

# **The impact of a firm's carbon risk profile on the cost of debt capital: Evidence from Australian firms**

**Juhyun Jung**

UQ Business School, The University of Queensland

**Kathleen Herbohn\***

UQ Business School, The University of Queensland

[k.herbohn@business.edu.au](mailto:k.herbohn@business.edu.au)

**Peter Clarkson**

UQ Business School, The University of Queensland *and*  
Beedie School of Business, Simon Fraser University

[p.clarkson@business.edu.au](mailto:p.clarkson@business.edu.au)

*First Version:* 15 September 2014

**Keywords:**

**JEL classification:**

---

\* Corresponding author. This study is based on Juhyun Jung's 'Graduate Diploma in Research Methods' thesis completed within the UQ Business School at The University of Queensland.

# **The impact of a firm's carbon risk profile on the cost of debt capital: Evidence from Australian firms**

## **Abstract:**

In this study, we investigate the association between a firm's exposure to carbon-related risk and its cost of debt. Specifically, we predict and test the following two propositions: (1) firms with higher carbon-related risk exposure face a higher cost of debt and (2) firms can mitigate this 'carbon risk' penalty to their cost of debt by providing evidence regarding its awareness of the carbon-related risks that it faces.

We conduct our investigation using a sample of 255 firm-year observations for 78 Australian companies from eight different industries over the period 2009-2013. We measure carbon-related risk exposure as the firm's recent (historical) carbon emissions and carbon risk awareness based on the firm's willingness to respond to the CDP survey questionnaire. Our results provide uniform support for both of our predictions. We consistently document a positive and significant association between the cost of debt and our carbon risk measure for firms that fail to respond to the CDP survey. Further, this association is economically meaningful, with a one standard deviation increase in the carbon risk measure mapping into a 73 basis point increase in the cost of debt for these firms. Equally, we find that this penalty is effectively negated for firms that respond to the CDP survey.

Taken together, we interpret these results as indicative that lenders not only consider a firm's recent (historical) carbon emissions but additionally, forward-looking indicators when assessing its carbon-related risk exposure and its mapping into the cost of debt.

## **1. Introduction**

In this study, we investigate the association between a firm's exposure to carbon-related risk and its cost of debt. Specifically, we seek to address the following two questions: (1) do firms with higher carbon-related risk exposure face a higher cost of debt? and (2) can a firm mitigate this 'carbon risk' penalty to its cost of debt by providing evidence regarding its awareness of the carbon-related risks that it faces? To conduct our study, we focus on the Australian setting and use a sample of Australian firms.

In recent years, public concern over climate change has grown considerably, driven in a large part by the occurrence of unusual and destructive weather patterns and increasing concentrations of greenhouse gases (Thompson, 1998). Climate change has the potential to cause not only disturbances of complex ecological systems but also unprecedented damages to economies and health of human populations (Labatt and White, 2007). It has already manifested in a range of ways and has caused serious economic losses throughout the world. For example, Hurricane Katrina hit the U.S. in 2005 causing an estimated insured loss of \$45 billion, greater than the combined insured losses of the four hurricanes that occurred in the south-eastern U.S. in 2004 (Labatt and White, 2007); severe flooding affected Europe in 2002 with an estimated \$16 billion of direct losses (Labatt and White, 2007). Moreover, the report by Stern (2007) estimated that a failure to act on climate change could cost the world economy between five and 20 percent of global gross domestic product (GDP) each year, but that this cost could be limited to around 1% of global GDP by acting promptly to avoid the worst impacts of climate change.

Concerns about climate change have prompted the governments of many countries to implement regulations and policies aimed at reducing and controlling industrial carbon emissions. In Australia, the National Greenhouse and Energy Reporting (NGER) system has been operational since 2008. Under the NGER scheme, firms which meet specific carbon emission thresholds are required to report their greenhouse gas emissions, energy production and consumption. In addition, in July 2012, the Carbon Pricing Mechanism (CPM) was implemented as a carbon emissions

reduction scheme which requires liable entities to pay a price for carbon emissions. However, with the recent proposal of the new Australian Government to dismantle the CPM (Natoli and Sack, 2014; Subramaniam *et al.*, 2013), the abolishment of the CPM remains uncertain at the time of writing. Nonetheless, it serves to illustrate that any form of carbon-related legislation is possible in the future.

Within the business context, carbon risk has become one of the dominant themes. There is an emerging consensus amongst academics and professionals that firms, in particular those in carbon-intensive industries, are significantly exposed to carbon risk (e.g. UNEP FI, 2006; Labatt and White, 2007; Hoffmann and Busch, 2008; Subramaniam *et al.*, 2013). In the past, a firm could mitigate the impact of carbon risk on its financial performance by externalising the cost of carbon emissions. However, with an increasing emergence of carbon-related regulations and policies around the world, firms are more likely internalising the cost of carbon emissions (Clarkson *et al.*, 2014). As such, firms likely incur additional costs, such as compliance costs with carbon-related regulations and costs related to the development of low carbon technologies, which can adversely affect their earnings and profitability. Further, with the realisation that climate change is related in part to corporations' unsustainable consumption of natural resources and the attendant pollution problems, there has been heightened public pressure for firms to place an emphasis on environmentally sustainable and responsible development (Thompson, 1998; Chen and Gao, 2012; Subramaniam *et al.*, 2013). If a firm is perceived as environmentally irresponsible, its brand image is likely to be damaged, potentially affecting its future operation and competitive position in the market (Labatt and White, 2007). Therefore, the financial consequences of problems arising from carbon risk exposure may increase the uncertainty surrounding firms' future activities and hence adversely affect corporate viability.

This increased public pressure and stricter regulations have led carbon risk to become an important component of a firm's overall risk profile. As such, it has come to influence the attitudes and practices of participants in the capital market, both shareholders and creditors, with a resultant

incorporation of carbon-related considerations into their decision-making process. It is well documented in prior literature that lending institutions are increasingly incorporating carbon and environmental risk into their lending decisions (e.g. Thompson, 1998; Coulson and Monks, 1999; Thompson and Cowton, 2004; Cogan *et al.*, 2008; Weber, 2012). However, empirical studies on the relation between a firm's carbon or environmental risk and its cost of debt are limited and provide mixed results (Sharfman and Fernando, 2008; Goss and Roberts, 2011; Schneider, 2011; Chen and Gao, 2012).

We conduct our investigation into the relation between carbon-related risk exposure and cost of debt using a sample of 255 firm-year observations for 78 Australian companies from eight different industries over the period 2009-2013. We measure carbon-related risk exposure as the firm's recent (historical) carbon emissions and carbon risk awareness based on the firm's willingness to respond to the CDP survey questionnaire. Our results provide uniform support for both of our predictions. We consistently document a positive and significant association between the cost of debt and our carbon risk measure for firms that fail to demonstrate an awareness of their carbon risk exposure as evidenced through their failure to respond to the CDP survey. Further, this association is economically meaningful, with a one standard deviation increase in the carbon risk measure mapping into a 73 basis point increase in the cost of debt for these firms. Equally, we find that this penalty is effectively negated for firms that respond to the CDP survey. In this sense, our results are consistent with the proposition advanced by Clarkson *et al.* (2013) that actions such as responding to the CDP survey can convey incremental information about the firm's carbon risk profile going forward beyond a simple knowledge of its historical carbon emissions level. Finally, we confirm these results and conclusions by separately examining subsamples of firms drawn from high emitting industries versus low emitting industries, again finding as expected, the results to be the most meaningful for the high emitting industries. We also find results and conclusions to be robust to the choice of scalar, the breadth of the carbon risk measure, and the timing of the carbon emissions and CDP data availability.

We argue that the study contributes to the extant literature in several ways. First, the growing importance of carbon risk within a business context makes a strong case for research into whether a firm's carbon risk is priced by the capital market, notably cost of debt. This study contributes by focusing narrowly on carbon risk. In contrast, prior studies focus primarily on corporate social responsibility and environmental performance (e.g. Sharfman and Fernando, 2008; Goss and Roberts, 2011; Schneider, 2011). Furthermore, the findings from prior literature on the relation between environmental risk and the cost of debt capital provide mixed results. For example, Sharfman and Fernando (2008) document that improved environmental risk management is associated with a higher cost of debt while Schneider (2011) provides evidence of a negative relation between environmental performance and bond yields.

Second, this study contributes to the debt literature by examining the link between a firm's carbon risk and its cost of debt. In recent years, academic and industry researchers have increasingly investigated the impact of carbon emissions on firms with a focus on firm value or financial performance (e.g. Deutsche Bank, 2009; Chapple *et al.*, 2013; Wang *et al.*, 2013; Clarkson *et al.*, 2014). Despite the importance of debt financing as a source of capital, there is a paucity of research on the relation between a firm's carbon risk and its cost of debt. Here, one recent study by Chen and Gao (2012) examines the relation between a firm's climate risk and its cost of capital (both equity and debt), but only for a sample of U.S. firms in a single industry (the electric utility industry). Here, we consider a sample of Australian firms from eight different industries, which for example allows for a comparison of the impact of carbon risk on the cost of debt between high and low carbon-intensive industries.

Third, the level of a firm's exposure to carbon risk likely differs depending on a firm's commitment to address the issues arising from carbon risk. UNEP FI (2006) documents that the preventative actions that firms have taken prior to the implementation of carbon-related policies will influence a firm's competitive position. Subramaniam *et al.* (2013) also argue that firms that are aware of carbon risks are more likely to integrate these risks into formal risk management

systems and able to address these risks before they become bigger problems. Furthermore, Cogan *et al.* (2008) argue that lenders consider not only the costs of carbon emissions but also whether firms develop carbon emissions reduction strategies in their lending decisions. To the extent that increased carbon risk awareness leads firms to implement more proactive carbon risk management strategies, one could argue that lenders are likely to have a favourable perception for firms with higher carbon risk awareness.

Finally, carbon risk is likely to arise from a legal environment that has effective carbon emissions monitoring and enforcements, whereby the stringency and intensity of regulatory systems influence investors' assessment of carbon risks (Clarkson *et al.*, 2014). By conducting the study within the Australian context, we examine the impact of carbon risk on the cost of debt in a setting where the reporting of carbon emissions is mandatory and the CPM is currently operational, and therefore where carbon risk is likely priced in the capital market (Chapple *et al.*, 2013). In contrast, most prior studies have examined the impact of carbon and environmental risk on the cost of debt in the context of the U.S. where a national mandatory carbon emissions trading scheme is not operational (e.g. Sharfman and Fernando, 2008; Schneider, 2011; Chen and Cao, 2012). Furthermore, Australia is considered as a more environmentally sensitive location due to potentially stronger regulations and societal pressure for firms to incorporate carbon and environmental issues into their business strategies (Sharfman and Fernando, 2008). Hence, the results from this study provide important insights into the relation between a firm's carbon risk and its cost of debt within the context of a potentially environmentally sensitive capital market.

The remainder of this paper is organised as follows. Section 2 provides a brief overview of the carbon-related legislation and regulation in Australia. The relevant literature on carbon and environmental risks in a lending context is reviewed in Chapter 3, culminating in the development of our two hypotheses. Section 4 then describes our econometric model and Section 5 describes the data. The results are presented in Section 6 and Section 7 concludes.

## **2. Legislative and Regulatory Background**

In this section, we present a brief overview of the regulatory developments with Australia as they relate to carbon emissions. One clear ‘take-away’ from this very cursory discussion is the growing importance of carbon emissions and associated risks for Australian entities. It also serves to highlight the significant uncertainty related to the future regulation in Australia, thereby further increasing risks associated with carbon emissions. In this sense, it illustrates the significance of carbon risks to both borrowers and lenders from a regulatory perspective.

### ***2.1 The international development of carbon emissions reduction schemes***

In recent years, there has been growing concern about climate change and the rising levels of greenhouse gas (GHG) concentrations. This growing concern has prompted international organisations and the governments of many countries to implement carbon reduction policies and actions. A variety of GHG emissions reduction schemes have been adopted, including cap and trade systems and adaptation rebates that either introduce a price for carbon or provide low carbon technologies and practices (Subramaniam *et al.*, 2012).

At the international level, the Kyoto Protocol was adopted by the member countries under the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 and came into force in 2005 (UNEP FI, 2006). It is an internationally binding agreement whereby participating countries pledge to reduce GHG emissions to meet national reduction targets (UNEP FI, 2006; Talberg and Swoboda, 2013). At the regional and national levels, legislated GHG emissions trading schemes are operational in several countries such as European countries under the European Union, New Zealand, Australia, and Kazakhstan (Talberg and Swoboda, 2013). The European Union Emissions Trading System (EU ETS) represents the longest standing cap-and-trade scheme. It was launched in 2005 to reduce GHG emissions and currently covers approximately 12,000 heavy energy-using installations in power generation and manufacturing industry, accounting for over 40 percent of all EU emissions (Talberg and Swoboda, 2013). In addition, some regional schemes exist

in the U.S., Canada, and Japan (Talberg and Swoboda, 2013). For example, the Regional Greenhouse Gas Initiative (RGGI), the first mandatory cap-and-trade program in the U.S., was launched in 2009 by nine states to reduce carbon emissions from the power sector (Talberg and Swoboda, 2013).

