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**Corporate Environmental Performance and its Impact on
Financial Performance and Financial Risk: Evidence from
Australia**

A thesis
submitted in fulfilment
of the requirements for the degree
of

Doctor of Philosophy in Finance

at
The University of Waikato
by

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THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

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Abstract

Corporate Environmental Performance and its Impact on Financial Performance and Financial Risk: Evidence from Australia

This thesis consists of four essays on Corporate Environmental Performance (CEP) and its impact on Corporate Financial Performance (CFP). The first essay is entitled “Emission Indices for Hazardous Substances: An Alternative Measure of Corporate Environmental Performance”. This essay reviewed significant interdisciplinary research and concluded that firm chemical release/emission can be used as a proxy for a firm measure of environmental performance. It also proposed that due to the variety of chemicals and different levels of toxicity, a risk factor should be calculated for all chemicals on the basis of human health risk, environment risk and risk of exposure. Once a single risk factor is calculated for each chemical, then it should be multiplied by the level of each company chemical release that is reported to National Pollutant Inventory in order to calculate the weighted average risk factor for each company. Thus, the weighted average risk is a robust measure having the combined effect of level of toxicity and volume of chemical emissions.

Once the environmental performance index is formulated, the second essay investigated the nature of the relationship between environmental performance and financial performance of publicly listed companies in Australia. The second essay provided evidence that the nature of the relationship between environmental performance and financial performance is positive. Further, this study divided the sample into a period of economic growth (2001-2007) and a period of economic contraction (2008-2010). The multivariate regression estimation shows a positive

relation between CEP and CFP in the period of economic growth but during the extra ordinary circumstances like the financial crisis this relationship is insignificant. This research is of great relevance for managers, academics and society at large.

The third essay investigates the relationship between Corporate Environmental Performance (CEP) and financial risk for Australian listed companies from 2001-2010. Three financial risk measures including firm market risk, systematic risk and downside risk were used. The analytical procedure based on fixed effects estimation provides strong evidence that environmental performance is negatively and statistically associated with market volatility and to different measures of downside risk. The third essay results show that downside risk is a better measure of firm risk especially when investors are not showing linear sensitivity to changes in prices. Therefore, this study concludes that environmental performance (reduction in toxic emissions) provides a wealth protection effect. The results are robust after controlling for several moderating effects including financial, institutional and environmental management.

The fourth essay analyses the causal relationship between firm financial performance and environmental performance. The results provide convincing support for the idea that there is a bi-directional relationship between CEP and CFP in both the short and long run. These results support the Hart and Ahuja (1996) hunch that a ‘virtuous circle’ exists with regard to the relationship between pollution prevention and CFP, that is, firms can realize cost savings and plough these savings back into further emission reduction projects for a number of years before the benefits balance turns negative.

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Chapter 1

Introduction

1.1 Introduction

The concept of corporate environmental performance (CEP) has evolved over recent decades. This has implications for corporate environmental policy and management. Corporations shifting from cleaner production towards green¹ and sustainable² production (Eweje, 2011) have sparked the interest of academics to look at the shareholders' response to environmental responsible initiatives (Darnall, 2009; Darnall, Henriques, & Sadowsky, 2010). Scientific discoveries are now disclosing the side effects³ of different pathways of economic growth and depletion of natural resources. Regulators are proactively looking for legislation to control corporate environmental misconduct and design climate mitigation policies (Aldy, Krupnick, Newell, Parry, & Pizer, 2010; Bates, 1995; Welford, 1999). Civil society is engaged via media campaigns and a diverse set of green movements. The business community, including investors, are also influenced by this massive wave of information and awareness. However, the degree of influence remains uncertain. This thesis tries to define environmental performance construct and its impact on corporate financial performance (CFP) and financial risk. It also tries to analyse the extant literature hunch of 'virtuous circle', CEP and CFP supports back and forth each other. In the next section, we will discuss the motivation for this study followed by an outline of the thesis.

¹ A "green" production is based on technologies with joint production of a private good and an environmental public good (Kotchen, 2006)

² A business approach that creates long term shareholder value by embracing opportunities and managing risks deriving from economic, environmental and social developments (Mandelbaum, 2007)

³ For example, In 1974, about 45 years after the discovery of the cooling agent, it was found that cooling agent used in refrigerators destroy the ozone layer and as a result increases ultraviolet radiation to earth (Beck, 2006).

1.2 Motivation

Environmental issues are becoming more material in modern knowledge based society. As it affects the majority, there is a widespread need for governments and institutions to take on their responsibilities and play a role to control and reduce the level of chemicals and toxic wastes produced during the production. Chemical management is a major issue in the modern world. It is a growing concern with economic, environmental and other dimensions. There is still a long way to go to achieve a single regulatory framework to implement globally harmonized system of classification, controlling and labelling of chemicals. Currently, many governments especially from developing countries hesitate to implement a chemical management system as it is believed an unnecessary production barrier to their industries that ultimately will slow down their economic growth. These countries are at risk of being left behind in the transition to low waste production as well as in future environmental adaptation and mitigation efforts. It therefore, triggers a complex conflict of interests and disagreement concerning legislation to control pollution, hazardous wastes and toxic chemical. This all results in unsatisfactory regulatory frameworks and ends up with a more polluted world that is a threat to biodiversity and to human quality of life.

There is an equal need in the area of economics and finance to further investigate the linkage between lower toxic chemical emissions and better financial performance. If research found any positive relationship then civil society in general and investors in particular can convince governments around the globe to agree and promote a unified regulatory framework for chemicals and hazardous waste control or encourage corporates to take preventive measure against production wastes/chemicals due to its potential economic benefits.

Research using Pollutant Release and Transfer Register (PRTR) data is quite mature in some countries. For example in the United States, there are number of papers that have used PRTR data as a proxy for environmental performance and analysed CEP/firm performance. In Australia the PRTR data was established in 1998 as National Pollutant Inventory (NPI). This thesis research has failed to locate a single study using this database when analysing CEP/firm performance. Therefore, this thesis uses PRTR data to study firm environmental performance in Australian market for the first time. The advantage of this database is its comprehensiveness and the public access to the data.

The majority of the extant literature has used gross weights of chemical emissions to form a proxy for environmental sustainability performance. Summing annual chemical emission of all substances for a company in a given year is a poor proxy for environmental performance as the potential harm caused by a specific substance depends on number of factors (Toffel & Marshall, 2004). There is added incentive when shareholders understand the toxicity of such materials and their potential impact on environment and public health. If shareholders believe their actions will improve the surrounding environment and their health, this may be enough of an incentive to act (Stephan, 2002). Very few authors have considered the relative risk of chemicals. There is evidence from some research that despite reducing the waste (mass of chemical emissions to air and water), toxicity from chemical emissions may be increasing through waste transfers (Harrison & Antweiler, 2003).

The question of what an emission means in terms of risk is also frequently raised in PRTR discussions. Toxic impact cannot be directly interpreted from the mass amounts of waste emission. Therefore, we need a comprehensive, transparent,

concise and composite approach that considers human health, the environment and exposure. In most cases the focus is on one of the three aspects. For example, Toffel and Marshall (2004) recommended United States Risk Screening Environmental Indicators for estimating impact to human health and the Tools for the Reduction and Assessment of Chemical Impacts for estimating impacts to the environment. Hence, the toxicity weighting system in this thesis is considered to be the most useful tool for comparing and analysing the relative risk of pollutants because it combines environment, human health and exposure in one single hazard risk score.

1.3 Survey of relevant research

A large body of academic studies have explored the question, “Does it pay to be green?” (El Ghouli, Guedhami, Kwok, & Mishra, 2011; Heinkel, Kraus, & Zechner, 2001; Horváthová, 2010; Muhammad & Scrimgeour, 2014a). This idea of improved corporate environmental performance leading to financial benefits continues to be explored in both the academic literature and the business press. Despite continued research over the last two decades, the relationship remains unclear. As a result, academic curiosity is growing with regards to identifying (1) more relevant performance criteria that may be used as proxy for CEP, (2) more valid performance criteria for corporate financial performance (3) providing relevant theoretical basis (4) identifying variables that may moderate the CEP–CFP relationship and (5) adopting more robust econometric techniques.

Developing reliable environmental performance criteria is the most difficult task. Extant literature has used a number of variables as proxy for CEP. These performance indicators include recycling of company waste, chemical release by companies, greenhouse gas emissions like CO₂ and ISO-14001 certificates

(Muhammad, Scrimgeour, Reddy, & Abidin, 2014). Some studies have used ratings developed by professional organisations like Kinder, Lydenberg & Domini (KLD), Corporate Environmental Data Clearinghouse (CEDC) and Ethical Investment Research Services (EiRiS). Apart from these ratings, other proxies are also used to measure corporate environmental performance. For example, perceptual measures like environmental strategy (Sharma & Vredenburg, 1998), environmental competitive advantages (Karagozoglu & Lindell, 2000; Marín, Rubio, & Maya, 2012), environmental management practices (Carmona-moreno & Cééspedes-lorente, 2004; González-benito & González-benito, 2005; Marti, Rovira-Val, & Drescher, 2013) and integration of environmental performance issues into strategic planning processes (Judge & Douglas, 1998; Weber, 2005).

Similarly extant literature is not consistent in using financial performance indicators. Some studies have used market based financial performance whereas others have used accounting bases financial performance. According to Muhammad and Scrimgeour (2014b), each financial performance indicator has its own characteristic and is meant to address different performance of the firm from different angles. Griffin and Mahon (1997) reviewed 51 studies and listed all of the financial measures. They found that researchers have used 80 different measures of corporate financial performance. Over 70% of financial performance measures were used only once and without repetition. They concluded that the use of a wide range of multiple measures for both CEP and CFP, with little or no replication or checks for validity and reliability, suggests a need to focus on a few, key CEP and CFP research measures to increase internal validity rather than generalizability.

