	0.758
Observations	2237	2237	2237	2237
Panel B – Australia				
CCP1	−0.125** (2.20)			
CCP2		−0.350*** (4.95)		
CCP3			−0.025 (−1.17)	
CCP4				0.007 (0.23)
Firm-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Adjusted *R*-squared	0.626	0.590	0.586	0.585
Observations	360	360	360	360
Panel C – Taiwan				
CCP1	−0.062** (−2.53)			
CCP2		0.037 (1.34)		
CCP3			0.015** (2.02)	
CCP4				0.023** (2.52)
Firm-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Adjusted *R*-squared	0.519	0.514	0.519	0.521
Observations	344	344	344	344
Panel D – South Korea				
CCP1	−0.114 (1.17)			
CCP2		−0.270** (2.21)		
CCP3			−0.043*** (−2.70)	
CCP4				−0.062*** (−2.85)
Firm-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Adjusted *R*-squared	0.343	0.350	0.356	0.356
Observations	358	358	358	358
Panel E – Excluding Japan				
CCP1	−0.485*** (3.94)			
CCP2		−0.419*** (2.78)		
CCP3			−0.102*** (−4.67)	
CCP4				−0.140*** (−4.29)
Firm-level control variables	Yes	Yes	Yes	Yes
Country-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted *R*-squared	0.424	0.383	0.368	0.368
Observations	1429	1429	1429	1429
Panel F – Excluding top three countries				
CCP1	−0.387*** (3.51)			
CCP2		−0.384*** (2.67)		
CCP3			−0.077*** (−2.87)	
CCP4				−0.098** (−2.25)
Firm-level control variables	Yes	Yes	Yes	Yes
Country-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted *R*-squared	0.500	0.474	0.455	0.454
Observations	725	725	725	725
Panel G – Excluding bottom five countries				
CCP1	−0.122*** (−4.56)			
CCP2		−0.085*** (−3.96)		
CCP3			−0.022** (−2.21)	
CCP4				−0.041*** (−2.68)
Firm-level control variables	Yes	Yes	Yes	Yes
Country-level control variables	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted *R*-squared	0.588	0.584	0.585	0.587
Observations	3599	3599	3599	3599

Notes: This table presents the baseline regression results for the sub-samples. Panels A, B, C, D, E, F and G present the results for Japan; Australia; Taiwan; South Korea; all countries without Japan; all countries without the top three countries; and all countries without the bottom five countries, respectively, with *t*-statistics reported in parentheses. Superscript *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively. DV = dependent variable. All variables are defined in Appendix A.

selection bias, heterogeneity and endogeneity problems, we use several alternative model specifications: Heckman's (1979) two-stage approach, PSM analysis,[9] and firm fixed-effects and country fixed-effects models[5]. We find our main results are robust to these concerns and continue to hold (especially for *CCP1* and *CCP2*). The results are also robust after accounting for the GFC years, using credit rating (CR) as an alternative measure of COD, using sub-samples, controlling for simultaneous causality and controlling for corporate governance variables[5].

This study provides significant insights and has several implications for firms' financial management, policy makers, creditors and investors. It adds to research streams in the finance and management literature and complements related research by specifying CCP as a channel through which CEP affects firms' financing costs and corporate financial performance (CFP). In particular, firms can reduce their COD and thereby improve firm value by improving their carbon performance (CCP). In the

[9] See Appendix B.

Table 9
Ordinary least squares (OLS) regression results for association between CCP and credit rating (CR).

	DV=*CR*	DV=*CR*	DV=*CR*	DV=*CR*
CCP1	0.420*			
	(1.88)			
CCP2		0.565**		
		(2.41)		
CCP3			0.118**	
			(2.14)	
CCP4				0.220**
				(2.47)
LOG_SIZE	0.967***	0.960***	0.908***	0.820***
	(4.17)	(4.32)	(3.96)	(3.61)
LOG_COV	0.933**	0.980**	0.870**	0.858**
	(2.09)	(2.20)	(2.04)	(2.05)
ROA	−12.038**	−12.273**	−11.373**	−10.702**
	(−2.16)	(−2.28)	(−2.19)	(−2.13)
LEVERAGE	−1.999	−1.999	−2.157	−2.066
	(−1.28)	(−1.28)	(−1.39)	(−1.34)
CAPINT	0.293	0.157	0.256	0.205
	(0.22)	(0.12)	(0.19)	(0.15)
BETA	−1.137***	−1.112***	−1.218***	−1.217***
	(−2.67)	(−2.65)	(−2.83)	(−2.78)
LIQUIDITY	0.797***	0.771***	0.755***	0.720***
	(2.98)	(2.98)	(2.87)	(2.78)
MARGIN	0.962	1.162	0.850	1.221
	(0.29)	(0.37)	(0.26)	(0.37)
GROWTH	−1.130	−1.230	−1.374	−1.050
	(−1.24)	(−1.37)	(−1.43)	(−1.14)
LOSS	−0.317	−0.283	−0.189	−0.175
	(−0.63)	(−0.57)	(−0.37)	(−0.34)
LOG_GDPC	1.734**	1.803**	1.752*	1.757*
	(2.08)	(2.30)	(1.92)	(1.93)
COMMNLAW	0.376	0.123	0.300	0.358
	(0.57)	(0.19)	(0.41)	(0.49)
ADR	−0.173	−0.022	−0.212	−0.151
	(−0.28)	(−0.04)	(−0.32)	(−0.23)
LOG_MCAP	−0.072	−0.446	−0.321	−0.303
	(−0.08)	(−0.55)	(−0.35)	(−0.34)
Intercept	−6.129	−3.155	−3.420	−3.841
	(−0.90)	(−0.47)	(−0.49)	(−0.56)
Year fixed-effects	Yes	Yes	Yes	Yes
Industry fixed-effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.502	0.512	0.493	0.499
Observations	870	870	870	870