## **2.2 The Carbon Pricing Mechanism (CPM) in Australia**

The decision to introduce a carbon pricing mechanism (CPM) in Australia was made after years of debate and discussion on the best ways to reduce Australia's GHG emissions (Subramaniam *et al.*, 2013). In 2007, the Australian government signed the Kyoto Protocol which aims to reduce the collective GHG emissions of developed countries by at least five percent below 1999 levels during 2008 to 2012. In 2008, the Garnaut Climate Change Review, commissioned by the Australian government to conduct an independent study of the impacts of climate change on the Australian economy, released its final report. One of the recommendations of the report was the introduction of an emissions trading system (Subramaniam *et al.*, 2013). Following this, the Australian government proposed an emissions trading system called the Carbon Pollution Reduction Scheme (CPRS) in late 2008 but the scheme was rejected by the Senate in 2009. In 2011, the Australian Labour government announced its 'Securing a Clean Energy Future' plan and subsequently the Clean Energy Legislative Package was introduced, a feature of which was the CPM.

The recent change in the Australian government from a Labour to a Liberal Coalition party following the federal election in late 2013 brought a dramatic turnaround in the carbon-related policy and legislation in Australia (Subramaniam *et al.*, 2013). The recently elected Government has introduced a package of bills to repeal the Clean Energy Legislative Package from 1 July 2014 and has also proposed its Direct Action Plan to meet its target of reducing emissions by 5 percent below 2000 levels by 2020 through the Emissions Reduction Fund (ERF) scheme (Natoli and Sack, 2014; Subramaniam *et al.*, 2013). The new Government's attempt to repeal the carbon tax failed as the repeal bill was rejected by the Senate in late 2013. At the time of writing, following the first

attempt to abolish the carbon tax, the repeal bill was passed in the House of Representatives again but not in the Senate as of yet, and the abolishment of the carbon tax in Australia remains uncertain.

### ***2.3 The National Greenhouse and Energy Reporting (NGER) scheme in Australia***

In Australia, the National Greenhouse and Energy Reporting Act 2007 (NGER Act) provides the legislative framework for the NGER scheme.<sup>1</sup> This scheme is a single national framework for reporting and disseminating company information about GHG emissions, energy production, energy consumption and other information specified under the NGER Act. The NGER scheme is administered by the Clean Energy Regulator.

Of note, under the NGER Act, businesses (either as an individual facility or as a corporate group) emitting more than threshold tonnes of carbon dioxide equivalent, or consuming more than threshold megawatt hours of electricity or threshold million litres of fuel in a financial year are required to register, to collect data and keep records, and to report their GHG emissions, energy production and consumption to the Clean Energy Regulator by 31 October each year following the financial year reporting period. The Clean Energy Regulator then publishes Scope 1 GHG emissions, Scope 2 GHG emissions, and net energy consumption for each registered corporation under the NGER Act that meets the publishing thresholds. Of direct relevance here, the carbon emissions publishing thresholds are corporate groups with Scope 1 and Scope 2 GHG emissions combined that are equal to or greater than 125 kilotonnes for reporting year 2008-09, 87.5 kilotonnes for reporting year 2009-10, and 50 kilotonnes for reporting year 2010-11 and all subsequent reporting years. Finally, the NGER Act also provides for greenhouse and energy audits of reporting corporations registered under the Act and the establishment of a register of greenhouse and energy auditors. Audits are used to determine if registered corporations are complying with the NGER Act.

---

<sup>1</sup> This information is sourced from the Clean Energy Regulator web site ([www.cleanenergyregulator.gov.au/national-greenhouse-and-energy-reporting/pages/default.aspx](http://www.cleanenergyregulator.gov.au/national-greenhouse-and-energy-reporting/pages/default.aspx)).

### 3. Literature Review and Hypotheses Development

#### 3.1 *The Debt Market in Australia*

The Australian debt market provides a unique structural and regulatory environment that is significantly different from the U.S. and other international markets (Suchard, 2007; Gray *et al.*, 2009; Alcock *et al.*, 2012), with the differences likely to have unique implications for debt contracting. First, the Australian debt market is relatively smaller, more concentrated and less liquid (Alcock *et al.*, 2012). In particular, while large firms have access to the wholesale debt market and can issue paper, there is not an actively traded listed debt market (Suchard, 2007). The limited availability of debt sources and liquidity premium arising from thin trading, particularly for smaller firms, constrain management choices in debt financing and affect optimal leverage (Alcock *et al.*, 2012).

Second, Australian firms have a relatively heavier reliance on private debt compared to public debt (Cotter, 1998; Gray *et al.*, 2009; Alcock *et al.*, 2012). Specifically, Cotter (1998) documented that public debt issues only accounted for 4.5 percent of total debt outstanding while unsecured and secured bank loans accounted for 40.9 percent and 13.3 percent respectively of total borrowings in a sample of Australian firms in 1995. Since private lenders typically have greater access to private information and are more likely to monitor borrowers, agency costs of debt are likely to be relatively lower (Bharath *et al.*, 2008; Gray *et al.*, 2009; Alcock *et al.*, 2012).

Third, Australian listed firms must comply with continuous disclosure obligations under the ASX Listing Rules 3.1. Thus, effective and timely disclosure of information to capital markets is likely to play an important role in mitigating information asymmetry between managers and investors and between different types of investors, which in turn reduces agency problems of debts in Australia (Gray *et al.*, 2009). Lastly, under the dividend imputation system operating in Australia, Australian corporate taxes paid by companies are distributed to eligible shareholders as a tax credit with dividend payments and the tax credit can be offset against the other Australian taxes of the shareholders (Twite, 2001). This tax system has been shown to impact on capital structure, with its

introduction leading to reduced debt financing and increased equity financing (Twite, 2001) and leverage for Australian firms appearing at very low levels by international standards (Ralston, 2013).

### **3.2 Carbon Risk and Carbon Risk Awareness**

The term ‘environmental risk’ is sometimes used in relation to the consequences from specific environmental events such as oil spills, although it can also refer to the more general, longer-term risks posed to business activities by climate change (Romilly, 2007). As an important subset of environmental risks, carbon risk often refers to ‘any corporate risk related to climate change or the use of fossil fuels’ (Hoffmann and Busch, 2008, p. 514). Similarly, carbon risk is defined as threats and opportunities that are associated with a firm’s management of carbon emissions (Subramaniam *et al.*, 2013). Carbon risk is often viewed as comprised as three separate but related types of risk, regulatory, physical, and business risks (Labatt and White, 2007).

Regulatory risk refers to the risk associated with current and future carbon-related policies and regulations that are likely to have a material impact on a firm’s financial performance (Labatt and White, 2007). The implementation of carbon-related policies and regulations increases the likelihood of additional costs of compliance associated with either adopting new technology and trading emissions credits (UNEP FI, 2006). Physical risk refers to the risk associated with the direct impacts of climate change, such as droughts, floods, storms, and rising sea levels (Labatt and White, 2007). While extreme weather systems in the form of hurricanes or floods may have the most immediate impact on some sectors, slower physical environmental changes like a gradual increase in ocean temperature can also have lasting negative consequences for other sectors, such as agriculture, fisheries, and forestry (UNEP FI, 2006; Labatt and White, 2007). Finally, business risk arises at the corporate level and includes legal, reputational and competitive risks (Labatt and White, 2007). In each instance, while the impact will likely vary significantly across industry sectors, it will also vary within sectors dependent upon the strategic and/or preventative actions that firms

undertake to confront and even pre-empt the risks and challenges posed by climate change (UNEP FI, 2006).

Turning now to the notion of ‘carbon risk awareness’, broadly within the business context, the concept of corporate environmental awareness has been described as a multidimensional construct, including the five components, environmental knowledge, environmental values, environmental attitudes, revealed willingness to act, and actual behaviour (Zsoka, 2008). Narrowly within our context, carbon risk awareness is defined as the capability of firms to proactively identify the key risks arising from carbon-related issues and seriously consider the consequence of the risks. Clearly, while carbon risk awareness alone is not enough, it is the starting point of carbon risk management. Firms that are aware of carbon risks are more likely to integrate these risks into formal risk management systems and to address these risks before they become bigger problems (Subramaniam *et al.*, 2013). For example, Centrica, a U.K.-based utility company, upon becoming aware of the possible impact of emissions trading and its competitive position in the light of carbon-related regulation, started to engage in carbon trading as one of its carbon risk management strategies (Okereke and Russel, 2010). Similarly, BHB Billiton, an Australian-based resources company, strategically exhibited an awareness of carbon-related policy developments at global and regional levels by conducting carbon pricing sensitivity analyses on new projects and investments, and re-launching its climate change policy (Okereke and Russel, 2010). The importance of carbon risk awareness is also highlighted by the underlying rationale of the Carbon Disclosure Project (CDP) which holds that raising corporate awareness of carbon and climate change risk through measurement and disclosure is critical to the effective management of carbon and climate change risk.

### ***3.3 Carbon Risk and Debt Contracting***

Credit risk management is the overall assessment and quantification of risk that determines whether lenders wish to lend, and if so, aspects of the lending arrangement such as the price of borrowing, the time to maturity, and the requirement for security (Coulson and Monks, 1999). Here,

given their importance, lenders are likely to continually integrate significant new types of risk such as carbon-related risk into their overall risk assessment. For example, financial liabilities such as costs of compliance with carbon-related regulations and fines for non-compliance with the regulations may impair the borrower's profitability and cash flows, thereby adversely affecting its ability to repay loans and in turn increasing the risk to the lenders (Thompson, 1998). Additionally, lenders may face reputational risks when they are viewed in a negative light by their stakeholders with respect to their lending policies and processes towards carbon-intensive projects. While this risk does not have a direct impact on the present value of an existing loan portfolio, it can impair a lender's ability to generate future customers and hence future revenue streams (Thompson, 1998).

Lending institutions have taken several initiatives to respond to environmental and social issues. The banking industry's first formal response to the environmental agenda was the United Nations Environmental Programme Statement by Banks on the Environment and Sustainable Development (UNEP Statement), launched by a small group of commercial banks in 1992 and developed as the UNEP Statement of Commitment by Financial Institutions on Sustainable Development (UNEP FI Statement) in 2010 (Weber *et al.*, 2008).<sup>2</sup> These two statements are aimed at financial institutions committing to the integration of environmental and social considerations into their operations. Currently, over 200 financial institutions around the world are signatories of the UNEP FI Statement including major Australian banks.

Following, the Equator Principles were developed by a group of major financial institutions in 2003 to present a set of voluntary guidelines that assist in assessing and managing environmental and social issues in the project finance sector (Labatt and White, 2007). Although not directly related to carbon-related risk mitigation, they represent a first step at integrating environmental considerations into project finance and may help the development of carbon-related management practices in the banking industry (Cogan *et al.*, 2008). Further and subsequently, several financial institutions have created management practices to deal with carbon and climate change risk. For

---

<sup>2</sup> This information is sourced from the UNEP FI web site (<http://www.unepfi.org/about/statements/history/index.html>).

example, the Carbon Principles were created by three U.S. leading banks to address the risks associated with regulatory uncertainty of carbon emissions in 2008 and to provide a consistent approach for banks to evaluate and address carbon risks (Rainforest Action Network, 2011).

Lastly, while there has been little research directly on whether, or how, lenders have responded to carbon-related issues in their lending practices, given that carbon risk is an important subset of environmental risk, findings from prior research on lenders' consideration of environmental issues can provide insights into carbon-related considerations in lending activities. Using predominantly qualitative approaches, prior literature provides evidence that with increasing regulations and public concern with regard to the environment, lending institutions have incorporated the associated risks into their lending operations through management policies and practices as a way to manage their exposure to these risks.

To illustrate, Coulson and Monks (1999) investigated how a bank incorporates environmental considerations within its lending process and the potential implications of such considerations for a corporate borrower. Using the case of Lloyds TSB Group, they concluded that as a result of developments in environmental legislation, a borrower's environmental issues reflected by its environmental policies and management practices should be assessed as part of the lending evaluation. Further, they concluded that while a firm with a serious environmental problem is unlikely to obtain finance without first addressing its problem, firms engaged in environmental management activities can more readily benefit from bank consideration of environmental performance within lending decisions, including more favourable loan conditions.

Continuing, Thompson (1998) examined the lending policies of a sample of U.K. banks through a series of semi-structured interviews with a focus on environmental risk management, market segmentation and the exploitation of marketing opportunities. He concluded that banks were increasingly aware of the importance of environmental issues to their lending operations and were therefore incorporating these issues through changes to credit risk criteria. He also found evidence that an assessment of environmental risks had moved from ad hoc and informal risk assessment

towards a more systematic and formal process. Thompson and Cowton (2004) extended the analysis to a larger sample of U.K. banks using both surveys and semi-structured interview. They also found that the majority of the banks incorporated environmental criteria as a part of their credit risk assessment procedures, with the main motivations for doing so being to avoid or mitigate environmental liabilities, to manage environmental risks and to comply with legislation. Additionally, they found that the most important environment-related reason for avoiding lending to companies was a poor environmental record rather than a firm's involvement in the environmentally sensitive industry, and further, that the most important environmental attribute in a bank's lending decision was whether a company met all known and likely future environmental control standards. More recently, Weber (2012) examined how Canadian banks and financial service institutions integrated environmental risks into corporate lending. Using environmental, corporate social responsibility or sustainability reports and employing both qualitative and quantitative methods, he found that most institutions indicated that they integrated environmental risks into their credit management processes at a more general level, although few indicated that they do so at a more detailed level. Further, they found that the Canadian banks were more proactive regarding the systematic environmental examination of loans, credits and mortgages than their global peers.