Another reason for inconsistent results is the lack of a robust theoretical lens. Since CEP involves ideas and knowledge from different disciplines, theoretical views are diverse. Under the neoclassical paradigm, environmental issues were merely considered as a regulator's issue and the private sector did not pay any significant attention beyond responding to regulations. On the other hand contemporary companies cannot avoid the negative impact of poor environmental performance on tangible costs and the balance sheet as shareholders in public corporations play a dual role in shaping the political agenda by active engagement and influencing various behaviours to enforce corporations to pay attention to some issues of importance like environment and climate change (Clark & Crawford, 2012). Hillman and Hitt (1999) claim that the political economy⁴ view focuses on structural relationships where financial and economic decisions are taken on socially-related perspectives. Political economy offers a descriptive, interpretive and critical approach to understand the implied motivations of corporate environmental performance from a social perspective. Corporations cannot function their financial and economic activities in isolation. Political economy links the functioning of the market and political process and the interaction between the two that finally has an impact on society (Preston & Post, 1975). As the ideas of political economy explain the theoretical framework at the broader level, there are several other theoretical perspectives including agency theory, instrumental stakeholder theory, good management theory, slack resource theory and the natural resource based view that have been used to understand environmental performance as an economic activity.

⁴ Political economy refers to the social, political and economic framework within which business activities occur (Hillman & Hitt, 1999)

The last reason for getting inconsistent results is the choice among models estimated. Ambec and Lanoie (2008) have categorized research methodologies into: (1) portfolio analysis; (2) event studies and (3) regression studies. In portfolio studies, different equity portfolios' financial performance is compared with the environmental performance. For example, Diltz (1995) divided companies into high polluting firms portfolio and low polluting firms portfolio. Event studies analyse the response of a firm to a particular event(s) like release of emission data, awards or lawsuits to financial performance. Lastly, regression analysis compares the relationship between firm characteristics which include environmental performance and financial performance.

Since the extant literature is divided for the aforementioned reasons, this thesis addresses several issues by investigating a new empirical market (Australia) and using data that is not been rigorously analysed, developing composite method to measure Corporate Environmental Performance (CEP) that can be used and replicated in other countries, analysing CEP impact on Corporate Financial Performance (CFP), Corporate Financial Risk (CFR) and also analysing whether there is any reverse causality. It will be discussed in more detail in following sections.

1.4 Contribution

First, the existing literature shows that the environmental performance measures used by researchers tend to be inconsistent. According to Delmas and Blass (2010), environmental performance indicators can be divided into 3 main categories:

(1) Environmental Impact; (e.g. emissions, usage of energy, toxicity/Spills, plant accidents and aftermaths of these accidents)

(2) Regulatory Compliance; (e.g. mandatory installation of treatment and recycling plant, lawsuits concerning improper disposal of hazardous waste and fines for its clean up)

(3) Organization Process; (e.g. environmental management system (ISO-14001 Awards), environmental reporting like Triple Bottom Line Reports and capital expenditures in pollution control technology (R&D).

Considering this divide, this study presented a new proxy for environmental performance based on publicly available chemical release information in form of Pollutant Release and Transfer Registers⁵ (PRTRs). This new proxy is based on chemical toxicity weighting system which may be used to study corporate environmental sustainability performance. It measures the current or past environmental performance of a firm, depicting the large volume of chemical release and environmental data in a comprehensive, transparent and concise manner, and if required they may be compared to the targets set. A growing number of researchers and professionals are using PRTR as a proxy for corporate environmental sustainability performance because of the comprehensiveness and easy availability of the data. Although there have been multiple efforts to measure sustainability, only a few of them have used a composite approach taking into account human health, the environment and exposure. In most cases the focus is on one of the three aspects. For example, Toffel and Marshall (2004) recommended United States Risk Screening Environmental Indicators for estimating impact to human health and the Tools for the Reduction and Assessment of Chemical Impacts for estimating impacts to the environment.

⁵ The Organization for Economic Co-operation and Development (OECD), in cooperation with the United Nations Economic Commission for Europe (UNECE) and the United Nations Environment Program developed and maintained the PRTR database. It keeps record of several key chemicals emitted to air, water and ground (PRTRs, 2012).

Hence, the toxicity weighting system developed in this thesis is considered to be the most useful tool for comparing and analysing the relative risk of pollutants because it combines environment, human health and exposure in one single hazard risk score.

Second, prior research has used both quantitative and qualitative research methods to determine the relationship between the variations in corporate environmental performance (CEP) and corporate financial performance (CFP). CEP plays an important role in the CFP, maybe because economic benefits could be reduced by the higher expenditure in CEP initiatives, or maybe due to the potential profitability or higher stock prices. However, a fundamental debate exists in relation to what happens to CEP in the actual economic environment. From this perspective, this thesis has sought to evaluate the effects of CEP on CFP prior and after the financial crisis. To analyse this effect, two hypotheses were posited: the first one, there is a positive relationship between CEP and CFP in period of economic growth and the second hypothesis that there is no relationship between CEP and CFP in period of financial crisis. Both hypotheses are not rejected. This means that CEP has a relationship with CFP and that this positive relationship is statistically significant only in time of economic growth. This study tries to overcome several methodological problems. For example, this study controls for firm level unobserved heterogeneity and utilises several financial and sustainability related dimensions as moderating variables that are not used in extant literature.

Third, there has been minimal work linking environmental performance with firm financial risk. Although, there is empirical evidence from the literature that investors give consideration to environmental performance when making

investment decisions (Heinkel et al., 2001; Mackey, Mackey, & Barney, 2007). We offer an alternative empirical pathway in relation to the CEP-CFP connection by investigating whether CEP has a wealth protective impact rather wealth maximisation impact on corporations. We utilised different measures of firm risk and in particular downside risk. Thus it is a significant contribution to the extant literature by employing different measures of firm risk as a key dependent variable.

Finally, the extant literature on the relationship between CEP and CFP shows inconclusive results. One of the most critical issue in this relationship is determining the direction of causality (i.e., whether CEP influences CFP, whether CFP influences CEP, or whether there is a bidirectional relationship) (Ambec & Lanoie, 2008; Molina-Azorín, Claver-Cortés, López-Gamero, & Tarí, 2009). There are very few papers focusing on causality at the firm level. For example, Wagner, Phu, Azomahou, and Wehrmeyer (2002) used simultaneous equation modelling to address the issue of causality. They find no evidence that CFP influences CEP but Nakao, Amano, Matsumura, Genba, and Nakano (2007) used the Granger causality test proposed by Hurlin and Venet (2001) in their study. They find that CFP positively influences CEP. Therefore, the research question *“is it corporate environmental performance that leads to better financial performance or do better financial performing companies have the ability to spend more on environmental responsive initiatives?”* need empirical investigation. Hence this study analysed the causal relationship between

environmental performance and financial performance at the firm level using ten years of panel data⁶ from Australia.

1.5 Outline of this Thesis

This thesis comprises four papers, presented respectively in chapters 2, 3, 4 and 5. In the first paper (Chapter 2) entitled “Emission Indices for Hazardous Substances: An Alternative Measure of Corporate Environmental Performance”, this study uses industrial chemical release, as listed in Pollutant Release and Transfer Registers (PRTRs) as a proxy for environmental performance and presents toxicity weightings for over ninety chemicals in the Australian PRTR. It incorporates three different dimensions: human health, the environment and exposure. The chapter identifies gaps in the literature where more research is required and propose several research questions. This paper is accepted for publication in an ISI-Indexed (Impact Factor = 2.054), peer reviewed journal (Corporate Social Responsibility and Environmental Management). Chapter 3 builds upon paper 1 (Chapter 2). In paper 2 (Chapter 3) entitled “The Relationship between Environmental Performance and Financial Performance in Periods of Growth and Contraction”, examines the nature of the relationship between environmental performance and financial performance of publicly listed companies in Australia. In particular, after controlling for unobserved company effects, and dividing the sample into pre-and-post the global financial crisis period. Paper 3 (Chapter 4) entitled “The relationship between environmental performance and financial risk: The Australian industry case”, builds upon paper 2 (wealth maximisation) and paper 1 (corporate environmental performance index). This paper 3 is accepted for publication in an ISI-Indexed (Impact Factor

⁶ We are using the most recent statistical technique for panel data by Dumitrescu and Hurlin (2012)

= 1.552), peer reviewed journal (Journal of Business Ethics). Paper 3 investigates the wealth protection effect from reduced toxic release. In particular, it utilises the downside measures of risk because behavioural finance studies show that investors are more sensitive towards downwards movements in market and ask for premiums to pay-off the extra risk and a safety first principle is prevailing. Paper 4 (Chapter 5) discusses the causal relationship between improved environmental performance and firm financial performance. It investigate a research question “is it corporate environmental performance that leads to better financial performance or better financial performing companies have the ability to spend more on environmental responsive initiatives?”. Further this study uses the most recent technique of Dumitrescu and Hurlin (2012) to study the long and short term causality in panel data context.

1.6 Conclusion

Despite wide-ranging studies conducted by various authors around the globe to evaluate the impact of corporate environmental performance initiatives as a response to increasing environmental concern in the last two decades, the effectiveness of corporate environmental performance initiatives in Australia remains unclear. Extant literature indicates that huge differences in environmental performance measures, methodologies and theoretical foundations have contributed towards the inconclusive results. This study extends prior research (i) adopting an innovative environmental performance measure (ii) studies the impact of environmental performance on financial performance in time of growth and contraction (iii) evaluates the impact of environmental performance on different measures of risk and (iv) studies the long and short term causal relationship

between corporate environmental performance and corporate financial performance.

Declaration about the role and contribution of Authors

I (Noor Muhammad) am chiefly responsible for the conceptualisation, review of literature and empirical analysis as well as the writing of this manuscript. Frank Scrimgeour supervised each step of this process. In particular, Frank Scrimgeour gave conception advice on this work and commented on all versions of the manuscript. Krishna Reddy and Sazali Abidin gave conception advice and edited the final paper.

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Chapter 2

Emission Indices for Hazardous Substances: An Alternative Measure of Corporate Environmental Performance

Abstract

Accurate measurement and interpretation of pollution emissions and reduction in these emissions is a crucial part of reporting to enhance environmental management and improve the sustainability of both business and the environment. This study uses industrial chemical release, as listed in Pollutant Release and Transfer Registers (PRTRs) as a proxy for environmental performance and presents toxicity weightings for over ninety chemicals in the Australian PRTR. It incorporates three different dimensions: human health, the environment and exposure. The use of toxicity weighted emission indicators has far-reaching advantages for corporate managers and policy makers, and external analysts. In contrast to mass-based emission indicators it provides robust guidance for risk amelioration.