Notes: This table presents the OLS regression results of the CCP–CR association. All regressions are estimated with clustered robust standard errors by firm and include year and industry fixed-effects, with t-statistics reported in parentheses. Superscript *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively. DV = dependent variable. All variables are defined in Appendix A.

current study, we provide evidence that lending institutions are likely to consider CCP in their lending decisions.

Our study provides additional insights for environmental policy makers. It assists them to handle carbon issues and mitigate this concern at the country level. Policy makers should consider firms' activities in mitigating the climate change problem and provide a cooperative relationship with their industry. In fact, firms' mitigation activities require sufficient funds to obtain new environmentally friendly technology and to increase their capabilities to mitigate climate change-related problems. Thus, more fiscal stimulus should probably be provided for environmentally responsible companies and direct lobbying should be directed at those which have assumed a lower level of environmental responsibility (green finance). In addition, policy makers need to be aware of the benefits of developing CCP information sources and of the importance of making carbon-related disclosures available to market participants. Indeed, the availability of such information will increase the market's efficiency. Here, the market mechanism could play an important role in addressing this concern (especially in countries with a weak governance mechanism), rather than being directly solved by government interventions. The government could then act as a guarantor and undertake complementary roles by enacting the required regulations and laws. As our results are based on a multi-country sample and tested across 14 countries, our results can be used as a reference for Asia-Pacific countries and other developing countries.

Our findings have two theoretical implications that explain the determinants of cost of debt (COD). Firstly, a win-win situation can be grounded in stakeholder theory. Supporters of stakeholder theory argue that when a firm effectively manages its relationships with key stakeholders, it will most likely achieve economic success and thus reduce cost of debt (COD). Conversely, if firms do not respond to mounting environmental pressure from diverse stakeholders, such as the media, the general public, regulators and environmental activists, they may experience a loss of their reputation; creditors may consider this an indicator of the presence of potential business risk; clients may boycott their products or services; or costly environmental fines may be charged; and, thus, their financial performance will be affected. Secondly, our results support the basic arguments of agency theory. Divergences in carbon-related policies and objectives between lenders and borrowers may lead to agency problems. As discussed earlier, management involvement in environmentally irresponsible actions may benefit shareholders at the expense of lenders and, thus, lenders are likely to demand higher interest rates.

This study has a few limitations. Firstly, as our data are limited to firms within the Asia-Pacific region, our results could not be generalised to other regions. Although we provide cross-country evidence of the CCP–COD relationship, we could not apply our findings to firms of other countries. Therefore, it would be fruitful for future research to be conducted in a different context. Secondly, in contrast with *CCP1* and *CCP2*, the adopted carbon performance measurements of *CCP3* and *CCP4* did not pass some of our robustness tests. Augmenting the coverage and the quality of carbon data would, in fact, contribute to the improvement of environmental management practices and environmental performance measurement. Thus, improvement in CCP measurements warrants further significant work. Finally, the availability of carbon data is lower in less-developed or developing countries, whereas our sample concentrates on countries like Japan and Australia. However, we provide evidence of a negative relationship between CCP and COD across almost all countries. Future increases in awareness in developing countries about the climate change problem will increase the availability of carbon data. It would be worthwhile for future research to conduct studies with a larger sample.

CRediT authorship contribution statement

Eltayyeb Al-Fakir Al Rabab'a: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing – original draft. **Afzalur Rashid:** Supervision, Writing – review & editing. **Syed Shams:** Visualization, Data curation, Methodology, Supervision.

Data availability

Data will be made available on request.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.irfa.2023.102641.