Finally, focusing on climate change risk, Cogan *et al.* (2008) examined the corporate governance and strategic approaches of 40 of the world's largest banks to the challenges and opportunities arising from climate change. Employing the Climate Change Governance Checklist,<sup>3</sup> they found that many were incorporating environmental and climate change issues in their business, with 30 of the banks having implemented general environmental risk assessment policies and 13 having adopted risk management policies or lending procedures that address climate change. Further, they reported that most of the policies were process oriented and applied to the power sector. For example, banks responded that they considered the potential costs of carbon in the firm's

---

<sup>3</sup> The Climate Change Governance Checklist is developed by the RiskMetrics Group to analyse corporate responses to climate change. This checklist consists of fourteen indicators to evaluate corporate climate change activities in five main governance areas of board oversight, management execution, public disclosure, emissions accounting, and strategic planning.

financing of power generation, required borrowers to disclose their carbon emissions and mitigation strategies in a consistent way, discussed with borrowers whether they have taken carbon pricing into account, or encouraged the large GHG emitters to develop carbon mitigation plans.

### ***3.4 Evidence on the Impact of Carbon and Environmental Risks on the Cost of Debt***

To date, few studies have directly investigated the relation between carbon risk and the cost of debt. However, since carbon risk is an important subset of environmental risk, findings from literature on the relation between environmental issues and the cost of debt are likely applicable. Here, the evidence appears mixed, with some studies finding that firms which exhibit superior environmental (or CSR) performance enjoy a lower cost of debt whereas others find the converse.

In detail, Sharfman and Fernando (2008) examined whether and how a firm's environmental risk management (KLD and TRI data) influenced its total cost of capital. Based on a sample of U.S. firms, they found that firms benefited from improved environmental risk management through a reduction in their cost of equity capital, a shift from equity to debt financing, and higher tax benefits associated with the ability to add debt. However, they also find a positive relationship between the cost of debt capital and their environmental risk management measure, a finding they suggest may be due to the perception by debt markets that investment in environmental risk management beyond that necessary for compliance is an inefficient use of scarce resources. In contrast, Schneider (2011) explored the relation between environmental performance (TRI data) and bond pricing using a sample of firms from the U.S. pulp and paper and chemical industries. He found that firms with relatively superior environmental performance had lower bond yields. Further, using bond ratings to proxy for bond quality, he found that while the impact of environmental performance on bond yields was large for the low-quality bonds, it became smaller for the medium-quality bonds and faded for the high-quality bonds.

Alternatively, Goss and Roberts (2011) examined the link between CSR performance (KLD data) and bank loans for a sample of U.S. firms, finding that firms with high CSR concerns paid

between seven and 18 basis points more than firms with low CSR concerns. They also found that lenders appeared more sensitive to CSR concerns in the absence of security, with low-quality borrowers that engaged in discretionary CSR spending facing higher loan spreads and shorter maturities whereas lenders appeared indifferent to CSR investments by high-quality borrowers.

More recently, Chen and Gao (2012) investigated the impact of climate risk on the cost of capital. Based on a sample of U.S. firms in the electric utility industry, they found a positive relation between climate risk (carbon dioxide emission rates) and the cost of capital, the implied cost of equity and the cost of debt. In conjunction, they also found some evidence consistent with the notion that equity and debt investors evaluate climate risk differently. Specifically, they found that the cost of debt decreased with increased levels of capital intensity, suggestive that debt investors value the increase in efficiency resulting from current capital investment. Further, they found that the cost of equity decreased but the cost of debt increased with asset newness.

### ***3.5 Hypotheses Development***

Agency theory has been broadly used by researchers to study different phenomena in accounting, economics, finance, marketing, as well as in other areas (Eisenhardt, 1989). In particular, much of the debt literature has adopted the agency-theory view of the firm (Armstrong *et al.*, 2010). In the context of carbon risk, agency problems may arise when the desires or goals of a lender and a borrower with regard to carbon-related issues are not aligned. As lenders are exposed to carbon risk through their lending activities, they are likely to expect borrowers to undertake actions to mitigate their carbon risk. For example, Thompson (1998) finds that lenders expect their borrowers to comply with environmental regulations and meet generally accepted industry standards. However, in contrast to lenders' desires, a borrower focusing on economic performance may make different decisions related to carbon issues. Here, while potentially profitable, carbon-intensive projects can also be seen as risky because they usually involve the externalisation of carbon pollution which is accompanied by the risk of having the implicit costs being shifted back to

firms (Goss and Roberts, 2011). With increasing carbon-related regulations and policies, a large portion of externalised costs are likely to be internalised. The problem here is that, if carbon-intensive projects are successful, shareholders will capture most of the gains, but if unsuccessful, creditors will bear most of the costs. Furthermore, even if successful, creditors may still face reputational risks associated with financing environmentally damaging projects.

The existence of information asymmetry between a borrower and a lender exacerbates agency problems (Armstrong *et al.*, 2010). Within context, lenders may face difficulties in evaluating a borrower's true underlying carbon-related risk. Coulson and Monks (1999) find that lenders often face difficulties in obtaining good quality information about the environmental risks faced by borrowers due to poor availability, and lack of standardisation, of environmental information. Notwithstanding, given the dominance of private debt within the Australian market, the agency problem arising from information asymmetry may be somewhat alleviated given that private lenders tend to have more access to the private information of a borrower and are able to more clearly monitor the borrower (Bharath *et al.*, 2008; Gray *et al.*, 2009; Alcock *et al.*, 2012). In conjunction, Choi *et al.* (2013) find that there has been a substantial increase in the number of Australian firms providing voluntary carbon disclosures in their annual reports or sustainability reports, especially following the introduction of the NGER Act in July 2008.

In relation to agency problems arising from carbon-related issues, several studies present evidence that following from developments in environmental and carbon-related legislation, lenders are increasingly incorporating environmental and carbon issues into their lending decisions (Thompson, 1998; Coulson and Monks, 1999; Thompson and Cowton, 2004; Cogan *et al.*, 2008; Weber, 2012). Here, the agency problem can also be mitigated by designing debt contracts that prevent borrowers from taking opportunistic behaviour with regard to their carbon-related activities, including price protection through interest rates (Armstrong *et al.*, 2010).

Our interest in this study is the effect, if any, that a firm's exposure to carbon-related risks has on its cost of debt. As discussed above, a firm is exposed to carbon risk from three perspectives,

regulatory, physical and business risks. For example, with the increasing carbon-related legislation and policies, firms may have to incur costs related to their carbon emissions through taxes, as well as the costs of reducing carbon emissions through the development of low-carbon technologies. As such, a firm's exposure to carbon-related risk has the potential to directly impact its operations, influencing profitability and cash flows. Several prior studies provide evidence on the negative impact of carbon liabilities on firms. For example, the European-based study by Clarkson *et al.* (2014) suggests that carbon emissions that exceed carbon allowances under the EU ETS negatively affect firm valuation. Similarly, the Australian-based study from Deutsche Bank (2009) estimated that the carbon liability arising from the proposed emissions trading scheme has a potential negative valuation impact on the top 25 emitters in Australia. In a similar vein, a U.S.-based study by Schneider (2011) suggests that for firms in polluting industries, environmental risk is one of the major idiosyncratic risks.

The potential negative impact of a firm's carbon-related risk on its profitability and firm valuation may indicate a greater uncertainty inherent in its future activities which can, in turn, affect its ability to repay debt and hence the level of default risk (Sharfman and Fernando, 2008). Increased default risk can exacerbate agency problems between a lender and a borrower. In the presence of agency problems, lenders are expected to implement possible solutions such as the incorporation of carbon risk into their credit risk assessment and price protection through interest rates. Therefore, on average, lenders are expected to impose a higher cost of debt on firms with higher carbon risk. Here, prior research provides support for this argument. For example, Schneider (2011) finds that firms with relatively superior environmental performance face lower bond yields than firms with relatively poorer environmental performance. Similarly, Goss and Roberts (2011) find that banks charge higher costs of borrowing to firms with higher CSR concerns, and Chen and Gao (2012) find a positive relation between a firm's climate risk and its cost of debt. Based on the above, our first hypothesis is stated in the alternative form as follows:

***H<sub>1</sub>: Firms with higher carbon risk face a higher cost of debt.***

Notwithstanding this over-arching interpretation, higher carbon risk *per se* may not necessarily result in a higher cost of debt. More specifically, a firm's exposure to carbon risk varies significantly across industries and even within industry due to firm-specific characteristics (UNEP FI, 2006). Firms, particularly in carbon-intensive industries, will naturally present higher carbon risk and, on average, are likely to be more aware of this risk. Firms' awareness of carbon risk could lead to them being able to not only identify the potential risk but also adopt measures to address their carbon risk. Therefore, if a firm identifies its carbon risk and effectively controls its carbon risk exposure through proactive carbon risk management, this risk may have a low probability of realisation.

As such, a demonstration of its awareness of carbon-related risks and a willingness to undertake a proactive stance may, at some level, serve to alleviate any potential negative impact of a firm's historical carbon risk profile on its cost of debt. A firm's commitment to mitigate its exposure to carbon risk should be viewed favourably by lenders. Coulson and Monks (2008, pp. 7) suggest that 'the higher the potential risk the more developed the customer's systems for controlling this risk and the greater comfort the lender can take'. Furthermore, firms with higher carbon risk awareness are likely to be able to communicate effectively with lenders about their carbon issues such as their carbon management strategies and competitive positions in the light of carbon-related policies during the lending process. This, in turn, may lead to lenders having a greater understanding of the issues and incorporating them in a systematic way in deciding a firm's carbon risk premium. This reduced information asymmetry between a lender and a borrower can also result in a lower the cost of debt. Thus, lenders are expected to impose lower carbon risk premium if a firm exhibits higher carbon risk awareness. Within this context, Coulson and Monks (1999) find that firms that address their environmental issues and engage in environmental management activities can more readily benefit from bank consideration of environmental issues within lending decisions in the form of the reduced costs of loan negotiations and more favourable loan conditions. Based on the above, our second hypothesis is stated in the alternative form as follows:

*H<sub>2</sub>: Firms' carbon risk awareness mitigates the negative impact of carbon risk on the cost of debt.*

## 4. Empirical Methodology

### 4.1 Econometric Model

In this study, our interest is in the association between a firm's carbon risk profile and its cost of debt. First, we are directly interested in whether a firm's historical carbon emissions profile serves to inform regarding its carbon risk profile as reflected in its cost of debt (*H<sub>1</sub>*). Second, we are interested in whether a firm can mitigate the message that its historical emissions profile conveys by undertaking actions that signal the extent of its carbon risk awareness and thereby the possibility that its historical performance may not accurately reflect its carbon risk profile going forward (*H<sub>2</sub>*). As discussed in the previous section, we conduct the study against the backdrop that lenders are increasingly focusing on carbon-related issues in their lending decisions (Cogan *et al.*, 2008) and further, with the introduction of the NGER Act and thereby the significant improvement in the extent of voluntary carbon disclosures made by Australian companies (Choi *et al.*, 2013), lenders are likely to have greater access to a firm's carbon-related information and hence will be better able to incorporate this information into their lending decisions.

The general form of the econometric model we use to test our two hypotheses is as follows:

$$COD_t = \delta_0 + \delta_1 CARBON_t + \delta_2 CDP_t + \delta_3 CARBON_t * CDP_t + \sum_k \lambda_k CONTROL_{kt} + \varepsilon_t \quad (1)$$

where

- $COD_t$  = cost of debt, measured as interest expense in year  $t$  divided by the average of the interest bearing debt in periods  $t-1$  and  $t$ ;
- $CARBON_t$  = historical carbon risk profile, measured as total scope 1 greenhouse gas (GHG) emissions for year  $t$  divided by year  $t$  sales revenue; and
- $CDP_t$  = an indicator variable designed to capture a firm's 'carbon awareness', set equal to one if a firm responds to the CDP questionnaire in year  $t$ , and zero otherwise.

and  $CONTROL$  is a vector of control variables. These three variables of primary interest ( $COD$ ,  $CARBON$ , and  $CDP$ ) are discussed in detail in the next section, and the choice and measurement of the control variables is discussed in the subsequent section.

Within the context of this model,  $H_1$  predicts a positive coefficient on the carbon risk measure, *CARBON*, consistent with firms with higher carbon risk facing a higher cost of debt (i.e.,  $\delta_1 > 0$ ).  $H_2$  then predicts a negative coefficient on the interaction terms, *CARBON* \* *CDP*, consistent with the argument that the negative impact of a firm's historical carbon risk profile on the cost debt is mitigated for firms with higher carbon risk awareness, as increased awareness is likely to lead firms to identify their carbon risk exposure and proactively implement carbon risk management strategies (i.e.,  $\delta_2 < 0$ ).

## **4.2 Dependent and Treatment Variables**

### **4.2.1 Cost of Debt**

As described above, in conducting this study, we measure the cost of debt as the firm's interest expense in year  $t$  divided by the average of its interest bearing debt in periods  $t-1$  and  $t$ . By way of context, several U.S.-based studies of traded debt have alternatively focused on the spread between the yield on each debt instrument and its comparable U.S. Treasury bond yield (e.g., Bharath *et al.*, 2008; Schneider, 2011). However, given a relatively greater reliance on private debt, market-based measures are not particularly relevant within our Australian setting (Aldamen and Duncan, 2013). Further, while some U.S.-based studies relating to private debt have used the yield spread over LIBOR accessible from the Dealscan database (e.g., Bharath *et al.*, 2008; Goss and Roberts, 2011), here Dealscan predominantly covers the U.S. loan market and as a result, it is not feasible for an Australian data set. As such, we follow prior studies that have employed a computed interest rate defined as disclosed interest expense divided by average interest-bearing debt (Pittman and Fortin, 2004; Francis *et al.*, 2005; Gray *et al.*, 2009).