Keywords: Emissions, Toxic Weighting, PRTR, Sustainability

2.1 Introduction

Agenda 21 of the United Nation Conference on Environment and Development (UNCED) at Rio de Janeiro in 1992 emphasized the global challenge of reducing industrial emissions. A specific goal within the agenda was to collect and track the emission inventories of member countries. Since the establishment of such databases, managers, regulators, non-profit organisations, and the media are increasingly using this data to measure corporate environmental sustainability performance.

The majority of the relevant management literature has used company-level measures of environmental sustainability performance based on Pollutant Release and Transfer Registers (PRTRs). For example, Horváthová (2012) examined environmental performance effects on financial performance using the Czech PRTR. Similarly, there is a significant amount of literature using the United States PRTR to analyse environmental performance and its impact on financial performance (Cohen, Fenn, & Konar, 1997; Connors, Johnston, & Gao, 2013; Gerde & Logsdon, 2001; Hart & Ahuja, 1996; Khanna, Quimio, & Bojilova, 1998; King & Lenox, 2002; Ragothaman & Carr, 2008). The majority of these studies have used gross weights of chemical emissions to form a proxy for environmental sustainability performance. Summing annual chemical emission of all substances for a company in a given year is a poor proxy for environmental performance as the potential harm caused by a specific substance depends on number of factors (Toffel & Marshall, 2004). There is added incentive when shareholders understand the toxicity of such materials and their potential impact on environment and public health. If shareholders believe their actions will improve the surrounding environment and their health, this may be enough of an

incentive to act (Stephan, 2002). Very few authors have considered the relative risk of chemicals as assessed in USEtox⁷ in their studies (Bosworth & Clemens, 2011) or used a ratio that divides the total emitted amount by the reporting threshold, if emissions are higher than the threshold (Horváthová, 2012).

In this paper we present a toxic weighting score that can be estimated at industry, company and individual facility level using Australian PRTR data. It is a composite toxicity measure that not only accounts for chemical toxicity to the environment but also for effects on human health and the consequences of large-scale population exposure to the substance. In the absence of a toxicity scheme and using only mass chemical data, there may be improper applications and erroneous conclusions made following the use of such emission data by both expert and less expert users. Differences in interpretation will reduce confidence in emission data and limit their use by industry and government (Department of the Environment and Heritage Australia, 2005). This study is important because there is evidence that despite reducing the mass of chemical emissions to air and water, toxicity from chemical emissions may have increased through waste transfers (Harrison & Antweiler, 2003). This has important implications for commerce, governments and other stakeholders. The use of a toxicity weighting score has far-reaching advantages over the use of mass emissions to express environmental information because it reduces the cost of information acquisition and increases participation by all stakeholders affected by emission outputs. Hence, it works as “*information as regulation*”. The availability of reliable and consistent information encourages stakeholders (including the media) to compare the performance of companies with each other. Companies that have poor

⁷ USEtox characterization factors are consensus based, include more chemicals, and account for the exposure pathways air, water, ground (Bosworth & Clemens, 2011)

performance indicators may be embarrassed and could face a backlash from stakeholders. Such companies could also be liable for stringent action from regulators. Concerns over liability and the accompanying costs may spur actions that otherwise would not occur (Stephan, 2002). The evaluation of production processes or products that imply the presence of toxic pollutants should always be accompanied by risk assessments.

In the next section, we discuss a number of ratings and proxies used to measure socially and environmentally responsible behaviour. Section 3 briefly introduces the Australian pollution inventory. In section 4, we describe index formation and the modelling of toxicants' relative risk factors. Section 5 provides comparative analysis and evaluates different toxicity systems and the last section concludes this study.

2.2 Measurement of Environmental Performance

The corporate environmental performance literature shows that industry and regulators did not pay much attention to this neglected area until the 1960s. One of the possible reasons for this negligence was the limited knowledge of policy makers regarding toxicants produced during the operations of a company (Beck, 2006). Basic pollution measurement techniques evolved during the 1970s but unfortunately, these were not readily available to different stakeholders (Gerde & Logsdon, 2001).

Quantitative measurement of Environmental Performance (EP) by companies is a difficult task. The most challenging part is the development of a reliable proxy that is widely accepted. This challenge has been well documented in the literature by Ilinitch, Soderstrom, and Thomas (1998). To date, there is no uniform environmental performance definition accepted by a range of stakeholders. In

recent years, significant progress has been made in defining environmental performance constructs both theoretically and empirically. Delmas and Blass (2010) have divided environmental performance indicators into 3 main categories: (1) Environmental impact: emissions, usage of energy, toxicity/spills, plant accidents and aftermaths of these accidents such as the Bhopal Carbide factory incident in India or more recently British Petroleum (BP) oil spills in the Gulf of Mexico. (2) Regulatory compliance: mandatory installation of treatment and recycling plants, lawsuits concerning improper disposal of hazardous waste and fines for its clean up (Cordeiro & Sarkis, 1997; Khanna & Damon, 1999; Klassen & McLaughlin, 1996). (3) Organisation process: improvement in environmental management systems, organisation processes and capital expenditures in pollution control technology (Gilley, Worrell, Iii, & Jelly, 2000; Klassen & McLaughlin, 1996; Montabon, Sroufe, & Narasimhan, 2007; Watson, Klingenberg, Polito, & Geurts, 2004). Different stakeholders use a mix of the above categories to define environmental performance.

After the Emergency Planning and Community Right to Know Act (1986) in the United States and the resultant media awareness, different stakeholders started to raise their voices for independent monitoring systems and databases and asked for more information regarding company processes and the pollution emitted by their production processes. During the 1990s, a number of data sources were developed in the US that focused on environmental activities and outputs of specific companies and facilities (Gerde and Logsdon (2001, p. 270). For example, the United States Environmental Protection Agency (EPA) launched its first pollutant database, the Toxic Release Inventory (TRI) in 1989. Its purpose was to inform workers and communities about their exposure to a range of hazardous/toxic

substances and encourage corporations to adopt better environmental policies (Howes, 2001). Kinder, Lydenberg & Domini (KLD), a private consulting organisation keeps records for nine aspects of environmental and social performance by firms (KLD Research & Analytics, 2003). Corporate Environmental Data Clearinghouse (CEDC) collects data for over 700 companies including the Standard and Poor's 500 firms. Firms' social and environmental performance is measured using 11 objective criteria and published in a report called 'SCREEN' (Gerde & Logsdon, 2001). Ethical Investment Research Services (EiRiS) provides its independent services to different investors on corporate environmental, social and governance (ESG) related issues. It keeps record of ethical performance indicators for 3,000 companies globally (EIRIS Foundation, 2012).

Apart from these ratings, other proxies are also used to measure corporate environmental performance. For example, environmental certificates like ISO-14001 (Ann, Zailani, & Wahid, 2006; Paulraj & Jong, 2011; Wahba, 2008), perceptual measures like environmental strategy (Sharma & Vredenburg, 1998), environmental competitive advantages (Karagozoglu & Lindell, 2000; Marín et al., 2012), environmental management practices (Carmona-moreno & Cééspedes-lorente, 2004; González-benito & González-benito, 2005; Marti et al., 2013) and integration of environmental performance issues into strategic planning processes (Judge & Douglas, 1998; Weber, 2005). These performance measures are not common across all countries and are influenced by the overall business, social and legal environment of respective countries. The desire to have similar and comparable environmental databases was fulfilled after the United Nation Conference on Environment and Development (UNCED) at Rio de Janeiro in

1992, where countries agreed to maintain industrial chemical emission data on specific substances that have potential risk to the environment and public health (Fenerol, 1997). Later on, the Organization for Economic Co-operation and Development (OECD), in cooperation with the United Nations Economic Commission for Europe (UNECE) and the United Nations Environment Program developed and maintained the first PRTR database (PRTRs, 2012).

This database maintains record of chemicals released to the environment. Different countries use different nomenclatures for PRTRs: for example, the National Pollutant Inventory (NPI) in Australia, the Toxic Release Inventory (TRI) in the United States, the Pollutant Emission Register (PER) in the Netherlands, and the National Pollutant Release Inventory (NPRI) in Canada. According to the OECD Council Recommendation C(96)41/FINAL, as amended by C(2003)87, the core objectives of a PRTR system are to group substances that have a harmful impact on humans and the environment, report their sources on a periodic basis, preferably annually, and make this information available to different stakeholders including the community and workers (PRTRs, 2012). In Australia, the PRTR is maintained under the Ministry for Environment and Heritage and is called National Pollutant Inventory.

NPI data is most useful after it has been analysed. This requires fundamental understanding of corporate environmental performance and its measurement. In this paper, insights concerning the corporate environmental performance are developed from the management and wider literature and the analysis of NPI data.

2.3 The National Pollutant Inventory (NPI)

The NPI was established in 1998 by National Environment Protection Council (NEPC) under the NEPC Act 1994 (Australian Government, 2012). On an annual

basis, it reports data concerning 93 substances. These substances have been identified as important due to their possible effect on human health and the environment (PRTRs, 2012). Currently, 4,200 industrial facilities are reporting to NPI each year. The main driver for establishing the NPI in Australia was the need to satisfy increasing community concerns about chemicals in the environment and demands for information about these as a community “right to know” (NPI, 2013). Another objective includes the call by the Organization for Economic Co-operation and Development (OECD) on member countries to institute PRTRs (Fenerol, 1997). The desire for governments in Australia to have a central database was outlined by the Federal Minister for the Environment at a speech upon the release of the first NPI report. According to Senator Robert Hill “Using the internet, the NPI allows all Australians to find out what large factories are discharging into the environment, as well as showing what actions a factory may be taking to reduce its emissions of pollution” (Hill, 2000). NPI information can be used to help in environmental planning and priority setting, encourage better corporate environmental behaviour and cleaner production (Department of the Environment and Heritage Australia, 2005; Hill, 2000).