Appendix A. Descriptions and sources of variables

Variable	Description	Source/Variable code
Firm-level variables		
COD	The cost of debt is calculated as follows: COD = [[(SD/TD)*(CS *AF)] + [(LD/TD)*(CL*AF)]]*[1-TR], where SD is short-term debt; TD is total debt; CS is pre-tax cost of short-term debt; AF is the debt adjustment factor; LD is long-term debt; CL is pre-tax cost of long-term debt; and TR is effective tax rate.	Bloomberg/WACC_COST_DEBT
CR	The company's credit rating as provided by Fitch (AAA (24 points); AA+ (23 points); AA (22 points); AA- (21 points); A+ (20 points); A (19 points); A- (18 points); BBB+ (17 points); BBB (16 points); BBB- (15 points); BB+ (14 points); BB (13 points); BB- (12 points); B+ (11 points); B (10 points); B- (9 points); CCC+ (8 points); CCC (7 points); CCC- (6 points); CC+ (5 points); CC (4 points); CC- (3 points); C (2 points); D (1 point); DD (1 point); and DDD (1 point).	Thomson-Reuters/ECSLO05V
CCP1	Total carbon emissions in tonnes divided by sales volume in US dollars multiplied by −1.	Researchers' calculation based on data from Thomson-Reuters/ENERO03S
CCP2	*CCP1* minus country–sector mean.	As above
CCP3	A score calculated as follows: 3 points are added if CCP1 is higher than the previous year; 2 points are added if CCP1 is higher than the country–sector median; 1 point is awarded if the firm has an environment management team; 1 point is added if the firm has a policy to improve its energy efficiency; 1 point is added if the firm sets targets or objectives to be achieved on emissions reduction; 1 point is added if the firm is aware that climate change can represent commercial risks and/or opportunities; 1 point is added if the firm make use of renewable energy; 1 point is added if the firm reports on initiatives to reduce, reuse, recycle, substitute or phase out SOx (sulphur oxides) or NOx (nitrogen oxides) emissions; and 1 point is added if the firm reports on its environmentally friendly or green sites or offices.	Researchers' calculation based on data from Thomson-Reuters/ENERO03S, ENRRDP004, ENRRDP0122, ENERDP0161, ENERDP089, ENRRDP046, ENERDP033 and ENRRDP052
CCP4	Equally weighted score of *CCP3*.	As above
LOG_SIZE	Natural logarithm of total assets recorded in billions of US dollars.	Researchers' calculation based on data from Thomson-Reuters/WC08001
LOG_COV	Natural logarithm of the coverage ratio. Coverage ratio = (income before extraordinary items + interest expenses)/interest expenses.	Researchers' calculation based on data from Thomson-Reuters/WC01551
ROA	Return on assets, calculated as the ratio of net income to total assets.	Thomson-Reuters/WC08326
LEVERAGE	Total debt/total assets.	Thomson-Reuters/WC08236
CAPINT	Capital intensity, measured as the ratio of net property, plant and equipment (PPE) to total assets.	Researchers' calculation based on data from Thomson-Reuters/WC02501 and WC02999
BETA	Systematic risk beta based on monthly returns, which shows the relationship between stock volatility and market volatility.	Thomson-Reuters/897E
LIQUIDITY	Current assets/current liabilities.	Thomson-Reuters/WC08106
MARGIN	Ratio of operating income divided by net sales.	Thomson-Reuters/WC08316
GROWTH	((Net sales at year *t*/net sales at year (*t-1*)) - 1)*100.	Thomson-Reuters/WC08631
LOSS	Equal to 1 if net income is negative at year *t* and *t-1*, and 0 otherwise.	Researchers' calculation based on data from Thomson-Reuters/WC01751
BSIZE	Total number of board members at the end of the fiscal year.	Thomson-Reuters/CGBSDP060
BINDP	Percentage of independent directors to total number of directors.	Thomson-Reuters/CGBSO07S
DUALITY	Equal to 1 if the company's CEO is also chairman of the board, and 0 otherwise.	Thomson-Reuters/CGBSDP061
DISC	Equal to 1 if carbon data are available, and 0 otherwise	Researchers' calculation
IMR	The inverse Mills ratio, calculated from the first stage of Heckman's (1979) two-stage model.	Researchers' calculation
High_CCP1	Equal to 1 if *CCP1* is higher than the industry–year median, and 0 otherwise.	Researchers' calculation
High_CCP2	Equal to 1 if *CCP2* is higher than the industry–year median, and 0 otherwise.	Researchers' calculation
High_CCP3	Equal to 1 if *CCP3* is higher than the industry–year median, and 0 otherwise.	Researchers' calculation
High_CCP4	Equal to 1 if *CCP4* is higher than the industry–year median, and 0 otherwise.	Researchers' calculation
Country-level variables		
GE	According to (World-Bank, 2019), "government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies"	World Bank
RQ	According to (World-Bank, 2019), "regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development"	World Bank
RL	According to (World-Bank, 2019), the "rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society and, in particular, the quality of contract enforcement, property rights, the police and the courts, as well as the likelihood of crime and violence"	World Bank
LOG_GDPC	Natural logarithm of gross domestic product (GDP) per capita in US dollars (annually based).	International Monetary Fund (IMF), World Economic Outlook Database
COMMNLAW	Equal to 1 if the company is based in a common-law country, and 0 otherwise.	La Porta et al. (2008)
ADR	The revised Anti-Director Rights Index (annually based).	Djankov et al. (2008)
LOG_MCAP	Natural logarithm of stock market capitalisation of the listed domestic companies in billions of US dollars (annually based).	World Bank. For Taiwan, data are available on the Taiwan Stock Exchange (TWSE) website.

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