The computed interest rate measure that we employ has not, however, been without criticism. Importantly, Pittman and Fortin (2004) and Aldamen and Duncan (2013) each point out that it can be potentially noisy, especially when the level of debt changes materially near year-end. In response, Aldamen and Duncan (2013) use a weighted average interest rate calculated from the interest rates

and quantity of each type of interest-bearing debt disclosed in the footnotes to the financial statements. Unfortunately, however, within our context, use of a weighted-average measure appears impractical. Specifically, a search of the footnotes reveals that less than one-third of our sample firms within the Materials sector disclosed the interest rate and type of debts in 2013.<sup>4</sup> As described in Section 4 and Table 1, 34.1% of our sample derives from this sector. As such, we revert to the use of the somewhat cruder measure based on total interest expense and average outstanding debt.

Finally, in constructing our proxy, we implement two procedures designed to reduce the limitations of this measure. First, the interest expense figure extracted from the Morningstar DatAnalysis database typically includes interest and finance charges arising from the unwinding of the discount on restoration and rehabilitation provisions, and excludes capitalised finance costs. Use of this unadjusted interest expense is potentially problematic for firms in the mining industry where a significant amount of unwinding of the discount on restoration and rehabilitation provisions is recorded as finance expenses and a significant amount of interest charges are capitalised.<sup>5</sup> To overcome this limitation, we adjust the interest expense figures for firms in the Materials and Energy sectors by excluding expenses related to unwinding of the discount on restoration and rehabilitation provisions and adding capitalised interest expenses.<sup>6</sup> Second, given the potential noise introduced into the measure when a firm's debt level materially changes near year-end, we apply the trimming procedure implemented by Pittman and Fortin (2004) by deleting firm-year observations at the 5% and 95% percentiles.

#### *4.2.2 Carbon risk*

In constructing the operational proxy for a firm's carbon risk, we utilise the GHG emissions data that is publicly available from the Clean Energy Regulator website. The Greenhouse Gas Protocol is the most widely used international accounting tool by government and business leaders

---

<sup>4</sup> This may be attributable to a change in accounting regulation. Previously, AAS 33 required firms to disclose effective interest rates, or the weighted average effective interest rate, for each class of financial asset and financial liability. With the adoption of IFRS, AAS 33 was replaced by AASB 7 and AASB 132 which do not require these disclosures (Aldamen and Duncan, 2012).

<sup>5</sup> Under AASB 123, a firm is allowed to capitalise borrowing costs (e.g. interest on bank overdrafts and borrowings) that are directly attributable to the acquisition, construction or production of a qualifying asset into the cost of that asset.

<sup>6</sup> The required details are obtained from the notes to the financial statements accessed from the Connect4 database.

to assess GHG emissions. It classifies GHG emissions at three levels: (1) Scope 1: ‘direct GHG emissions caused by a company’s fuel combustion or emitted through industrial processes owned or controlled by a company’; (2) Scope 2: ‘indirect GHG emissions from purchased electricity’; and (3) Scope 3: ‘indirect emissions from other sources not owned or controlled by the company, such as suppliers and products in use’ (Salo and van Ast, 2009, p. 6). We focus Scope 1 GHG emissions which are currently covered under the CPM in Australia.<sup>7</sup> As discussed in the previous section, carbon risk manifests in three ways: regulatory, physical and business risks. Given that a significant proportion of carbon risk arises from the carbon-related policies (UNEF FI, 2006), Scope 1 GHG emissions likely capture a significant proportion of carbon risk.

A firm’s carbon risk exposure can be measured using either an absolute or relative GHG emissions measure (Salo and van Ast, 2009; UNEF FI, 2013). Here, absolute carbon emissions are expressed as the amount of emitted GHG (typically in the form of tonnes of CO<sub>2</sub>-equivalent per year) whereas relative carbon emissions are expressed as absolute carbon emissions normalised by a variety of variables such as revenues or market capitalisation (typically in the form of tonnes of CO<sub>2</sub>-equivalent per unit of revenue) (UNEF FI, 2013). The measure of tonnes of GHG emitted compared to revenue has been referred to as ‘carbon intensity’ in the literature and is interpreted as indicative of the extent to which a firm’s business model depend on GHG emissions (Salo and van Ast, 2009).

While both absolute and relative GHG emissions measures have been used within the literature, they are designed to capture different dimensions of a firm’s GHG profile. For example, Clarkson *et al.* (2014) use total carbon emissions to proxy for a firm’s carbon liability while Wang *et al.* (2013) use total carbon emissions to measure the environmental performance. Alternatively, Chen and Gao (2012) use total carbon emissions divided by electricity generation in MWh to proxy for climate risk exposure for their sample of U.S. electricity companies while more broadly, Chapple *et al.*

---

<sup>7</sup> As discussed in Chapter 2, at the time of writing, the Abbott Federal Government introduced a package of bills to withdraw the CPM in late 2013. While the abolishment of the CPM in Australia remains uncertain, the CPM was a real possibility during the study’s time period.

(2013) use total GHG emissions divided by sales revenue to measure carbon intensity. In this sense, absolute GHG emissions appear useful for understanding potential carbon liabilities while relative GHG emissions allow for a comparison of the relative carbon performance and carbon exposure of firms of different sizes and sectors (Salo and van Ast, 2009; UNEF FI, 2013). As such, we use carbon intensity, measured as Scope 1 GHG emissions for year  $t$  divided by sales revenues for year  $t$ , to proxy for a firm's carbon risk (*CARBON*).

#### 4.2.3 Carbon risk awareness

To proxy for a firm's 'carbon risk awareness', we focus on its willingness to respond to the CDP's information request. Prior research suggests that the use of a recognised environmental management system such as ISO 14001 is a reasonable indicator of a firm's commitment to manage environmental risks (e.g., Coulson and Monks, 1999). From this perspective, given that the CDP has been generally recognised as the most significant source of information on the business risks and opportunities arising from carbon emissions and climate change (e.g., Chapple *et al.*, 2013), following Eljido-Ten and Clarkson *et al.* (2014) we argue that the decision to respond to the CDP survey can be considered as an indicator of a firm's increased awareness of carbon risk. Specifically, we argue that since the CDP questionnaire covers broad dimensions of a firm's activity with regard to climate change including management, risks and opportunities, and emissions, firms responding to the survey are likely to have greater carbon risk awareness and potentially implement effective carbon risk management.

The CDP is a non-profit organisation that provides climate change information for more than 3,000 organisations in 60 countries (Choi *et al.*, 2013). Each year, the CDP requests information on GHG emissions, energy use and the risks and opportunities associated with climate change from a number of companies across the globe, and the provision of information to the CDP is made on a voluntary basis (Choi *et al.*, 2013). Based on information gathered from the questionnaire, the CDP produces annual climate change reports for each country or regional area that contain response analysis, climate disclosure scores and climate performance bands, Climate Performance

Leadership Indices (CPLI), Climate Disclosure Leadership Indices (CDLI), key emission statistics (i.e. Scope 1, Scope 2 and Scope 3 emissions), key governance, management and communication statistics, and key emissions reduction statistics together with the lists of non-responding and responding companies. The CDP's annual climate change report for Australia and New Zealand provides information for ASX 200 companies and NZX 50 companies. Since only a relatively small subset of firms that have their disclosure and performance rated by the CDP, to measure 'carbon awareness' we alternatively use an indicator variable of *CDP* set equal to one if a firm responds to the CDP survey for year  $t$  and zero otherwise. In categorising firms into responding and non-responding firms, firms which answered the questionnaire are considered as responding firms; firms which declined to participate, firms which provided information in another form of reports (e.g. CSR report), and firms which did not respond are considered as non-responding firms.<sup>8</sup>

### 4.3 Control Variables

The control variables included in our econometric model have been identified as affecting the cost of debt in prior literature (as cited) and are as follows:

$SIZE_t$	=	firm size, measured as the natural log of total assets in year $t$ (Bharath <i>et al.</i> , 2008; Gray <i>et al.</i> , 2009; Goss and Roberts, 2011; Schneider, 2011);
$LEV_t$	=	leverage, measured as total debt divided by total assets in year $t$ (Bharath <i>et al.</i> , 2008; Gray <i>et al.</i> , 2009; Goss and Roberts, 2011; Schneider, 2011; Chen and Gao, 2012);
$ROA_t$	=	profitability, measured as earnings before interest and taxes divided by of total assets in year $t$ (Gray <i>et al.</i> , 2009; Goss and Roberts, 2011);
$AUS\_ZSCORE_t$	=	default risk, measured using the Australian Z-score developed by Aldamen and Duncan (2012) and then multiplied by -1 so that higher values represent a higher default risk (Bharath <i>et al.</i> , 2008; Goss and Roberts, 2011; Schneider, 2011; Aldamen and Duncan, 2012); <sup>9</sup>
$MB_t$	=	market-to-book ratio, measured as the market value of equity plus the book

<sup>8</sup> The CDP divides a firm's response status into 'Answered Questionnaire', 'Declined to Participate', Information provided and No response. 'Answered Questionnaire' indicates that a firm answered some or all of the questions in the questionnaire; 'Declined to Participate' indicates that a firm declined to participate in the project; 'Information Provided' indicates that a firm provided information relevant to the questionnaire in another form of report (e.g. CSR report) but did not answer the questionnaire; and 'No Response' indicates that a firm did not reply to the CDP regarding their request. To test whether results are sensitive to coding firms that decided to provide the information in another form as 0, we alternatively excluded these observations and re-ran the analyses, finding results to be qualitatively identical to those based on the full sample.

<sup>9</sup> Given our Australian setting, we use an Australian Z score model from Aldamen and Duncan (2012) to estimate a firm's default risk, with the calculated Z score then multiplied by -1 so that higher values represent a higher default risk. Aldamen and Duncan's (2012) Z score is computed as: Z score = - 0.38 + 2.05 (Retained Earnings/Total Assets) + 3.06 (EBIT/Total Assets) + 1.09 (Sales/Total Assets) - 2.91 (Book Value of Total debt/Total Assets) + 0.16 (Working Capital/Total Assets).

	=	value of debt, divided by total assets in year $t$ (Bharath <i>et al.</i> , 2008; Goss and Roberts, 2011; Chen and Gao, 2012);
$CUR\_RAT_t$	=	current ratio, measured as current assets divided by current liabilities in year $t$ (Bharath <i>et al.</i> , 2008; Gray <i>et al.</i> , 2009);
$INT\_COV_t$	=	interest coverage ratio, measured as earnings before interest and taxes divided by interest expense in year $t$ (Bharath <i>et al.</i> , 2008; Gray <i>et al.</i> , 2009);
$EAR\_VOL_t$	=	earnings volatility, measured as the standard deviation of net income before extraordinary items, scaled by average assets, over the past three years in year $t$ (Gray <i>et al.</i> , 2009; Chen and Gao, 2012);
$CF\_VOL_t$	=	cash flow volatility, measured as the standard deviation of cash flow from operations, scaled by average assets, over the past three years in year $t$ (Gray <i>et al.</i> , 2009; Chen and Gao, 2012);
$TANG_t$	=	tangible assets, measured as net property, plant and equipment divided by total assets in year $t$ (Bharath <i>et al.</i> , 2008);
$NEW_t$	=	asset age (newness), measured as net property, plant and equipment divided by gross property, plant and equipment in year $t$ (Chen and Gao, 2012; Schneider, 2011);
$CAP\_INT_t$	=	capital intensity, measured as capital expenditures divided by sales revenues in year $t$ (Chen and Gao, 2012); and
$CAS\_RAT_t$	=	official cash rate, measured as the average cash rate in year $t$ (Goss and Roberts, 2011)

To begin, prior research suggests that firm size ( $SIZE$ ) is negatively associated with the cost of debt, with larger firms argued to have, on average, longer histories and more collateral assets, and less likely to be affected by negative shocks to cash flow and thus less likely to default. Alternatively, prior research suggests that firm leverage ( $LEV$ ) is positively associated with the cost of debt, with higher leverage is likely to increase the probability of bankruptcy or default risk and hence increase the cost of debt. Profitability ( $ROA$ ) is included as a determinant of the cost of debt following the argument that more profitable firms are likely to have excess free cash flow and are better able to meet their debt obligations, therefore reducing the default risk.

More fundamentally, much of the prior research suggests that a firm's cost of debt is positively associated with its default risk. Here, prior research suggests that it is important to recognise that the independent variable of interest could capture a component of a firm's default. We therefore include  $AUS\_ZSCORE$  to control for the possibility that without it, the carbon risk measure could capture general default risk. The market-to-book ratio ( $MB$ ) is included because prior research finds it to be negatively associated with the cost of debt. Additionally, short-term liquidity measured using both

the current (*CUR\_RAT*) and interest coverage (*INT\_COV*) ratios is included because it has also been shown to be negatively associated with the cost of debt.

The model also includes several direct measures of risk. Specifically, it includes measures of earnings volatility (*EAR\_VOL*) and cash flow volatility (*CF\_VOL*) since prior research that volatility is positively associated with the cost of debt. Further, it includes a measure of asset ‘tangibility’ (*TANG*), with higher asset tangibility argued to increase bankruptcy recovery rates, mitigating a creditor’s loss on repayment and lowering the cost of debt.

Several prior studies include asset newness (*NEW*) as a determinant of the cost of debt, yet its relation with the cost of debt is unclear. For example, Chen and Gao (2012) find a positive relation whereas Schneider (2011) finds a negative relation. Notwithstanding, both view their finding in terms of the implications of asset age for the environmental efficiency of the firm’s assets and its need for future expenditures.<sup>10</sup> Lastly, we include the official cash rate (*CAS\_RAT*) to controls for prevailing macroeconomic conditions. As debt instruments are usually priced at a benchmark rate plus a margin, higher benchmark rates are likely to result in higher interest rates.<sup>11</sup> As a final step, we then include Industry dummies to control for a potential industry effect. Based on 2-digit Global Industry Classification Standard (GICS) codes, average GHG emissions scaled by sales revenues differ by industry in the sample, with the Telecommunication sector having the lowest GHG emissions and the Utilities sector the highest.