The overall aim of the NPI is the development of a comprehensive database of environmental information that is readily available to individuals and groups to assist them with choices about environmental actions and issues. The objectives of NPI programmes are to maintain and improve air and water quality, minimize environmental impacts associated with hazardous waste, and improve the sustainable use of resources (NPI, 2013). They also help government and other stakeholders to identify priorities for environment protection and encourage industry to adopt cleaner production techniques in order to reduce hazardous

substances emission (Department of the Environment and Heritage Australia, 2005; NPI, 2013).

Although, NPI data is a good starting point for identifying and monitoring the majority of pollutants from companies, NPI data cannot be used directly as a measure of corporate environmental performance. Performance measurement for a company or industry requires aggregation of data with different characteristics. Diverse substances have to be combined into one single toxicity risk score in order to provide better comparison.

2.4 Toxicity Risk Score

The Technical Advisory Panel to NPI developed a comprehensive list of toxic substances for inclusion and recommended a robust system of scoring and ranking. Each substance is evaluated on a 0-3 scale to reflect the risk to human health, the environment and exposure. These scores are based on the European Commission (EC) Risk Phrases (Appendix 1) and other information like the Pacific Air and Noise (PAAN) criteria.

The health hazard effects and environment hazard effects were added to give a 0-6 hazard score, and this was multiplied by the exposure score so as to give a total risk score on a 0-18 scale that simplified scoring and ranking of the toxic substances (National Environment Protection Council, 1999, p. 24).

$$\textit{Total Toxicity Risk Score} = \textit{Hazard} \times \textit{Exposure}$$

Hazard itself is divided into human health effects and environmental effects.

2.4.1 Human health effects:

The Human hazard score (Appendix 2) assesses the acute toxicity, chronic toxicity, carcinogenicity, and reproductive toxicity of a given substance. Each

descriptor is evaluated on European Commission (EC) Risk Phrases to compute a score as to its effects on human health (National Environment Protection Council, 1999, pp. 14-15).

$$\text{Human Health} = \frac{\text{Acute toxicity} + \left[\frac{\text{Chronic} + \text{Reproductive Toxicity} + \text{Carcinogenicity}}{3} \right]}{2}$$

For example, *acute toxicity* of formaldehyde is considered by the EC to occur if formaldehyde is inhaled (EC R23) swallowed (EC R25) or comes in contact with skin (EC R24) and also causes burns (EC R34). These descriptors equal a score of '2'. For *chronic toxicity* there is no EC risk phrase descriptor for formaldehyde but examination of the descriptors indicates that formaldehyde meets one of the descriptors for a score of '3'. So formaldehyde scores a '3' for chronic toxicity in human health. Formaldehyde is considered by the EC to have a possible risk of causing irreversible cancer or acting as a mutagen. This descriptor produces a carcinogenicity score of '1'. *Reproductive toxicity* of formaldehyde receives a score of zero as it does not trigger either the EC risk phrase descriptors or the default descriptors.

After assigning values and processing, the resultant human health score is 1.5

2.4.2 Environment effects:

The Environment hazard score (Appendix 3) assesses the acute toxicity, chronic toxicity, persistence, and bioaccumulation of a given substance. EC R-phrases 50 to 59 are used for the environment. The Pacific Air and Noise score is used in the absence of EC information (National Environment Protection Council, 1999, p. 20).

$$\begin{aligned}
 & \textit{Environment} = \\
 & = \frac{\textit{Acute toxicity} + \left[\frac{\textit{Chronic} + \textit{Persistence} + \textit{Bioaccumulation}}{3} \right]}{2}
 \end{aligned}$$

For example, the *acute toxicity*⁸ of formaldehyde is considered by the EC to be very high for aquatic organisms (EC R50). This descriptor scores a '2'. For *chronic toxicity*, there are no EC risk phrase descriptors for formaldehyde but examination of the descriptors indicates that formaldehyde meets one of them for a score of '1'; and in addition as there is no EC risk phrase the descriptors of *bioaccumulation* and *persistence* have a score of '0'.

After assigning values and processing, the resultant environment score is 1.2

2.4.3 Exposure:

Exposure evaluates the potential release of a substance in Australia through a combination of point and diffuse sources, its bioavailability, environmental fate and the volume of production (Appendix 4) (National Environment Protection Council, 1999, p. 21).

Exposure

$$= \frac{\left(\textit{Point Sources} + \textit{Diffused Source} \left[\frac{\textit{Quantity X Fate}}{3} \right] \right)}{6} \times \textit{Biodiversity}$$

For example; formaldehyde is a widely used and produced substance and so scores a '2' both in the *point source* and *production volume* categories. Formaldehyde though does not disperse widely into the environment and therefore only scores a '1'; but as it is an individual organic substance it is assumed to be widely *bioavailable* and scores a '3'.

⁸ Note this is a different measure to human health acute toxicity

After assigning values and processing, the resultant exposure score is 1.3.

Therefore, the total toxicity risk score is $(1.5 + 1.2) * 1.3 = 3.6$.

After applying this system of ranking, only one substance has a risk score above 10, there are 22 substances in the range 6-10, and 57 substances in range of 3-5. The final ranking and risk scores of the top twenty substances are given in Appendix 5.

2.4.4 Weighted Average Risk Factor

The Australian National Pollutant Inventory (NPI) data for the year 2010/11 was downloaded from the official website. This data includes all substances emitted by all facilities in the country. Risk factors for all chemicals in each facility are assigned through a systematic process discussed in the previous section. According to Wright (2007, p. 4) “the basis for the toxicity-weighting tool is that the mass of emission and a Hazardous Air Pollution (HAP) toxicity are two significant factors in determining a HAP’s potential impact on public health. Therefore, in the toxicity-weighted emission approach, the mass of the HAP release (in tonnes per year) is multiplied times a toxicity factor”. Hence, this study has adopted a similar kind of weighted average approach as given below;

$$WAR = \sum_{i=0}^n (TRS_i * E_i)$$

Where WAR is the Weighted Average Risk for a Company, TRS is the Toxicity Risk Score of given substance and E is Emission in kg of a given substance to environment in a year.

In this study, the toxicity risk score of reported substances varies from 0-18 magnitude, and thus will have a significant impact on the ranking. For example as

shown in Appendix 6, acetone and n-hexane are ranked 20th and 17th respectively in the top twenty substances reported by the manufacturing sector in 2010/11. After multiplying by the respective risk scores, acetone ranked 17th and n-hexane ranked 20th as toxicant substances (Appendix 7).

Modelling toxicity in this way allows stakeholders to compare different substances and industries. It allows policy makers to prioritize utilization of resources in addressing more hazardous industries/substances. It also allows stakeholders to summarise large amount of data through graphs and charts for comparison and to assist in making informed judgements.

2.5 Comparison and Evaluation of the Toxicity Risk Factors

The advances desired in section 4 are clear when this new approach is compared with contemporary alternatives. Combining the impact of different substances emitted by a company/facility in one single number in such a way that it represents the combine risk factor is a complex process. Identifying potential impacts on human health and the environment depends on several factors (US-EPA, 2004). These factors include health (e.g. kidney and respiratory effects, cancer incidence), release medium (air, water, land) and level of exposure of living organisms (PRTRs, 2012). Several methods have been suggested to assess the potential risk impact of these pollutant substances. For example, in the United States, the Environmental Protection Agency has developed the National Air Toxic Assessment (NATA) to assess risks caused by Hazardous Air Pollutants (HAPs) (PRTRs, 2012). The Maine Department of Environmental Protection has also developed a toxicity weighting tool to prioritise pollutants of great concern (Wright, 2007). There are a number of limitations affecting such toxicity weighting models. According to Wright (2007) “a detailed assessment of the HAP

inventory in the state of Maine by Maine's Air Toxics Advisory Committee (ATAC), found significant errors in the National Emission Inventory and Toxic Release Inventory for Maine. Many of these errors resulted in an underestimation of risk for important source sectors" (p.2). Pope and Strum (2007) have also identified several limitations in NATA toxicity weighting. For example, it does not give consideration to fate, exposure, acute toxicity and chronic toxicity and hence fails to reflect the overall risk. Similarly, the toxic weighting developed by the ATAC does not consider persistence and bioaccumulation (Wright, 2007). Similarly, Toffel and Marshall (2004) compared 13 toxicity weighting methods⁹ in terms of their sophistication, complexity and comprehensiveness. They recommended the US-EPA's Risk Screening Environmental Indicator (RSEI) for estimating impact to human. There are several limitations and weaknesses in Toffel and Marshall (2004) recommended methods. For example, the US-EPA's RSEI does not evaluate risk to individuals, nor does it provide a detailed or quantitative assessment of risk (*e.g.*, excess cases of cancer). RSEI is not designed as a substitute for more comprehensive, site-specific risk assessments. RSEI evaluates information submitted by sources required to report to the US-PRTR only; it does not account for all sources of chemical exposure (Bouwes & Hassur, 1997).

The RSEI model only addresses chronic human toxicity (cancer and non-cancer effects, such as developmental toxicity, reproductive toxicity, neurotoxicity, etc.) associated with long-term exposure. It does not address acute health effects

⁹ 1) Human Toxicity Potential, 2) Indiana Relative Chemical Hazard Score, 3) Risk-Screening Environmental Indicators, 4) EcoIndicator99, 5) Environmental Design of Industrial Products, 6) Tools for the Reduction and Assessment of Chemical Impact, 7) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Reportable Quantities (RQ), 8) Threshold Limit Value-Time Weighted Average, 9) Minimal Risk Levels, Short-Term Exposure Limit (STEL), 10) Permissible Exposure Limit (PEL), 11) Permissible Exposure Limit, 12) Reference Exposure Levels, Acute RELs for Airborne Toxicants and 13) Cancer Unit Risk Potency Factors.

associated with short-term, periodic exposures to higher levels of these same chemicals, and does not address ecological effects (EPA, 2013). Toxicity weights are chemical-specific in RSEI and are based upon the single, most sensitive chronic-health endpoint for inhalation or oral exposure, and do not reflect severity of effects or multiple health effects. Neither acute human toxicity nor environmental toxicity are modelled. RSEI makes several significant assumptions regarding the toxicity of metals and metal compounds, because of limitations in the reporting of these chemical categories. RSEI assigns metal compounds the same toxicity weight as the parent metal, although the chronic toxicity of some metal compounds may be higher or lower. Metals and metal compounds are assumed to be released in the valence (or oxidation) state associated with the highest chronic toxicity weight. RSEI results reflect changing population size at the local level: a facility's relative contribution to the risk-related score could increase or decrease even without changes in its releases over time. Therefore, population trends should be considered when examining a facility's environmental management practices for the causes of changes in relative risk over time. RSEI results have greater certainty when examining national or other aggregated levels as compared to disaggregated results at the local or facility level. Because RSEI is designed for US toxic release inventory, the results may not be generalisable to other Pollutant Release and Transfer Inventories (Bouwes & Hassur, 1997; EPA, 2013).