## 5. Sample Data

As developed in the previous section, to conduct our study we require the following: (1) GHG emissions data; (2) CDP data; and (3) firm financial data. We collect the GHG emissions data from

---

<sup>10</sup> Chen and Gao (2012) interpret their finding as implying that if firms with newer equipment have relatively high carbon emission rates, required additional future capital expenditures on equipment with improved carbon emission rates will reduce cash flows available for debt payments and increase default risk. In contrast, Schneider (2011) attributes his finding to the fact that firms with new equipment may exhibit superior environmental performance thereby lowering the cost of debt.

<sup>11</sup> While Goss and Roberts (2011) use the 3-month U.S. dollar LIBOR rate, given our Australian setting, we use the official Reserve Bank of Australia (RBA) cash rate. While the 90-day bank bill swap rate (BBSW) published by the Australian Financial Markets Association (AFMA) is widely used as a benchmark interest rate for floating rate financial instruments, due to the inaccessibility of the historical BBSW data, we revert to official RBA cash rate which has been shown to be highly correlated with the BBSW (Morningstar, 2013).

the NGER data available on the Clean Energy Regulator website. The Clean Energy Regulator publishes Scope 1 GHG emissions, Scope 2 GHG emissions, and net energy consumption for each registered corporation under the NGER Act that meets the publishing thresholds (described in Section 2). The CDP data are sourced from annual CDP Australia and New Zealand reports available on the CDP website which contains information on climate change disclosure scores and climate change performance bands for the ASX200 and NZX50 (available from 2011), as well as whether firms responded to the CDP questionnaire (available from 2008). Data for non-ASX200 firms that voluntarily participated in the CDP survey are collected directly from the CDP website. Financial data were sourced from the Morningstar DatAnalysis database, with missing data drawn from annual reports on Connect4 database. Lastly, the official cash rate data are sourced from the Reserve Bank of Australia website.

Given these data requirements and sources, our preliminary sample consists of all ASX listed firms that met the publishing thresholds under the NGER Act over the period 2009–2013. We then searched the official list of listed companies available on the ASX website for each corporation name extracted from the NGER database to identify currently listed firms and their ASX codes. Since the official list does not contain delisted firms, the same procedure was then conducted using the Morningstar DatAnalysis database which enabled the identification of delisted firms and those listed firms that changed their names. This set of names was then subjected to an internet search to identify type of corporation for the purpose of identifying controlling corporations that report their greenhouse gas emissions under the name of their subsidiaries.<sup>12</sup> This process resulted in a preliminary sample of 573 firm-year observations.

Of these 573 firm-year observations, 126 firm-year observations had incomplete financial data, 10 observations were merged into controlling entities' observations, 16 had no debt or only lease liabilities, 71 firm-year observations were from the Financials industry,<sup>13</sup> and 67 firm-year

---

<sup>12</sup> The following sources were used: Google Search (<http://www.google.com.au>); ABN Lookup (<http://www.abr.business.gov.au>); and ASIC Company Search (<https://creditorwatch.com.au/express/asic/search/false/company>).

<sup>13</sup> Firms in the Financial sector were excluded because they are subject to industry-specific regulations, which may result in their capital market decisions being fundamentally different from those of non-financial firms (Pittman and Fortin, 2004).

observations were without the CDP data. Finally, the previously described trimming procedure for the dependent variable, *COD*, led to the deletion of 28 firm-year observations outside the 5<sup>th</sup> or 95<sup>th</sup> percentiles of the pooled. The final sample consists of the remaining 255 firm-year observations relating to 78 unique firms.

Table 1 presents a frequency distribution for the final sample by year and industry. As revealed, there has been a relatively consistent increase in the total number of sample observations over the 5-year study period, starting with 41 firm-year observations in 2009 and increasing to 61 firm-year observations in 2013. This increase is most likely to changes in the NGER publishing thresholds discussed in Section 2. Alternatively, in terms of industry sector composition, the Materials sector has the greatest representation with 87 firm-year observations, amounting to 34.1% of the total sample. This is followed by the Industrials sector (48 firm-year observations; 18.8%) and the Consumer Staples sector (32 observations; 12.5%). The Energy, Utilities, and Consumer Discretionary sectors provide 27 (10.6%), 22 (8.6%), and 18 (7.1%) firm-year observations, respectively. Health Care and Telecommunication Service represent a smaller portion of the sample with 12 (4.7%) and 9 (3.5%) firm-year observations, respectively.

Table 2 presents descriptive statistics for the key measures that appear within the study. Panel A begins by providing statistics for the full sample of 255 firm-year observations. Panel B then presents statistics for the sample partitioned into high (184 firm-year observations) and low (71 firm-year observations) emitting industries based on the industry sector mean value of *CARBON*. In support, prior research suggests that firms in the carbon intensive sectors are significantly exposed to carbon risk, leading lenders to be more sensitive to carbon-related issues for firms in those sectors and hence applying specific carbon risk assessment procedures (UNEP FI, 2006; Cogan *et al.*, 2008).<sup>14</sup> In a similar vein, industry research on carbon emissions has identified carbon intensive sectors such as Independent Power Producers and Energy Traders, Multi-Utilities, Construction

---

<sup>14</sup> A focus on firms from high polluting industries is relatively common in the academic literature that explores environmental performance. For example, Clarkson *et al.* (2008) focus on the five most polluting industries: Pulp and Papers, Chemicals, Oil and Gas, Metals and Mining, and Utilities while Schneider's (2011) sample comprises the two highest polluting industries: Pulp and Papers, and Chemicals.

Materials Metals and Mining, and Airlines (VicSuper, 2009). The high emitting sectors are Energy, Industrials, Materials, and Utilities and the low emitting sectors are Consumer Discretionary, Consumer Staples, Health Care and Telecommunication Services.<sup>15</sup>

To begin, as revealed in Panel A, there is considerable cross-sectional variable for all measures. For the cost of debt (*COD*), the mean and median values are 7.18% and 7.19%, ranging from a minimum of 3.23% to a maximum of 12.17%. The mean and median figures are similar to those reported by Gray *et al.* (2009) also for a sample of Australian firms.<sup>16</sup> Turning to the carbon risk measure (*CARBON*), its mean (median) value is 0.0005 (0.0001). Thus, on average, firms in the sample emit 0.4838 tonnes of Scope 1 GHG emissions per \$1,000 of sales. In addition, there is considerable variation in *CARBON*, ranging from a minimum 0.0002 to a maximum of 17.4770 tonnes per \$1,000 of sales. With regard to the *CDP* variable, its mean value of 0.65 indicates that 65% of firms in the sample responded to the CDP questionnaire.

Descriptive statistics for the control variables, reported in the remaining columns, reveal the firms to be relatively large, somewhat levered, and on average, profitable. The mean values of *SIZE*, *LEV*, and *ROA* are 9.691 (), 0.266, and 0.087, respectively. For *AUS\_ZSCORE*, its mean (median) value is -0.20 (-0.28) with minimum and maximum values of -5.31 and 16.23 respectively. This negative value of *AUS\_ZSCORE* indicates that the sample firms, on average, exhibit relatively low default risk. The mean (median) values for *MB*, *CUR\_RAT*, and *INT\_COV* are 1.18 (0.99), 1.48 (1.31), and 6.92 (4.75), respectively. Here, while the current ratio falls below so often viewed “acceptable benchmark” of 2.0, the coverage ratio well exceeds its “acceptable benchmark” of 3.0. Thus, on balance, the sample firms exhibit a reasonable level of liquidity. The mean (median) values for *EAR\_VOL* and *CF\_VOL* are 0.03 (0.01) and 0.04 (0.02), respectively, both of which

---

<sup>15</sup> The mean values of *CARBON* are 0.0031, 0.0189, 0.0034 and 0.0013 tonnes of Scope 1 GHG emissions per \$1,000 of sales for Consumer Discretionary, Consumer Staples, Health Care and Telecommunication Services, respectively. The mean values of *CARBON* are 1.0314, 0.1869, 0.4080 and 2.2885 tonnes of Scope 1 GHG emissions per \$1,000 of sales for Energy, Industrials, Materials and Utilities, respectively.

<sup>16</sup> Gray *et al.* (2009) reported mean and median values of 8.7% and 7.1%. Here, any marginal difference is likely attributable to the relatively low interest rate environment during our study period. In support, Gray *et al.* reported that the mean and median cash rates over their sample period of 1998-2005 were 5.10% and 5.00%, respectively. In contrast, during our study period 2009-2013, the mean and median cash rates in Australia were 4.12% and 4.25% respectively (data retrieved June 3, 2014, from <http://www.rba.gov.au/statistics/historical-data.html>).

reveal a reasonable degree of risk when benchmarked against the mean *ROA* of 8.7%. Lastly, the sample firms exhibit significant degree of variation in terms of tangibility, asset newness, and capital intensity. For *TANG*, its mean (median) value is 0.43 (0.41), ranging from 0.04 and 0.90; for *NEW*, its mean (median) value is 0.61 (0.61), ranging from 0.15 to 0.99; and for *CAP\_INT*, its mean (median) value is 0.22 (0.07), ranging from approximately 0 to 9.09.

Turning to Panel B and the partitioned data, the statistics immediately reveal that the two subsamples differ along several important dimensions. First and by construction, firms in the high emitting industries have higher mean values of *CARBON* ( $p < 0.001$ ). Firms from the high emitting industries, on average, also are more slightly smaller, less profitable, have greater default risk, lower market-to-book ratios, and exhibit greater earnings and cash flow volatility. Interestingly, they also have a higher current ratio, as well as more tangible assets and newer assets, and greater capital intensity. Interestingly, however, notwithstanding these various differences, on average the two groups experience the same cost of debt. The mean (median) value of *COD* for the high emitting industry group is 7.24% (7.28%) whereas its counterpart for the low emitting industry partition is 7.03% (6.96%). The null hypothesis of no difference in mean values cannot be rejected at conventional levels ( $p = 0.430$ ).

Finally, Table 3 presents a Pearson pair-wise correlation matrix for the various measures of interest. Of note, the correlations between *COD* and each of *CARBON* and *CDP* are of the predicted sign but insignificant at conventional levels. Thus, the univariate perspective fails to provide support for either of our two hypotheses. Importantly, from a statistical perspective, with the exception of the correlation between *EAR\_VOL* and *CF\_VOL*, none of the pairwise correlations among the independent variables in our econometric model exceed 0.6. Thus, there appears to be threat associated with multicollinearity (Gujarati, 2004). Nevertheless, more formally, variance inflation factors (VIFs) are below ten which suggests that multicollinearity is unlikely a major concern (Hair *et al.*, 1998; Gujarati, 2004).

## 6. Empirical Results

### 6.1 Primary Results

Results for the tests of our two hypotheses,  $H_1$  and  $H_2$ , are presented in Table 4. Model I presents the results for the reduced form of the model which includes only the carbon emissions measure, *CARBON*, and thereby only speaks to  $H_1$ . Model II then presents the results for the full model which, as portrayed in equation (1), additionally includes the ‘carbon risk awareness’ measure, *CDP*, and the term interacting it with the carbon emissions measure, *CARBON* \* *CDP*, which allows it to speak to both hypotheses. Each model includes all control variables as described in Section 3 as well as industry indicators. The models are estimated using OLS with standard errors clustered by firm and year (Petersen, 2009).<sup>17</sup>

As revealed in Table 4, the results from the two models provide consistent support for our two hypotheses. As a preliminary step, beginning with Model I, the reduced model, we find the coefficient estimate on *CARBON* to be positive and significant at the 5% level (2.201,  $p = 0.042$ ). Thus, consistent with  $H_1$ , the results indicate that firms with higher current carbon risk as reflected in their historical carbon emissions have a higher cost of debt. This result can also be interpreted for economic significance. The coefficient estimate of 2.210 implies that a one standard deviation increase in *CARBON* leads to an increase in the cost of debt of 31 basis points ( $0.0014 * 2.201 = 0.0031$ ). Further, this coefficient estimate implies that moving from the best firm within our sample (*CARBON* = 0.000) to the worst (*CARBON* = 0.0175) maps into a 385 basis point increase in the cost of debt. In this sense, the results clearly highlight the material impact on a firm’s cost of debt of its current carbon risk profile as reflected in its historical carbon emissions.

More importantly and of primary interest, when we turn to the results for the full model, Model II, we find support for both hypotheses. Specifically, consistent with  $H_1$ , the coefficient on

---

<sup>17</sup> As described in Section 3, in developing our measure of carbon risk (*CARBON*), we use sales revenue as the scalar. However, as noted by Clarkson *et al.* (2011), sales revenue is, in fact, a measure of economic performance and hence the carbon risk measure may be affected by economic performance through the scalar rather than carbon risk itself. As an alternative, we use gross property, plant, and equipment as the scalar and repeat our analyses. Here, we find all results and conclusions to be robust to the choice of scalar. For example, for the full model (Model II), based on this alternative measure, the coefficient on the rescaled measure of *CARBON* remains positive and significant (9.646,  $p = 0.019$ ) and the coefficient on the interaction term remains negative and significant (-12.540,  $p = 0.005$ ). Thus, our results do not appear to be sensitive to the choice of scalar for determining the carbon risk measure, *CARBON*.

*CARBON* is positive and significant at the 1% level (3.152,  $p = 0.004$ ). Thus, the results again indicate that for the firms exhibiting low carbon awareness ( $CDP = 0$ ), an increase in their carbon risk profile as reflected in their historical carbon emissions leads to a higher cost of debt. Further, from an economic perspective, a one standard deviation increase in *CARBON* now leads to an increase in the cost of debt of 73 basis points ( $0.0023 * 3.152 = 0.0073$ ) for this ‘low carbon awareness’ subset of firms.

Continuing, consistent with  $H_2$ , the coefficient on the interactive term, *CARBON* \* *CDP*, is negative and significant at the 1% level (-7.410,  $p = 0.002$ ). Thus, importantly the results also indicate that this effect is mitigated or even reversed for firms exhibiting greater carbon risk awareness as exhibited by their willingness to respond to the CDP survey ( $CDP = 1$ ). Specifically, a test of the linear restriction reveals the net coefficient to be weakly negative ( $3.512 - 7.410 = -4.258$ ;  $p = 0.08$ ). Here, however, given the limited range covered by the *CARBON* measure for this subset of firms (from a minimum value of 0.000 to a maximum value of 0.002), a one standard deviation change in *CARBON* only maps into a 2 basis point change in the cost of debt. Thus, from an economic perspective, the effect appears negligible.

Taken together, we interpret these results as implying that, in a fashion consistent with our two hypotheses, a firm’s carbon risk profile as proxied for by its historical carbon emissions level is relevant in an assessment of the firm’s cost of debt, but notably only for the subset of firms which exhibit limited carbon risk awareness. For those firms that exhibit a relatively greater degree of carbon risk awareness as reflected in their willingness to respond to the CDP survey, the results indicate that there is no meaningful relationship between a firm’s historical carbon emissions level and its cost of debt. In this sense, firms appear to be able to mitigate the interpretation of their historical carbon emissions level and hence their carbon risk profile through the use of voluntary disclosures such as the CDP survey. Specifically, our results indicate that, as suggested by Clarkson *et al.* (2013), such affirmative actions appear to convey incremental information about the firm’s carbon risk profile going forward beyond a simple knowledge of its historical carbon emissions

level. Thus, overall, the results provide empirical evidence to support the argument from prior research that lending institutions incorporate a firm's carbon risk into their lending decisions (Cogan *et al.*, 2008). Specifically, lenders appear likely to penalise firms with higher carbon risk by imposing a higher carbon risk premium, but reward firms with higher carbon risk awareness by reducing this carbon risk premium. The results also imply that lenders appear to take account into not only past carbon intensity indicators but also forward-looking indicators when assessing a firm's carbon risk premium.

## **6.2 Partitioned Analysis**

The results presented above indicate that an assessment of a firm's carbon risk profile as reflected in its cost of debt is dependent not only on its historical carbon emissions level but also on mitigating factors that suggest that its carbon risk profile going forward may differ. For example, the results presented above suggest that by choosing to respond to the CDP survey, a firm reveals an increased carbon risk awareness and hence its historical carbon emissions level is only of very limited interest for establishing its cost of debt. In this section, we partition our data accordingly to high and low emitting industry sectors as described in Section 4. Recall, based on their industry sector mean value of *CARBON*, firms in the Energy, Industrials, Materials, and Utilities sectors have been designated as high emitting, and those in the Consumer Discretionary, Consumer Staples, Health Care and Telecommunication Services sectors as low emitting.

The results, presented in Table 5, suggest that this industry partitioning is meaningful. Specifically, the results for the sub-sample of high emitting industries presented in the first set of columns indicates that the coefficient on *CARBON* is positive and significant (3.025,  $p = 0.034$ ) and the coefficient on the interaction term, *CARBON\*CDP*, is negative and significant (-7.889,  $p = 0.004$ ). Further, a test of linear restriction capturing the marginal effect of carbon risk on the cost of debt conditional on carbon risk awareness is weakly significant ( $3.025 - 7.889 = -4.864$ ;  $p = 0.07$ ). Thus, in a fashion consistent with the results for the full sample, results based on the subsample of

firms from the high emitting industry sectors provide support for both hypotheses. Specifically, while these firms face an increased cost of debt with increased carbon risk, the negative impact of carbon risk on the cost of debt is effectively eliminated for high emitting firms with greater carbon risk awareness.

Results for the subsample of firms from the low emitting industry sectors are presented in the second set of columns. Here also, the coefficient on *CARBON* is positive and significant (1,353.328,  $p = 0.003$ ) and the coefficient on *CARBON\*CDP* negative and significant (-872.717,  $p = 0.009$ ). Now, however, the linear restriction remains positive and weakly significant ( $1,353.328 - 872.717 = 480.611$ ;  $p = 0.09$ ). Thus, for this subset of firms, while they appear able to mitigate the penalty applied to their cost debt through an indication of carbon awareness, they also appear unable to fully do so. As a final note, as hinted at by the size of the coefficient estimates, there is relatively little cross-sectional variation in the primary measures for this subset of firms. As revealed in Panel B of Table 2, the mean value of *CARBON* is 0.000, ranging from 0.0000 to 0.0001. Thus, the magnitude of the penalty implied by the coefficient estimate on *CARBON* is negligible from an economic perspective. Lastly, also for this subsample, the coefficient on *CDP* is positive and significant (0.014,  $p = 0.017$ ) whereas it is insignificant at conventional levels in the analysis based on both the full sample and the subsample of firms from the high emitting industry sectors. Thus, for this subsample only, a firm's cost of debt appears positively associated with its carbon risk awareness. Given that firms in low emitting industries are less exposed to carbon risk, one possible explanation is that lenders may see investments in carbon risk awareness by firms in the low emitting industries as an inefficient, over-investment of scarce resources, consistent with the over-compliance view (Sharfman and Fernando, 2008; Goss and Roberts, 2011).

Taken together, the results from this partitioned analysis support conclusions drawn from the full sample as discussed in the previous section. Specifically, lenders appear to impose a higher carbon risk premium on firms with higher carbon risk but reduce this carbon risk premium when firms exhibit higher carbon risk awareness. Hence, it appears that lenders, in general, consider

investments in carbon risk awareness as an efficient way to reduce a firm's carbon risk and hence reward firms that engage in such behaviour. However, the results from this partitioned analysis also suggest that there may be a difference in the way in which lenders perceive a firm's carbon risk between high and low emitting industries.

### **6.3 Additional Considerations**

In this section, we discuss results of additional analyses designed to consider the sensitivity of our results and conclusions to several of our design decisions. First, we consider the use of sales revenue as the scalar in the measurement of carbon risk. Second, we consider the implications of restricting the carbon risk measure to only Scope 1 emissions. Third and finally, we examine sensitivity to the delayed timing of GHG emissions and CDP data availability. In each instance, we find our results and conclusions robust to our initial design decision.

In detail, in our primary analyses, we use sales revenue as the scalar in developing the measure of carbon risk (*CARBON*). One possible concern is that sales revenue is in fact a measure of economic performance (Clarkson *et al.*, 2011). Therefore, the carbon risk measure may be affected by economic performance through the scalar rather than carbon risk itself. To examine the sensitivity of the results to the choice of scalar, we alternatively use gross property, plant, and equipment (PP&E) as the scalar.<sup>18</sup> Use of this alternative scalar leaves results (not tabulated) qualitatively unchanged. For example, for the full model based on the complete sample, the coefficient on *CARBON* remains positive and significant (9.646,  $p = 0.019$ ) and the coefficient on *CARBON \* CDP* negative and significant (-12.540,  $p < 0.001$ ). Thus, results and conclusions appear robust to the choice of scalar.

Second, we base our primary carbon risk measure narrowly on the firm's Scope 1 emissions based on the fact that the currently proposed CPM covers only Scope 1 GHG emissions. However, use of only Scope 1 GHG emissions may faithfully represent a firm's carbon risk if Scope 2 GHG emissions imply additional exposure of firms to carbon risk. To examine the sensitivity of the

---

<sup>18</sup> Clarkson *et al.* (2011) also use property, plant and equipment as the scalar of PP&E in their sensitivity analysis.

results to the choice of GHG emissions' categories, we extend the measure to include both Scope 1 and Scope 2 GHG emissions when developing the measure of carbon risk and repeat the regression analyses.<sup>19</sup> Again, the results (not tabulated) are qualitatively unaltered. For example, for the full model and using the complete sample, the coefficient on *CARBON* is again positive and significant (3.133,  $p = 0.004$ ) and the coefficient on *CARBON \* CDP* negative and significant (-6.240,  $p = 0.002$ ). Thus, results and conclusions also appear robust to the choice of GHG emissions measure.

Third and finally, we use current year data for GHG emissions and CDP responses in the development of our carbon risk and carbon awareness measures, *CARBON* and *CDP*, under the assumption that lenders are able to access the most up-to-date information with regard to carbon related issues at the time when lending decisions are made. Nevertheless, GHG emissions and CDP data are typically disclosed publically with a delay. For the GHG emissions data, registered corporations under the NGER Act must report their data to the Clean Energy Regulator by October of each year and this information is posted publicly in the following February via the Clean Energy Regulator website. Similarly, for the CDP data, participating firms submit their CDP response by May of each year, with the information published in September on the CDP website. This represents a delayed public reporting of carbon related information. As such, current period data may not, in fact, be in the public domain and thereby not fully reflected in the current year's cost of debt. To examine the sensitivity of the results to this issue, we alternatively use previous year's GHG emissions and CDP data. As a result, the sample is reduced to 188 firm-year observations mainly due to the unavailability of GHG emissions data for the year 2008 on the Clean Energy Regulator website. Here again, the results (not tabulated) are qualitatively unaltered. For example, for the full model and using the complete sample, the coefficient on *CARBON* is again positive and significant (3.461,  $p = 0.007$ ) and the coefficient on *CARBON \* CDP* negative and significant (-5.058,  $p = 0.024$ ). Thus, results and conclusions also appear robust to the timing of the release of GHG emissions and CDP data.

---

<sup>19</sup> Wang *et al.* (2013) use total Scope 1 and 2 GHG emissions to measure the environmental performance. Similarly, Chapple *et al.* (2013) use total Scope 1 and 2 GHG emissions to measure carbon intensity. However, their samples cover the periods before the CPM came into force.

## 7. Summary and Conclusions

The focus of this study is on the relation between a firm's carbon risk and its cost of debt. We predict that a firm's cost of debt will be increasing in its historical carbon risk profile but that evidence regarding its awareness of the carbon-related risks that it faces will serve to mitigate the penalty. For a sample of 255 firm-year observations on ASX-listed Australian firms from the period 2009–2013 relating to 78 unique firms from eight industry sectors, we measure their historical carbon risk profile using a carbon intensity measure based on their recent carbon emissions. To proxy for their awareness of carbon-related risks, we focus on their willingness to respond to the CDP survey, arguing that firms willing to respond are more likely aware of the underlying risks they face associated with carbon and thereby the more likely they are to implement a carbon risk strategy.

Our results provide uniform support for both predictions. We consistently document a positive and significant association between the cost of debt and our carbon risk measure for firms that fail to demonstrate an awareness of their carbon risk exposure as evidenced through their failure to respond to the CDP survey. Further, this association is economically meaningful, with a one standard deviation increase in the carbon risk measure mapping into a 73 basis point increase in the cost of debt for these firms. Equally, we find that this penalty is effectively negated for firms that respond to the CDP survey. In this sense, our results are consistent with the proposition advanced by Clarkson *et al.* (2013) that actions such as responding to the CDP survey can convey incremental information about the firm's carbon risk profile going forward beyond a simple knowledge of its historical carbon emissions level.

We confirm these results and conclusions by separately examining subsamples of firms drawn from high emitting industries versus low emitting industries, again finding as expected, the results to be the most meaningful for the high emitting industries. We also find results and conclusions to be robust to the choice of scalar, the breadth of the carbon risk measure, and the timing of the carbon emissions and CDP data availability.

We argue that our findings have several important implications. First, our finding that it is not only a firm's historical (recent) carbon emissions profile that is relevant but also information that relates to this profile into the future. This highlights the importance of jointly considering these factors rather than just the firm's historical carbon profile in any investigation of the economic implications of the firm's carbon risk profile. Specifically, lenders appear to incorporate forward-looking indicators in their lending decisions in addition to measures of historical performance.

Second, the findings may assist the regulators of capital markets in the development of future policies with respect to the disclosure of firms' carbon-related activities. They indicate that investors need the following information in order to fully assess a firm's carbon-related profile: (1) information related to a firm's historical exposure to carbon risk such as carbon intensity and the level of carbon emissions and (2) information related to a firm's commitment to address its carbon risk. A provision of only historical carbon emissions data provides an incomplete picture.

As always, our study faces several limitations or challenges which arguably open new areas for future research. First, in conducting our analysis, we do not consider other contractual mechanisms available in debt contract. Prior literature documents that lenders use other contractual mechanisms to mitigate agency problems such as debt covenants, the maturity of debt, and collateral requirements (Armstrong *et al.*, 2010). To the extent that lenders require more stringent debt contracting terms (e.g. restrictive covenants and shorter maturity) in order to mitigate agency problems, they could substitute for a higher cost of debt in the case of borrowing firms with high carbon risk. Such a substitution may serve to disguise the true effect of carbon risk on the cost of debt.