Considering these limitations in the prevailing toxicity weighting methods, we can conclude that there are many advantages to the toxicity weighting method presented in this paper. For example, this is a composite system of risk weighting that addresses multifaceted issues. Unlike RSEI which is focused on human

health, this weighting system is taking into account environment, human health and exposure simultaneously. It applies simple combinations of component scores, which are not a feature of the prioritisation processes involved in toxic release inventories drawn up in other countries (National Environment Protection Council, 1999). This makes it transparent and it is easy for interested parties to work through the process. This is also a robust risk-weighting system. Robustness is achieved when the overall score is sensitive to individual component scores, but is not markedly dependent upon any single component score, being thus protected against the inadvertent use of inappropriate data or defaults used when relevant data are unavailable (National Environment Protection Council, 1999).

2.6 Conclusion

This paper presents a chemical toxicity weighting system which may be used to study corporate environmental sustainability performance. Environmental sustainability performance indicators measure the current or past environmental performance of a firm, depicting the large volume of chemical release and environmental data in a comprehensive, transparent and concise manner, and if required they may be compared to the targets set. A growing number of researchers and professionals are using PRTR as a proxy for corporate environmental sustainability performance because of the comprehensiveness and easy availability of the data. Unfortunately, a general unease felt towards PRTRs internationally is the problem of interpreting the data, especially for non-scientifically trained or business users. The question of what an emission means in terms of risk is frequently raised in PRTR discussions. Toxic impact cannot be directly interpreted from the mass amounts emitted. There is even evidence from some research that despite reducing the mass of chemical emissions to air and

water, toxicity from chemical emissions may be increasing through waste transfers (Harrison & Antweiler, 2003).

Although there have been multiple efforts to measure sustainability, only a few of them have used a composite approach taking into account human health, the environment and exposure. In most cases the focus is on one of the three aspects. For example, Toffel and Marshall (2004) recommended United States Risk Screening Environmental Indicators for estimating impact to human health and the Tools for the Reduction and Assessment of Chemical Impacts for estimating impacts to the environment. Hence, the toxicity weighting system reviewed in this paper is considered to be the most useful tool for comparing and analysing the relative risk of pollutants because it combines environment, human health and exposure in one single hazard risk score.

Understanding the hazardousness of toxicant substances and their impact on human health, the environment and population exposure is an ongoing research area. No single best weighting method can evaluate a trade-off between scientific sophistication and comprehensiveness of PRTRs (Toffel & Marshall, 2004). If indices and rating systems are poorly constructed, this mis-measurement will lead to misleading results and conclusions. Thus, comparative analysis and sensitivity analysis can help in testing the transparency and robustness of the index.

From managerial, government and other stakeholders' points of view, the use of a toxicity weighting system has far-reaching advantages over the use of mass emission data in expressing all the available environmental information. There are certain aspects that can hardly ever be captured by mass emissions. When assessing the corporate environmental sustainability performance of a production process, a more comprehensive analysis of all environmental burdens, human

health and exposure is required; otherwise, the results reported could be misleading and useless when comparing two production processes or products from an environmental point of view. Hence, the evaluation of production processes or products that implies the presence of toxic pollutants should always be accompanied by risk assessments.

The preferences that motivate corporate environmental performance differ across countries and need thorough research. Additionally, future research investigating the causal relationships, like how environmental performance improves preferences or exogenously formed preferences influence the environmental performance may be promising.

Declaration about the role and contribution of Authors

I (Noor Muhammad) am chiefly responsible for the conceptualisation, review of literature and empirical analysis as well as the writing of this manuscript. Frank Scrimgeour supervised each step of this process. In particular, Frank Scrimgeour gave conception advice on this work and commented on all versions of the manuscript. Krishna Reddy and Sazali Abidin gave conception advice and edited the final paper.

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Chapter 3

The Relationship between Environmental Performance and Financial Performance in Periods of Growth and Contraction: Evidence from Australian Publicly Listed Companies

Abstract

This study investigates the nature of the relationship between environmental performance and financial performance of publicly listed companies in Australia. The environmental performance data was collated from environmental reports submitted by the companies to the National Pollutant Inventory (NPI) and firm performance data was collated from the ASX database. After controlling for unobserved company effects, we report a strong positive association between environmental performance and financial performance during the pre-financial crisis period (2001-2007) and no relationship between environmental performance and financial performance during the financial crisis (2008-2010). Our results are robust after controlling for moderating effects such as financial and environmental management.

Keywords: Environmental Performance, Financial Performance, Financial Crisis

JEL Classification: C33, G01, Q53,

3.1 Introduction

The challenges faced by managers in pursuing financial goals are on-going. Further, managers operate in a world of real and perceived environmental constraints where they seek to enhance company performance in terms of shareholders value. Manager action in response to environmental concerns impacts company performance. The extant literature has provided inconclusive results about the nature of this impact. According to the Horváthová (2010) review of literature, 55% of studies find a positive, 30% find a negative and 15% find no association between improved environmental practices and financial performance. Therefore, the case for sustainable finance is inconclusive. The situation is likely to be further complicated by the state of the business environment when firms set environmental objectives and make related decisions. Behaviour during the recent global financial crisis can potentially shed evidence on this observation.

Cheney and McMillan (1990) consider that during economic contraction, companies' behaviour become more conservative and defensive. Also they become more reluctant to invest in sustainable projects and thus fail to balance the expectations of stakeholders (Karaibrahimoğlu, 2010; Rodríguez, 2013). According to the Njoroge (2009), financial crisis has significant impact on corporate social and environmental responsibility projects. He argued that, the financial crisis may result in delaying or cancellation of such projects. Karaibrahimoğlu (2010) called this phenomenon as a 'dilemma' because he considers that companies need to adopt even more social/environmental responsible activities during the financial crisis. On the contrary Rodríguez (2013) find that firms, corporate social and environmental scores did not decrease during

the time of crisis rather slightly increased. Similarly, Gallego-Álvarez, García-Sánchez, and de Silva Vieira (2013) find that companies that care about social and environmental initiatives in time of economic crisis perform better, and therefore companies must continue to invest in sustainable projects to enhance relations with their stakeholders, resulting in superior economic benefits.

The motivation of this research is to investigate the relationship between CEP and CFP in the Australian context from 2001 to 2010. Further, we are interested to evaluate CEP pre-crisis (2001-2007) and during crisis (2008-2010) periods¹⁰. It is pertinent to note that the literature is dominated by Anglo-American empirical evidences (Horváthová, 2010). Unlike other Anglo-American markets, mining companies dominate Australian market and makes this study distinct from the extant literature. Australia is a developed, urbanised, federal country with growing economic and financial links to many developing countries in the region. It has an open system economy that is more dependent on natural resources than other developed economies including OECD countries. Agriculture and the mining sector account for over 61 per cent of export earnings derived from trade in commodities, mainly in the Asia-Pacific region (Australian Government, 2013).

In the next section, we review relevant earlier work followed by a description of the data and its sources. The econometric model employed is described in section 4. Results are presented in section 5 followed by discussion in section 6. The final section concludes the study.

¹⁰ Firm financial reports in 2007 are based on the performance of 2006. Similarly 2010 reports are based on 2009 performance. Therefore, 2007 is included in growth period and 2010 is included in recession period.

3.2 Literature Review

A review of literature on the relationship between corporate environmental performance (CEP) and corporate financial performance (CFP) shows inconclusive results (e.g. see Albertini, 2013; Ambec & Lanoie, 2008; Dixon-Fowler, Slater, Johnson, Ellstrand, & Romi, 2013; Horváthová, 2010; Orlitzky & Benjamin, 2001). The primary argument of studies that claim positive results are that CEP represents an innovation and operational efficiency (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013; Porter & van der Linde, 1995), improves firm competitive advantage (Hart, 1995; Russo & Fouts, 1997), increases company environmental reputation and in turn employee commitment (Dögl & Holtbrügge, 2013), enhances firm legitimacy (Hart, 1995), and reflects strong organisational and management capabilities (Aragón-Correa, 1998).

Since pollution is regarded as the sign of an incomplete, inefficient, or ineffective use of resources (Porter & van der Linde, 1995), control and prevention strategies can allow companies to make significant cost savings. Product stewardship, integrating the voice of the environment into product design and manufacturing processes, can lead to a competitive advantage through a “first mover” strategy in emergent green market products (Hart, 1995).

Similarly, Turban and Greening (1997) suggest that firms may develop competitive advantage by being perceived as attractive places of employment because of their performance in regard to quality products and services, treatment of the environment, and issues of diversity. Dögl and Holtbrügge (2013) conducted an empirical study among 215 firms in China, Germany, India and the USA and concluded that corporate environmental responsibility (CER) is

becoming more and more relevant as a determinant of employer attractiveness and employee commitment.

Although a majority of studies have found a positive relationship between CEP and CFP, there are some studies that fail to find positive relationship. For example, Gilley et al. (2000) find no relationship between environmental initiatives and anticipated firm performance. Wagner et al. (2002) also failed to find positive relationship in the paper industry. Similarly, Cordeiro and Sarkis (1997) argue that there is lack of evidence to support the view that companies sacrifice profits for social interests.

The corporate environmental performance literature can be divided into two broad strands: first, studies can be differentiated on the basis of the type of environmental performance measures used; second, studies that have employed econometric methodology. Each of the above groups can be further divided into three subgroups.

Delmas and Blass (2010) have divided environmental performance indicators into 3 main categories: (1) Environmental impact: emissions, usage of energy, toxicity/spills, plant accidents and aftermaths of these accidents e.g. Bhopal Carbide factory incident in India or more recently British Petroleum (BP) oil spills in the Gulf of Mexico; (2) Regulatory compliance: mandatory installation of treatment and recycling plant, lawsuits concerning improper disposal of hazardous waste and fines for its clean up (Cordeiro & Sarkis, 1997; Khanna & Damon, 1999; Klassen & McLaughlin, 1996) and (3) Organization process: improvement in environmental management systems, organisation processes and capital expenditures in pollution control technology (Gilley et al., 2000; Klassen & McLaughlin, 1996; Montabon et al., 2007; Watson et al., 2004). Different

stakeholders use a mix of the above categories to define environmental performance.

Similarly, Ambec and Lanoie (2008) have categorized research methodologies into: (1) portfolio analysis; (2) event studies and (3) regression studies. In portfolio studies, different equity portfolios' financial performance is compared with the environmental performance. For example, Cohen et al. (1997) divided companies into high polluting firms portfolio and low polluting firms portfolio. Event studies analyses the response of a particular event(s) like release of emission data, awards or lawsuits to financial performance. Lastly, regression analysis compares the relationship between firm characteristics which include environmental performance and financial performance.

The extant literature provides two main theoretical perspectives on environmental performance. The agency perspective postulated by Friedman (1970) states that corporate managers are agents, who should work in the best interest of the shareholders. The shareholders objective is to increase profit and therefore, a private enterprise pronouncement of promoting "social aspirations" is neither realistic nor pursued.

Friedman (1970) considers manager decisions to invest in pollution efficient technology beyond the legal requirements as deviation from the wealth maximisation goal. He considers that such decisions are driven by self-interested behaviour. For example, where managers wanting to be applauded in society seek attention from media and use it to entrench themselves by building external goodwill and support. Therefore, Friedman (1970) considers expenditure on pollution efficient technology beyond the legal requirements as 'spending other people's money' for self-interest.

Another approach is provided by stakeholder theory. According to this view corporations are organizations owned by stockholders, run by managers and workers, and thus constitute a broad group of stakeholders. These stakeholders have either direct/explicit or indirect/implicit interest in the operations of a company. According to Freeman (1984) a stakeholder is “any group or individual who can affect or is affected by the achievement of an organisation’s objectives”(p.25). Contrary to Friedman’s (1970) argument, Freeman (1984) stresses the view that corporations should consider the implications of their actions for all constituencies even if it reduces the shareholder wealth.

Considering theoretical framework and previous empirical evidences, we put forward the following:

Hypothesis 1: CEP and CFP has a positive relationship in period of growth.

The above stated hypothesis assumes that firms are open to consider objectives other than profit making. Therefore, firms started to incorporate social and environmental issue into their business strategies. According to Sharma and Narwal (2006), firms’ capabilities and strategies to adapt to new situation are tested during the crisis. Testing CEP behaviour in time of economic contraction is very important because Hart and Ahuja (1996) term the CEP-CFP relationship as a ‘virtuous circle’. Hart and Ahuja (1996) argue that investing in CEP improves CFP, which in turn must be reinvested in intangibles in order to improve CEP. In other words, financially successful firms may have the resources necessary to improve their environmental performance, which in turn increases financial benefits that again can be ploughed back into further improvements of CEP (Hart & Ahuja, 1996; Makni, Francoeur, & Bellavance, 2009; Surroca, Tribó, & Waddock, 2010). This argument fundamentally is complemented by the slack

resource theory (McGuire, Sundgren, & Schneeweis, 1988; Waddock & Graves, 1997). Slack is defined as “difference between total resources and total necessary payments” (Cyert & March, 1963, p. 42). According to the Daniel, Lohrke, Fornaciari, and Turner (2004) review of literature, the majority studies have used superior financial performance as a proxy for slack resources. Slack is a resource cushion that a firm can use in a discretionary manner, both to encounter threat and exploit opportunities. Financial crisis reduces firm slack resources and which reduces manager discretion to invest in voluntary initiatives including environment and social activities (Daniel et al., 2004).

Fernández-Feijóo Souto (2009) and Njoroge (2009) argue that financial crisis has challenged corporate behaviour towards social and environmental responsible role. Karabrahimoğlu (2010) also state that in time of financial crisis firms scramble to reduce expenses by restructuring and laying-off employee and putting other austerity practices in place. Based on the slack resource theory we state following:

Hypothesis 2: CEP and CFP has no relationship in periods of financial crisis.

3.3 Data and Methodology

This section describes the data and method used in this study.

3.3.1 Data and Measurement:

Corporate Environmental Performance (CEP) measures used in previous studies differ considerably, which may constitute an important source of the inconclusiveness of previous empirical findings and may account subsequently for the failure to establish consensus (Busch & Hoffmann, 2011; Ilinitch et al., 1998; Telle, 2006; Ullmann, 1985).

Several studies have used Pollutant Release and Transfer Registers (PRTRs) as a proxy for CEP. For example, Horváthová (2012) examined environmental performance effects on financial performance using the Czech PRTR. Similarly, there is a significant amount of literature using the United States PRTR to analyse environmental performance and its impact on financial performance (Cohen et al., 1997; Connors et al., 2013; Gerde & Logsdon, 2001; Hart & Ahuja, 1996; Khanna et al., 1998; King & Lenox, 2002; Ragothaman & Carr, 2008). In this paper we are using Australian PRTR data¹¹ as a proxy for CEP. Unlike the majority of extant literature we are not aggregating all different chemicals without considering their toxicity. Rather, we are using toxicity weighting scores presented in the (Muhammad et al., 2014) study. It is a composite toxicity measure that not only accounts for chemical toxicity to the environment but also for effects on human health and the consequences of large-scale population exposure to the substance. According to Muhammad et al. (2014) the Toxicity Risk Score (TRS)¹² of a given substance is multiplied to the emission level (E) in kg in order to get a Weighted Average Risk (WAR) for a chemical. This process is repeated for all chemicals to calculate WAR at the facility level and in the end a company level WAR is estimated by adding all facilities in a given company.

We employed two CFP measures from both accounting and market based methods. The accounting measure is return on assets (ROA) whereas the market based measures is Tobin's Q (TBQ). Following Horváthová (2012) and King and Lenox (2002), we employed return on asset (ROA) for accounting financial performance. The return on assets ratio is the proportion of earnings before

¹¹ Australian PRTR keep record of 93 different chemicals for over 4000 facilities (NPI, 2013)

¹² Toxicity Risk Score=(Human Health Hazard + Environmental Hazard) X Exposure (Muhammad et al., 2014)

interest and tax (EBIT) to total assets. ROA indicates the efficient use of firm's total assets and also an indicator of the amount of profit a firm generates for each unit of investment in assets (Palepu et al., 2010). Following King and Lenox (2001) and Wagner (2010), we used Tobin's q (TBQ) to measure the market based-CFP. TBQ measures the market value of a firm relative to the replacement cost of its assets (Chung & Pruitt, 1994). If the TBQ value is greater than one, it indicates that a firm's assets could be purchased more cheaply than the firm itself and the market is overvaluing the company. If the TBQ ratio is less than one, it indicates that the market is undervaluing the company.

After selecting dependent and independent variables, a number of additional variables have been chosen based on extant literature (Dixon-Fowler et al., 2013; Horváthová, 2010; Orlitzky, Schmidt, & Rynes, 2003; Wagner, 2010). These variables include firm size (measured as logarithm of the firm asset) as suggested by Wagner (2010), debt to equity ratio (D2E) as suggested by Horváthová (2012), current ratio (CR) (measured as current assets divided by current liabilities) as suggested by Coleman (2010), dividend yield (DY) (measured as income available to shareholder divided by number of shares outstanding) as suggested by Salama, Anderson, and Toms (2011).

We control for the moderating effect of overall management strategy because it may influence CEP-CFP relationship. This study operationalises three variables as a proxy for firm management strategy. The first variable is environmental awards (E-awards) as Boiral (2007) states that environmental awards represents both an internal management tool and a way of advertising an organisation's legitimacy among stakeholders. E-awards show that either company has received product awards with respect to environmental responsibility. The second variable is

environmental management team (E-team). Eteam shows that either company has an environmental management team to identify environmental related problems and implement management strategy. The third variable is environmental supply chain management (ESCM) as suggested by Hoejmosé, Roehrich, and Grosvold (2013). ESCM is either company use environmental criteria (ISO 14000, energy consumption, etc.) in the selection process of its suppliers or sourcing partners.

3.3.2 Econometric Model

To study the relationship between company financial performance and environmental performance, the following generic regression model is used:

$$CFP_{i,t} = \alpha_i + \beta_1 CEP_{i,t-1} + \beta_2 x_{i,t-1} + \varepsilon_{i,t}$$

where $CFP_{i,t}$ represents the measure of financial performance (ROA and TQ) and $CEP_{i,t}$ represents the measure of environmental performance. $x_{i,t}$ represents control variables and $\varepsilon_{i,t}$ is the error term.

To control for the noise effect due to the outliers in the dataset, all the financial measures and financial control variables are winsorized at the 1% level (Oikonomou, Brooks, & Pavelin, 2012). To account for any missing values, we used linear interpolation¹³. Outliers and missing values treatment is important because: (i) we are using firm-year observations; and (ii) very high variations in observation and missing values have potential to sway the adjusted R^2 (goodness of fit) of the estimated models towards their direction (Baltagi, 2005).

Selecting the most suitable panel data regression model is vital in empirical studies. The effectiveness and reliability of the predicted constant and beta

¹³ Linear interpolation may bias our results using OLS estimations therefore, to ensure robustness this thesis has estimated the models with missing values. The results do not change substantially.

coefficients are characterised on the selection of the proper and suitable estimator, each having characteristic properties (Baltagi, 2005). Table 3.1 shows that more than 50% of our sample companies are from the mining sector and this may bias our results towards large capital intensive Australian publicly traded companies. According to Baltagi (2005), “the fixed effects model is an appropriate specification if we are focussing on a specific set of N firms ... and our inference is restricted to the behaviour of this set of firms” (p. 12). On the other hand, the random effects estimation model is suitable when the companies in a sample are supposed to represent random draws from universe or a larger population (Baltagi, 2005, p. 14). Following the extant literature (e.g. King & Lenox, 2001; King & Lenox, 2002; Wagner, 2010), we are also employing fixed effects model for our study. We also performed the Hausman test ($p=0.01$), that strongly suggests the use of fixed effects model in our estimation.