Second, as discussed in Section 4, our empirical proxy for the cost of debt can be potentially noisy when a firm changes its level of debt near year end (Pittman and Fortin, 2004; Aldamen and Duncan, 2013). While the trimming procedure proposed by Pittman and Fortin has been employed to address this problem, it is unlikely to be represent a complete resolution. Future research can be conducted by employing other empirical proxies such as a weighted average interest rate suggested

by Aldamen and Duncan (2013) although as noted this measure would be limited by data availability. Third, restricting our analysis to publically listed firms, we clearly restrict the generalizability of our results. Finally, as documented by Cogan *et al.* (2008), lending institutions incorporate a variety of carbon-related information of borrowers such as the cost of carbon emissions and carbon emissions reduction strategies in their lending decisions. Within this study, we attempt to capture the extent of the firm's awareness of the carbon-related risks that it faces and thereby its likelihood of implementing carbon-risk management strategies through its decision to respond to the CDP survey. Here, we concede that this is a relatively crude summary measure. Clearly, the opportunity exists for work that leads to a further understanding of the effect of a firm's carbon risk management strategy in explaining the association between carbon risk and debt contracting.

## References

- Alcock, J., Finn, F. and Tan, K. J. K. (2012). The determinants of debt maturity in Australian firms. *Accounting and Finance*, 52, 313-341.
- Aldamen, H. and Duncan, K. (2012). Does adopting good corporate governance impact the cost of intermediated and non-intermediated debt?. *Accounting and Finance*, 52, 49-76.
- Aldamen, H. and Duncan, K. (2013). Pricing of innate and discretionary accruals in Australian debt. *Accounting and Finance*, 53, 31-53.
- Armstrong, C. S., Guay, W. R. and Weber, J. P. (2010). The role of information and financial reporting in corporate governance and debt contracting. *Journal of Accounting and Economics*, 50, 179-234.
- Bharath, S. T., Sunder, J. and Sunder, S. V. (2008). Accounting quality and debt contracting. *The Accounting Review*, 83(1), 1-28.
- Chapple, L., Clarkson, P. M. and Gold, D. L. (2013). The cost of carbon: capital market effects of the proposed Emission Trading Scheme (ETS). *Abacus*, 49(1), 1-33.
- Chen, L. H. and Gao, L. S. (2012). The pricing of climate risk. *Journal of Financial and Economic Practice*, 12(2), 115-131.
- Choi, B. B., Lee, D. and Psaros, J. (2013). An analysis of Australian company carbon emission disclosures. *Pacific Accounting Review*, 25(1), 58-79.
- Clarkson, P. M., Li, Y., Richardson, G. D. and Vasvari, F. P. (2008). Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. *Accounting, Organizations and Society*, 33, 303-327.
- Clarkson, P. M., Li, Y., Richardson, G. D. and Vasvari, F. P. (2011). Does it really pay to be green? Determinants and consequences of proactive environmental strategies. *Journal of Accounting and Public Policy*, 30, 122-144.
- Clarkson, P. M., Fang, X., Li, Y. and Richardson, G. (2013). The relevance of environmental disclosures: Are such disclosures incrementally informative?. *Journal of Accounting and Public Policy*, 32, 410-431.
- Clarkson, P. M., Li, Y., Pinnuck, M. and Richardson, G. (2014). The valuation relevance of greenhouse gas emissions under the European Union Carbon Emissions Trading Scheme. *The European Accounting Review* (available online 19 June 2014)
- Cogan, D., Good, M. and McAteer, E. (2008). *Corporate governance and climate change: The banking sector*. Ceres. Retrieved from <http://www.ceres.org/resources/reports/corporate-governance-banking-sector>
- Cotter, J. (1998). Utilisation and restrictiveness of covenants in Australian private debt contracts. *Accounting and Finance*, 38(2), 181-196.
- Coulson, A. B. and Monks, V. (1999). Corporate environmental performance considerations within bank lending decisions. *Eco-Management and Auditing*, 6, 1-10.
- Deutsche Bank. (2009). *Australian Carbon Pollution Reduction Scheme: De-carbonising the CPRS*. Sydney.
- Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *The Academy of Management Review*, 14(1), 57-74.
- Elijido-Ten, E. and P. Clarkson, 2014. Sustainability performance and proactive climate change strategies: Evidence from the world's largest corporations. Working paper, Swinburne University.
- Francis, J., LaFond, R., Olsson, P. and Schipper, K. (2005). The market pricing of accruals quality. *Journal of Accounting and Economics*, 39, 295-327.
- Goss, A. and Roberts, G. S. (2011). The impact of corporate social responsibility on the cost of bank loans. *Journal of Banking and Finance*, 35, 1794-1810.
- Gray, P., Koh, P. S. and Tong, Y. H. (2009). Accruals quality, information risk and cost of capital: Evidence from Australia. *Journal of Business Finance and Accounting*, 36, 51-72.
- Gujarati, D. N. (2004). *Basic econometrics* (4<sup>th</sup> ed.). New York: McGraw-Hill.
- Hair, J. F., Anderson, R. E., Tatham, R. L. and Black, W. C. (1998). *Multivariate data analysis* (5<sup>th</sup> ed.). Upper Saddle River, N.J: Prentice-Hall International.
- Hoffmann, V. H. and Busch, T. (2008). Corporate carbon performance indicators. *Journal of Industrial Ecology*, 12(4), 505-520.
- Labatt, S. and White, R. R. (2007). *Carbon finance: The financial implications of climate change*. Hoboken, N.J: John Wiley & Sons, Inc.
- Morningstar (2013). *Australian income securities research*. Retrieved from [http://www.morningstar.com.au/s/documents/Australian\\_Income\\_Securities\\_Review\\_November\\_2013\\_Final.pdf](http://www.morningstar.com.au/s/documents/Australian_Income_Securities_Review_November_2013_Final.pdf)

- Natoli, S. and Sack, J. (2014, January 27). Australia: the new carbon policy landscape. *Mondaq*. Retrieved from <http://www.mondaq.com/australia/x/288208/Climate+Change/The+New+Carbon+Policy+Landscape>
- Okereke, C. and Russel, D. (2010). Regulatory pressure and competitive dynamics: Carbon management strategies of UK energy-intensive companies. *California Management Review*, 52(4), 100-124
- Petersen, M. (2009). Estimating standard errors in finance panel data sets: Comparing approaches. *Review of Financial Studies*, 22(1), 435-480.
- Pittman, J. A. and Fortin, S. (2004). Auditor choice and the cost of debt capital for newly public firms. *Journal of Accounting and Economics*, 37, 113-136.
- Rainforest Action Network. (2011). *The Principle matter: Banks, climate and the Carbon Principles*. Retrieved from <http://www.ran.org/principle-matter-banks-climate-carbon-principles>
- Ralston, D. (2013). *Funding Australia's future: summary*. Australian Centre for Financial Studies. [http://fundingaustraliasfuture.com/sites/faf.acfs.actuateit.net/files/papers/FAF\\_Stage\\_One\\_Summary.pdf](http://fundingaustraliasfuture.com/sites/faf.acfs.actuateit.net/files/papers/FAF_Stage_One_Summary.pdf)
- Romilly, P. (2007). Business and climate change risk: A regional time series analysis. *Journal of International Business Studies*, 38(3), 474-480.
- Salo, J. and van Ast, L. (2009). *Carbon risks and opportunities in the S&P 500*. Boston, MA: Trucost.
- Schneider, T. B. (2011). Is environmental performance a determinant of bond pricing? Evidence from the U.S. pulp and paper and chemical industries. *Contemporary Accounting Research*, 28(5), 1537-1561.
- Sharfman, M. P. and Fernando, C. S. (2008). Environmental risk management and the cost of capital. *Strategic Management Journal*, 29, 569-592.
- Stern, N. H. (2007). *The economics of climate change: the Stern Review*. Cambridge: Cambridge University Press.
- Subramaniam, N., Collier, P., Wines, G., Leung, P., Ferguson, C. et al. (2012). *Carbon Risk Management (CRM): A survey of carbon-intensive organisations in Australia*. Centre for Sustainable and Responsible Organisations. Retrieved from <http://www.deakin.edu.au/buslaw/research/csaro/docs/carbon.pdf>
- Subramaniam, N., Wahyuni, D., Cooper, B. J., Leung, P. and Wines, G. (2013). Integration of carbon risks and opportunities in enterprise risk management systems: Evidence from Australian firms. forthcoming, *Journal of Cleaner Production*.
- Suchard, J. A. (2007). The impact of right issues of convertible debt in Australian markets. *Journal of Multinational Financial Management*, 17, 187-202.
- Talberg, A. and Swoboda, K. (2013). *Emissions trading schemes around the world*. Department of Parliamentary Services. Retrieved from [http://parlinfo.aph.gov.au/parlInfo/download/library/prspub/2501441/upload\\_binary/2501441.pdf;fileType=application/pdf](http://parlinfo.aph.gov.au/parlInfo/download/library/prspub/2501441/upload_binary/2501441.pdf;fileType=application/pdf)
- Thompson, P. (1998). Bank lending and the environment: Policies and opportunities. *International Journal of Bank Marketing*, 16(6), 243-252.
- Thompson, P. and Cowton, C. J. (2004). Bringing the environment into bank lending: Implications for environmental reporting. *The British Accounting Review*, 36, 197-218.
- Twite, G. (2001). Capital structure choices and taxes: Evidence from the Australian dividend imputation tax system. *International Review of Finance*, 2(4), 217-234.
- UNEP FI. (2006). *Global climate change: Risk to bank loans*. Retrieved from [http://www.unepfi.org/fileadmin/documents/global\\_climate\\_change\\_risk.pdf](http://www.unepfi.org/fileadmin/documents/global_climate_change_risk.pdf)
- UNEP FI. (2013). *Portfolio carbon: Measuring, disclosing and managing the carbon intensity of investments and investment portfolios*. Retrieved from [http://www.unepfi.org/fileadmin/climatechange/UNEP\\_FI\\_Investor\\_Briefing\\_Portfolio\\_Carbon.pdf](http://www.unepfi.org/fileadmin/climatechange/UNEP_FI_Investor_Briefing_Portfolio_Carbon.pdf)
- VicSuper. (2009). *VicSuper carbon count 2009: The importance of disclosing carbon emissions for Australian business*. Melbourne.
- Wang, L., Li, S. and Gao, S. (2013). Do greenhouse gas emissions affect financial performance? – An empirical examination of Australian public firms. *Business Strategy and the Environment*, Early view. doi:10.1002/bse.1790.
- Weber, O. (2012). Environmental credit risk management in banks and financial service institutions. *Business Strategy and the Environment*, 21, 248-263.
- Weber, O., Fenchel, M. and Scholz, R. W. (2008). Empirical analysis of the integration of environmental risks into the credit risk management process of European banks. *Business strategy and the Environment*, 17, 149-159.
- Zsoka, A. N. (2008). Consistency and awareness gaps in the environmental behaviour of Hungarian companies. *Journal of Cleaner Production*, 16, 322-329.

**Table 1 Frequency Distribution by Year and Industry for a Sample of 255 Firm-Year Observations for Australian Firms over the Period 2009–2013**

<b><u>GICS Industry (Code)</u></b>	<b><u>2009</u></b>	<b><u>2010</u></b>	<b><u>2011</u></b>	<b><u>2012</u></b>	<b><u>2013</u></b>	<b><u>Total</u></b>
Energy (10)	6	5	5	5	6	<b>27</b>
Materials (15)	13	13	19	19	23	<b>87</b>
Industrials (20)	8	10	11	9	10	<b>48</b>
Consumer Discretionary (25)	2	4	4	3	5	<b>18</b>
Consumer Staples (30)	5	6	7	7	7	<b>32</b>
Health Care (35)	1	2	3	3	3	<b>12</b>
Telecommunication Services (50)	2	1	2	2	2	<b>9</b>
Utilities (55)	<u>4</u>	<u>5</u>	<u>4</u>	<u>4</u>	<u>5</u>	<b><u>22</u></b>
<b>Total</b>	<b>41</b>	<b>46</b>	<b>55</b>	<b>52</b>	<b>61</b>	<b>255</b>

**Table 2 Descriptive Statistics for a Sample of 255 Firm-Year Observations for Australian Firms over the Period 2009–2013**

	<i>COD</i>	<i>CARBON</i>	<i>CDP</i>	<i>SIZE</i>	<i>LEV</i>	<i>ROA</i>	<i>AUS_Z</i>	<i>MB</i>	<i>CUR_RAT</i>	<i>INT_COV</i>	<i>EAR_VOL</i>	<i>CF_VOL</i>	<i>TANG</i>	<i>NEW</i>	<i>CAP_INT</i>
<i>Panel A: The full sample (n = 255)</i>															
Mean	.0718	.0005	0.65	9.691	0.266	0.087	-0.200	1.181	1.482	6.924	0.031	0.040	0.426	0.609	0.219
Median	.0719	.0001	1.00	9.678	0.238	0.084	-0.282	0.987	1.307	4.749	0.013	0.022	0.409	0.608	0.072
Std. Dev	.0204	.0014	0.48	0.521	0.157	0.081	1.858	0.792	0.939	22.291	0.066	0.052	0.213	0.154	0.613
Minimum	.0323	.0000	0.00	8.404	0.000	-0.677	-5.314	0.170	0.163	-264.484	0.001	0.000	0.038	0.146	0.004
Maximum	.1217	.0175	1.00	11.103	0.760	0.328	16.229	7.992	9.091	119.042	0.683	0.379	0.899	0.987	9.090
<i>Panel B: The sub-samples partitioned on the basis of the industry mean of carbon risk (CARBON)</i>															
<b>High emitting industries (n = 184)</b>															
Mean	.0724	.0007	0.69	9.651	0.265	0.074	-0.034	1.077	1.569	6.043	0.038	0.048	0.478	0.635	0.280
Median	.0728	.0002	1.00	9.681	0.233	0.074	-0.258	0.895	1.426	4.130	0.017	0.028	0.477	0.629	0.093
Std. Dev	.0215	.0017	0.46	0.532	0.173	0.087	2.029	0.746	1.028	25.292	0.076	0.058	0.205	0.161	0.713
Minimum	.0323	.0000	0.00	8.404	0.000	-0.677	-5.314	0.170	0.163	-264.484	0.001	0.001	0.038	0.146	0.004
Maximum	.1217	.0175	1.00	11.103	0.760	0.328	16.229	7.992	9.091	119.042	0.683	0.379	0.899	0.987	9.090
<b>Low emitting industries (n = 71)</b>															
Mean	.0703	.0000	0.56	9.796	0.272	0.123	-0.630	1.450	1.260	9.206	0.013	0.020	0.291	0.543	0.063
Median	.0696	.0000	1.00	9.673	0.246	0.115	-0.596	1.268	1.124	6.224	0.009	0.014	0.262	0.552	0.046
Std. Dev	.0174	.0000	0.50	0.479	0.104	0.050	1.226	0.847	0.605	11.105	0.016	0.022	0.170	0.110	0.045
Minimum	.0330	.0000	0.00	8.833	0.082	-0.021	-3.127	0.324	0.264	-0.946	0.001	0.000	0.052	0.318	0.005
Maximum	.1069	.0001	1.00	10.635	0.559	0.293	2.275	4.939	3.624	81.779	0.097	0.125	0.675	0.801	0.202
<i>t</i> -statistic	0.790	5.342	1.854	-2.108	-0.392	-5.661	2.855	-3.256	2.960	-1.385	4.286	5.666	7.430	5.219	4.107
( <i>p</i> -value)	(0.430)	(0.000)	(0.066)	(0.037)	(0.696)	(0.000)	(0.005)	(0.001)	(0.003)	(0.167)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