In the above equation, we have used α_i as intercept notation depicting that intercept varies in cross section (firms) but is invariant in time series. It is important to note is that we have not explicitly used set of industry dummy variables in our estimated equation because this part of cross-sectional heterogeneity is constant over time¹⁴ and is thus embedded in the intercepts. The estimation of robust standard errors is another important issue in panel data estimation. If the residuals of the estimated model for a given company are correlated across years (time-series dependence) or the residuals for a given year are correlated across companies (cross-sectional dependence) then the standard errors of the estimated coefficients will be upward or downward biased (Baltagi, 2005; Brooks, 2002). In the latter case, the statistical significance of the results of

¹⁴ We are assuming that a company does not significantly alter its business orientation during the study period.

the study will be overestimated and the conclusions drawn may be spurious (Petersen, 2009). There is reason to expect that time-series dependence may arise in the residuals of the estimated models since CEP is generally quite constant for the same company and environmental/social dimensions across time¹⁵. Persistence and resolve in the application of CEP principles seems the most rational way to ensure the accrument of its long-run valuable economic impacts. The presence of fixed effects (dummy variables) in the specified models deals with this issue and leads to unbiased standard errors, as long as this time-series dependence is fixed and not time-decreasing (Petersen, 2009, p. 464). Contrarily, there are no particular grounds to anticipate that cross-sectional dependence will arise in the residuals of the fixed effects model. Moreover, the detection of such dependence is not an easy process considering both the two-dimensional nature of the residuals and the fact that cross-sections are randomly (alphabetically) stacked (Oikonomou et al., 2012; Petersen, 2009). Therefore, the robust function in STATA is used to estimate robust standard errors¹⁶. To minimise simultaneity bias due to contemporaneous reverse causality among CEP-CFP that will result in endogeneity problems, we used one year lag environmental performance and all control variables in our estimated fixed effects (Brooks, 2002; Fujii, Iwata, Kaneko, & Managi, 2013; Oikonomou et al., 2012; Wagner, 2010).

¹⁵ We are assuming that a company does not significantly alter its CEP orientation over a longer time period therefore we only control for the cross sectional dependence (cross sectional fixed effects). To check robustness, this thesis has controlled for time series dependence and the results are consistent.

¹⁶ The 'Robust' function in STATA corrects the error term for heteroskedasticity (which states that variance in error term should be constant) and also for autocorrelation. We performed bootstrapping for robustness checking as to whether coefficients are consistent as our data failed to pass the normal distribution in the error term diagnostics. The results were consistent after bootstrapping.

Table 3.1 Industry break up of sample

Code	Industry Name	Sub Sector	Sub Total	Total
1	Basic Materials	Industrial Metals & Mining	7	
		Mining	32	
		Chemicals	4	43
2	Consumer Goods & Services	Food Producers	4	
		Beverages	3	
		Travel & Leisure	1	
		General Retailers	1	9
3	Health Care	Pharmaceuticals & Biotechnology	1	
		Health Care Equipment & Services	2	3
4	Industrials	Construction & Materials	6	
		General Industrials	1	
		Industrial Engineering	2	
		Industrial Transportation	1	
		Support Services	1	11
5	Oil & Gas	Oil & Gas Producers	7	
		Oil Equipment & Services	1	8
6	Utilities	Gas, Water & Multi-utilities	2	2

3.4 Results

Table 3.2 reports the basic descriptive statistics for the dependant, independent and control variables used in this study. The mean (median) of ROA is 7.15% (5.35%), suggesting that on average managers' of these companies did utilise assets in an efficient manner. However, median of ROA is 5.35%, indicates that assets were not used efficiently for more than half of companies. The mean (median) of TBQ is 2.84 (1.91), suggesting that on average companies have high market value. The mean (median) of independent variable or CEP is -1.23 (-0.008). This suggests that on average 1.23 units of toxic chemicals are released for every one unit of total assets. However, the very low median suggests that CEP in sample companies has large variance. This result is consistent with that reported by Horváthová (2012) who used a similar database and reported min(max) toxic substances as 0 (19333) with a very high standard deviation of 1969.

Table 3.2 Summary of statistics–Cross sectional data for 76 ASX listed companies

	COUNT	MEAN	MEDIAN	SD	MIN	MAX
ROA	760	7.15	5.35	2.85	-45	96.7
TQ	760	2.84	1.91	3.06	0.22	18.6
CEP	758	-1.23	-0.008	9.61	-153.9	0
AWARDS	760	0.18	0	0.37	0	1
ETEAM	760	0.35	0	0.46	0	1
ESCM	760	0.22	0	0.40	0	1
DY	760	2.01	1.10	2.48	0	16.4
CR	760	3.82	1.54	6.84	0	62.4
D2E	760	0.50	0.40	0.91	-7.64	11.0
SIZE	759	13.0	13.4	2.69	2.30	18.7

Table 3.3 reports the pairwise correlation coefficients of the dependent and independent variables used in this study. The correlation coefficient of CEP with ROA is 0.250 and with TBQ is 0.0125. Although this is only weak positive linear relationship, it tentatively provides support to our hypothesis-1 that overall CEP and CFP are positively correlated. Our results are consistent with prior studies (e.g. Al-Tuwajri, Christensen, & Hughes, 2004; Hart & Ahuja, 1996; King & Lenox, 2001; King & Lenox, 2002; Wagner, 2010) that find reduction in toxic substances are correlated with financial performance.

With the exception of E-awards, E-team and ESCM, the other independent variables are significantly correlated with the dependent variables. The highest correlation coefficient reported in Table 3.3 is 0.453. According to Gujarati (2004), in multivariate analysis, multi-collinearity problem will arise if the correlation coefficient among variables exceeds the rule of thumb level (0.80). Thus, there are no obvious concerns or anomalies in the data. In additional analysis (unreported), we conduct Variance Inflation Factors (VIFs) test to diagnose multi-collinearity among variables in our estimated model. The results show that the highest VIF is 2.57 and the average of VIFs is 1.25 suggesting that

multi-collinearity is not an issue in our estimation as O'Brien (2007) states that the VIFs should be less than 10 (rule of thumb) to avoid multi-collinearity.

Table 3.4 report ROA results for the period both pre-crisis (2001-2007) and during crisis (2008-2010). Our results for pre-crisis period are reported in column 2, 3 and 4. Model 1 is estimated using only CEP as explanatory variable. Model 2 is estimated using CEP and financial control variables. Whereas, in Model 3 all financial and sustainability related control variables are included. Our results show that CEP has positive impact on ROA during the pre-crisis period in all three models ($\beta = 0.70$ [*t-stat* = 3.10], $\beta = 0.60$ [*t-stat* = 3.94] and $\beta = 0.45$ [*t-stat* = 1.81] respectively), thus provide strong support to our hypothesis-1.

The coefficient for CEP in our base Model 1 is ($\beta = 0.70$) means that if the corporate environmental performance increases by one unit, the predicted ROA will, on average, increase by approximately 0.70 units, holding all other factor fixed. Similarly, after controlling for the firm financial related characteristics, the coefficient for CEP in our Model 2 is ($\beta = 0.60$) meaning that on average one unit CEP will increase 0.60 units ROA, ceterus-paribus. Lastly, the coefficient for CEP in our Model 3 is ($\beta = 0.45$) meaning that on average one unit CEP will increase 0.45 ROA, ceterus-paribus. It should be noted that such a percentage change is economically large given that mining firm are more visible and their footprint are covered in media more frequently.

Table 3.3 Correlation coefficients matrix for all variables included in the model.

	ROA	TQ	CEP	AWARDS	ETEAM	ESCM	DY	CR	D2E	SIZE
ROA	1									
TQ	0.154***	1								
CEP	0.250***	0.0125*	1							
E-AWARDS	-0.027	0.0310	-0.124***	1						
E-TEAM	-0.004	0.0225	0.035	0.171***	1					
ESCM	0.0222	0.0912**	0.028	0.292***	0.389***	1				
DY	0.219***	0.190***	0.097***	-0.006	0.0695*	0.056	1			
CR	-0.124***	-0.0718**	-0.116***	-0.0575	-0.0211	-0.089**	-0.242***	1		
D2E	0.147***	-0.0233	0.0815**	0.0527	0.0566	0.0180	0.135***	-0.140***	1	
SIZE	0.388***	0.414***	0.271***	0.0262	0.128***	0.139***	0.453***	-0.356***	0.273***	1

Notes: (1) * denotes significance at 10% ($p < 0.10$), ** denotes significance at 5% ($p < 0.05$), *** denotes significance at 1% ($p < 0.01$)

However, CEP and ROA relationship during crisis period is reported column 5, 6 and 7. The results show that none of coefficient in any of the three models is statistically significant ($\beta = 0.29$ [$t\text{-stat} = 1.45$], $\beta = 0.66$ [$t\text{-stat} = 0.94$] and $\beta = 0.56$ [$t\text{-stat} = 0.83$] respectively), thus provide support to our hypothesis-2.