*Variable definitions:* *COD* is interest expense divided by average interest-bearing debt; *CARBON* is total Scope 1 GHG emissions divided by sales revenues; *CDP* is an indicator variable equal to one if a firm responds to the CDP survey, and zero otherwise; *SIZE* is the logarithm of total assets; *LEVERAGE* is total debt divided by total assets; *ROA* is earnings before interest and taxes divided by total assets; *AUS\_ZSCORE* is an Australian Z score from Aldamen and Duncan (2012); *MB* is the market value of equity plus the book value of debt divided by total assets; *CUR\_RAT* is current assets divided by current liabilities; *INT\_COV* is earnings before interest and taxes divided by interest expense; *EAR\_VOL* is the standard deviation of net income before extraordinary items, scaled by average assets, over the past three years; *CF\_VOL* is the standard deviation of cash flow from operations, scaled by average assets, over the past three years; *TANG* is net property, plant and equipment divided by total assets; *NEW* is net property, plant and equipment divided by gross property, plant and equipment; and *CAP\_INT* is capital expenditures divided by sales revenues.

The *t*-test is for difference in mean values between the high and low emitting industries (*p*-values are two-tailed).

**Table 3 Pearson Correlation Matrix for a Sample of 255 Firm-Year Observations for Australian Firms over the Period 2009–2013**

	<i>COD</i>	<i>CARBON</i>	<i>CDP</i>	<i>SIZE</i>	<i>LEVERAGE</i>	<i>ROA</i>	<i>AUS_ZSCORE</i>	<i>MB</i>	<i>CUR_RAT</i>	<i>INT_COV</i>	<i>EAR_VOL</i>	<i>CF_VOL</i>	<i>TANG</i>	<i>NEW</i>
<i>COD</i>	1.000													
<i>CARBON</i>	0.021	1.000												
<i>CDP</i>	-0.103	-0.095	1.000											
<i>SIZE</i>	-0.306***	-0.233***	0.451***	1.000										
<i>LEVERAGE</i>	0.083	0.273***	-0.074	0.023	1.000									
<i>ROA</i>	0.041	-0.236***	0.132**	0.184***	0.028	1.000								
<i>AUS_ZSCORE</i>	-0.037	0.718***	-0.242***	-0.222***	0.584***	-0.379***	1.000							
<i>MB</i>	-0.101	-0.039	0.024	0.014	-0.023	0.535***	-0.142**	1.000						
<i>CUR_RAT</i>	-0.012	-0.052	0.053	-0.167***	-0.379***	0.141**	-0.197***	0.231***	1.000					
<i>INT_COV</i>	-0.051	-0.044	0.108*	0.133**	-0.159**	0.759***	-0.240***	0.332***	0.219***	1.000				
<i>EAR_VOL</i>	0.192***	-0.001	-0.159**	-0.273***	-0.043	0.214***	0.036	0.471***	0.121*	0.139**	1.000			
<i>CF_VOL</i>	0.115*	-0.036	-0.158**	-0.321***	-0.122*	0.136**	0.001	0.233***	0.323***	0.103	0.755***	1.000		
<i>TANG</i>	-0.157**	0.169***	0.056	0.114*	0.267***	0.029	0.155**	0.116*	-0.110*	0.043	0.194***	0.147**	1.000	
<i>NEW</i>	0.010	-0.065	0.027	0.041	0.221***	0.108*	0.072	0.156**	-0.011	0.095	0.245***	0.258***	0.421***	1.000
<i>CAP_INT</i>	0.049	0.177***	0.053	-0.009	0.040	-0.135**	0.117*	0.086	0.192***	-0.065	0.147**	0.109*	0.202***	0.292***

Variable definitions: *COD* is interest expense divided by average interest-bearing debt; *CARBON* is total Scope 1 GHG emissions divided by sales revenues; *CDP* is an indicator variable equal to one if a firm responds to the CDP survey, and zero otherwise; *SIZE* is the logarithm of total assets; *LEVERAGE* is total debt divided by total assets; *ROA* is earnings before interest and taxes divided by total assets; *AUS\_ZSCORE* is an Australian Z score from Aldamen and Duncan (2012); *MB* is the market value of equity plus the book value of debt divided by total assets; *CUR\_RAT* is current assets divided by current liabilities; *INT\_COV* is earnings before interest and taxes divided by interest expense; *EAR\_VOL* is the standard deviation of net income before extraordinary items, scaled by average assets, over the past three years; *CF\_VOL* is the standard deviation of cash flow from operations, scaled by average assets, over the past three years; *TANG* is net property, plant and equipment divided by total assets; *NEW* is net property, plant and equipment divided by gross property, plant and equipment; and *CAP\_INT* is capital expenditures divided by sales revenues.

\*, \*\*, \*\*\* Indicate that correlation is significant at the 10 percent, 5 percent and 1 percent levels, respectively.

**Table 4 Regression results for a Sample of 255 firm-year Observations for Australian Companies over the Period 2009–2013**

<u>Variable</u>	<u>Sign</u>	<u>Model I</u>		<u>Model II</u>	
Intercept		0.165	(< 0.001)	0.165	(< 0.001)
<i>CARBON</i>	+	<b>2.201<sup>**</sup></b>	<b>(0.042)</b>	<b>3.152<sup>***</sup></b>	<b>(0.004)</b>
<i>CDP</i>	?	---		0.002	(0.654)
<i>CARBON * CDP</i>	-	---		<b>-7.410<sup>***</sup></b>	<b>(0.002)</b>
<i>SIZE</i>	-	-0.012 <sup>***</sup>	(< 0.001)	-0.012 <sup>***</sup>	(< 0.001)
<i>LEV</i>	+	0.021	(0.136)	0.021	(0.133)
<i>ROA</i>	-	0.064 <sup>*</sup>	(0.053)	0.071 <sup>**</sup>	(0.033)
<i>AUS_ZSCORE</i>	+	-0.004 <sup>***</sup>	(0.003)	-0.004 <sup>***</sup>	(0.001)
<i>M_B</i>	-	-0.009 <sup>***</sup>	(< 0.001)	-0.009 <sup>***</sup>	(< 0.001)
<i>CURR_RATIO</i>	-	0.001	(0.318)	0.002	(0.235)
<i>INT_COV</i>	-	0.000	(0.134)	0.000 <sup>*</sup>	(0.099)
<i>EAR_VOL</i>	+	0.141 <sup>***</sup>	(< 0.001)	0.138 <sup>***</sup>	(< 0.001)
<i>CF_VOL</i>	+	-0.077 <sup>**</sup>	(0.040)	-0.084 <sup>**</sup>	(0.022)
<i>TANG</i>	-	-0.021 <sup>***</sup>	(0.002)	-0.017 <sup>***</sup>	(0.008)
<i>NEW</i>	?	0.004	(0.726)	0.004	(0.739)
<i>CAP_INT</i>	-	0.002	(0.112)	0.005 <sup>***</sup>	(0.001)
<i>CAS_RAT</i>	+	0.410 <sup>**</sup>	(0.017)	0.432 <sup>**</sup>	(0.011)
<i>Industry Indicators</i>		Y		Y	
<i>Adjusted R<sup>2</sup></i>		0.300		0.317	

*Variable definitions:* *COD* is interest expense divided by average interest-bearing debt; *CARBON* is total Scope 1 GHG emissions divided by sales revenues; *CDP* is an indicator variable equal to one if a firm responds to the CDP survey, and zero otherwise; *SIZE* is the logarithm of total assets; *LEV* is total debt divided by total assets; *ROA* is earnings before interest and taxes divided by total assets; *AUS\_ZSCORE* is an Australian Z score from Aldamen and Duncan (2012); *MB* is the market value of equity plus the book value of debt divided by total assets; *CUR\_RATIO* is current assets divided by current liabilities; *INT\_COV* is earnings before interest and taxes divided by interest expense; *EAR\_VOL* is the standard deviation of net income before extraordinary items, scaled by average assets, over the past three years; *CF\_VOL* is the standard deviation of cash flow from operations, scaled by average assets, over the past three years; *TANG* is net property, plant and equipment divided by total assets; *NEW* is net property, plant and equipment divided by gross property, plant and equipment; *CAP\_INT* is capital expenditures divided by sales revenues; and *CAS\_RAT* is the average cash rate.

\*, \*\*, \*\*\* statistically significant at the 10 percent, 5 percent and 1 percent levels, respectively.

Models are estimated using OLS regressions with industry indicators and clustered standard errors by firm and year.

**Table 5 Regression results for a Sample of 255 firm-year Observations for Australian Companies over the Period 2009–2013 Partitioned by Carbon Intensity**

<u>Variable</u>	<u>Sign</u>	<u>High Emitting (n = 184)</u>		<u>Low Emitting (n = 71)</u>	
Intercept		0.193	(< 0.001)	0.165	(< 0.001)
<b>CARBON</b>	+	<b>3.025<sup>***</sup></b>	<b>(0.034)</b>	<b>1353.328<sup>***</sup></b>	<b>(0.003)</b>
<b>CDP</b>	?	0.002	(0.618)	<b>0.014<sup>**</sup></b>	<b>(0.017)</b>
<b>CARBON * CDP</b>	-	<b>-7.889<sup>***</sup></b>	<b>(0.004)</b>	<b>-872.717<sup>***</sup></b>	<b>(0.009)</b>
<i>SIZE</i>	-	-0.014 <sup>***</sup>	(0.004)	-0.008	(0.162)
<i>LEV</i>	+	0.030 <sup>***</sup>	(< 0.001)	-0.021	(0.609)
<i>ROA</i>	-	0.072 <sup>*</sup>	(0.051)	0.032	(0.589)
<i>AUS_ZSCORE</i>	+	-0.005 <sup>*</sup>	(0.097)	-0.005	(0.172)
<i>M_B</i>	-	-0.006 <sup>***</sup>	(0.006)	-0.008 <sup>**</sup>	(0.026)
<i>CURR_RATIO</i>	-	0.002	(0.107)	0.000	(0.930)
<i>INT_COV</i>	-	0.000	(0.272)	-0.001 <sup>**</sup>	(0.041)
<i>EAR_VOL</i>	+	0.118	(0.178)	0.196	(0.229)
<i>CF_VOL</i>	+	-0.084 <sup>***</sup>	(0.005)	-0.124	(0.311)
<i>TANG</i>	-	-0.022 <sup>**</sup>	(0.041)	0.003	(0.832)
<i>NEW</i>	?	-0.003 <sup>***</sup>	(0.007)	-0.030	(0.372)
<i>CAP_INT</i>	-	0.005	(0.836)	0.083 <sup>*</sup>	(0.099)
<i>CAS_RAT</i>	+	0.399 <sup>***</sup>	(< 0.001)	0.294	(0.268)
<i>Industry Indicators</i>		Y	(0.055)	Y	
<i>Adjusted R<sup>2</sup></i>		0.322		0.509	

*Variable definitions:* *COD* is interest expense divided by average interest-bearing debt; *CARBON* is total Scope 1 GHG emissions divided by sales revenues; *CDP* is an indicator variable equal to one if a firm responds to the CDP survey, and zero otherwise; *SIZE* is the logarithm of total assets; *LEV* is total debt divided by total assets; *ROA* is earnings before interest and taxes divided by total assets; *AUS\_ZSCORE* is an Australian Z score from Aldamen and Duncan (2012); *MB* is the market value of equity plus the book value of debt divided by total assets; *CUR\_RATIO* is current assets divided by current liabilities; *INT\_COV* is earnings before interest and taxes divided by interest expense; *EAR\_VOL* is the standard deviation of net income before extraordinary items, scaled by average assets, over the past three years; *CF\_VOL* is the standard deviation of cash flow from operations, scaled by average assets, over the past three years; *TANG* is net property, plant and equipment divided by total assets; *NEW* is net property, plant and equipment divided by gross property, plant and equipment; *CAP\_INT* is capital expenditures divided by sales revenues; and *CAS\_RAT* is the average cash rate.

\*, \*\*, \*\*\* statistically significant at the 10 percent, 5 percent and 1 percent levels, respectively.

Models are estimated using OLS regressions with industry indicators and clustered standard errors by firm and year.