Table 3.4 Environmental performance and its impact on ROA 2001-2010

	2001-2007			2008-2010		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
CEP	0.71*** [3.10]	0.6600*** [3.94]	0.4556* [1.81]	0.2995 [1.45]	0.66 [0.94]	0.5605 [0.83]
E-AWARDS			-1.8287 [-0.33]			-1.6441 [-0.30]
E-TEAM			-2.7906 [-1.15]			-1.6035 [-0.43]
ESCM			-2.8884 [-0.84]			4.7232 [1.24]
D2E		0.8081 [0.76]	0.7419 [0.69]		4.0523 [1.55]	4.2091 [1.51]
DY		1.5137*** [3.24]	1.5211*** [3.29]		0.382 [1.18]	0.3579 [1.09]
CR		0.0742 [0.53]	0.0644 [0.46]		-0.1638 [-0.40]	-0.1552 [-0.37]
SIZE		2.9118*** [5.85]	3.0493*** [6.05]		2.0012** [2.47]	1.9212** [2.38]
Constant	0.1138 [0.09]	-41.09*** [-5.42]	-41.247*** [-5.51]	2.033 [1.35]	-27.6943** [-2.26]	-27.0532** [-2.39]
N	530	530	530	228	228	228
R ²	0.2715	0.37	0.3747	0.2556	0.2819	0.2883

Notes: (1) * denotes significance at 10% ($p < 0.10$), ** denotes significance at 5% ($p < 0.05$), *** denotes significance at 1% ($p < 0.01$); (2) Number in parenthesis below each coefficient show t-statistics

Table 3.5 report TBQ results for the period both pre-crisis (2001-2007) and during crisis (2008-2010). Our results for pre-crisis period are reported in column 2, 3 and 4. Model 1 is estimated using only CEP as explanatory variable. Model 2 is estimated using CEP and financial control variables. Whereas, in Model 3 all financial and sustainability related control variables are included. Our results show that CEP has positive impact on TBQ during the pre-crisis period in all three models ($\beta = 0.22$ [$t\text{-stat} = 2.90$], $\beta = 0.03$ [$t\text{-stat} = 2.21$] and $\beta = 0.03$ [$t\text{-stat} =$

2.30] respectively), thus provide strong support to our hypothesis-1. The coefficient for CEP in our base Model 1 is ($\beta = 0.22$) means that if the corporate environmental performance increases by one unit, the predicted TBQ will, on average, increase by approximately 0.22 units, holding all other factor fixed. Similarly, after controlling for the firm financial related characteristics, the coefficient for CEP is our Model 2 and Model 3 is ($\beta = 0.03$) meaning that on average one unit change in CEP will increase 0.03 units of TBQ, ceterus-paribus. However, CEP and TBQ relationship during crisis period is reported column 5, 6 and 7. The results show that none of coefficient in any of the three models is statistically significant ($\beta = 0.19$ [*t-stat* = 1.63], $\beta = 0.003$ [*t-stat* = 0.26] and $\beta = 0.23$ [*t-stat* = 0.91] respectively), thus provide support to our hypothesis-2.

Table 3.5 Environmental performance and its impact on TBQ 2001-2010

	2001-2007			2008-2010		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
CEP	0.223*** [2.90]	0.0305** [2.21]	0.0306** [2.30]	0.1927 [1.63]	0.0031 [0.26]	0.2353 [0.91]
E-AWARDS			-0.0596 [-0.17]			0.436 [0.71]
E-TEAM			-0.3571 [-1.00]			-0.1161 [-0.32]
ESCM			0.5707 [1.37]			0.1651 [0.36]
D2E		-0.472*** [-2.65]	-0.4669** [-2.58]		-0.5292*** [-3.14]	-0.5456*** [-3.19]
DY		0.0174 [0.31]	0.0255 [0.44]		-0.0209 [-0.30]	-0.0179 [-0.26]
CR		0.0372** [2.06]	0.0394** [2.08]		0.0283 [0.79]	0.0315 [0.87]
SIZE		0.5645*** [8.37]	0.5630*** [8.06]		0.7165*** [5.86]	0.7109*** [5.80]
Constant	2.85*** [21.45]	-4.375*** [-5.57]	-4.376*** [-5.44]	2.86*** [13.58]	-6.691*** [-4.46]	-6.714*** [-4.41]
N	530	530	530	228	228	228
R ²	0.29	0.399	0.4033	0.259	0.3614	0.3657

Notes: (1) * denotes significance at 10% (p<0.10), ** denotes significance at 5% (p<0.05), *** denotes significance at 1% (p<0.01); (2) Number in parenthesis below each coefficient show t-statistics

3.5 Discussion

This study has attempted to address what has become a perennial question: whether CEP is associated with CFP and, if so whether this relationship exists in periods of financial crisis. In undertaking the research, this study is exploring whether or not strategic linkages exist between CEP behaviours and CFP. Employing a greatly improved measure of CEP, we evaluated the association between CEP and CFP both prior to financial crisis (2001-2007) and during financial crisis (2008-2010) using data from the Australian market.

While several studies, on the basis of narrow profit making objective have noted that a general conclusion cannot be made or that the only conclusion to be extracted is that CEP and CFP has no relationship or negative relationship (Cordeiro & Sarkis, 1997; Gilley et al., 2000). In support of those studies that have found positive association in the past (e.g. Ambec & Lanoie, 2008; Hart & Ahuja, 1996; Horváthová, 2012; King & Lenox, 2001), we find that CEP with associated to CFP and that the sign of the relationship is positive in the time of economic growth (2001-2007). This is consistent with Buysse and Verbeke (2003) and Darnall et al. (2010) studies that CEP is associated with actively managing the changing norms and making a trade-off among the interests of all stakeholders. This proposition is supported by natural resource-based view of the firm and stakeholder theory, firms are utilising its resources to accommodate the need of all constituent parties (Aragon-Correa & Sharma, 2003; Hart, 1995; Russo & Fouts, 1997; Sarkis, Gonzalez-Torre, & Adenso-Diaz, 2010; Surroca et al., 2010).

During financial crisis period 2008-2010, this study finds that CEP has no impact on CFP. These results are consistent with Fernández-Feijóo Souto (2009) and

Karaibrahimoğlu (2010), that there is significant drop in numbers and extent of firm CEP related projects in time of financial crisis.

This is quite important because the mining industry plays a major role in Australia's economy, producing over one-third of the value of its export earnings. Mining is a cyclical industry, driven by international markets; the prices of minerals and costs of production remain key factors in determining environmental management practices and use of pollution efficient technology in this industry.

The existing approach for environmental management in Australia can be explained as a partnership approach. It uses both state regulatory enforcement and encourages firm to adopt voluntary instruments. Voluntary approaches (both government-industry agreements and industry-only initiatives) are also useful promoting superior CEP. For example, the Australian Minerals Industry Code for Environmental Management and the Best Practice Environmental Management in Mining publications, which have become instrumental in Australia and abroad. Other voluntary programmes, such as the Greenhouse Challenge initiative and environmental licensing are important initiatives because substantial efforts are being made to develop systems that allow government to avoid expenditures on regulation enforcement, environmental audits and inspections. Financial crisis poses significant threat to such voluntary initiatives and affects CEP. Thus, our results are supported by Jacob (2012). The financial crisis had a clear impact on firms social and environmental initiatives because of exceptional economic pressure. Jacob (2012) argued that in pursuit of survival, firms did massive layoffs and expenditure cuts on community and environmental involvement programs. Our result are also supported by Waddock and Graves (1997) virtuous circle notion that CEP and CFP support each other. The potential theoretical explanation

of this phenomenon is in slack resource theory (Daniel et al., 2004; Surroca et al., 2010). In time of crisis firm slack resources are reduced which ultimately reduces its ability to spent money on discretionary and voluntary expenditures.

This study results are in conflict with some prior studies analysing CEP and CFP relationship in time of financial crisis. For example, Gallego-Álvarez, García-Sánchez, and Silva Vieira (2013) and del Mar Miras, Escobar, and Carrasco (2014) find that in times of financial crisis, the synergy between CEP and CFP is higher, in other words, firms must continue to invest in sustainable projects in order to improve relations with their stakeholders leading to superior CFP. Similarly, Jacob (2012) found that financial crisis had not negatively impacted on all sustainability (environment, social and economic) related initiatives. Some of the sustainability related initiatives (such as organisational governance, environmental policies and compensation policies) were pushed forward and gained more attraction after the crisis.

3.6 Conclusion

CEP plays an important role in the CFP, maybe because economic benefits could be reduced by the higher expenditure in CEP initiatives, or maybe due to the potential profitability or higher stock prices. Studies that claim a negative relationship draw support from the neoclassical economic models or conservative shareholder capitalism and argue that business has a single responsibility in society to maximise the shareholder value. Contrarily, others claim that CEP can lead to differentiation, enhance reputation, goodwill and employee commitment and improve efficiency and competitive advantages that affects a corporation's profits. Later arguments claim that there may be a reciprocal relationship between

CEP and CFP i.e. profitable firms are being able to improve CEP that improves CFP which is plough backed to improve CEP.

However, a fundamental debate exists in relation to what happens to CEP in the actual economic environment. From this perspective, this study has sought to evaluate the effects of CEP on CFP prior and after the financial crisis. To do this, we analysed 76 companies from Australian market. We used national pollutant inventory data as a proxy for CEP. We divided our sample period in pre-crisis (2001-2007) and during crisis (2008-2010) periods.

To analyse this effect, two hypotheses were posited: the first one, there is a positive relationship between CEP and CFP in time of economic growth and the second hypothesis that there is no relationship between CEP and CFP in time of financial crisis. Both hypotheses are not rejected. CEP has a relationship with CFP and this positive relationship is statistically significant only in time of economic growth.

This research is of great relevance for entrepreneurs, managers, academics and society at large as the results are consistent with Buysse and Verbeke (2003) and Darnall et al. (2010) studies that CEP is associated with actively managing the changing norms and making a trade-off among the interests of all stakeholders and also consistent with Hart (1995) natural resource-based view of the firm which is based on three interconnected strategies namely pollution prevention, product stewardship and sustainable development.

This study is also supported by the Al-Tuwaijri et al. (2004) and Waddock and Graves (1997) notion that environmental performance and financial performance go hand-in-hand. For example, in time of economic growth CEP and CFP had a

positive relationship and during extra ordinary circumstances like the financial crisis this relationship is insignificant. Further, these results are consistent with Porter's theoretical advocacy that focusing on long term interests, management should seek resource productivity model rather than the pollution control model as environmental impact is embedded in the overall process of improving productivity and competitiveness.

Lastly, this research successfully employs a new empirical proxy for environmental performance. In contrast to studies that either use qualitative environmental performance or use toxic substances without having regards to toxicity to human or environment. These results are potentially comparable to similar studies using data from similar databases in other Organisation for Economic Co-operation and Development (OECD) member countries.

Declaration about the role and contribution of Authors

I (Noor Muhammad) am chiefly responsible for the conceptualisation, review of literature and empirical analysis as well as the writing of this manuscript. Frank Scrimgeour supervised each step of this process. In particular, Frank Scrimgeour gave conception advice on this work and commented on all versions of the manuscript. Krishna Reddy and Sazali Abidin gave conception advice and edited the final paper.

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Chapter 4

The Impact of Corporate Environmental Performance on Market Risk: The Australian Industry Case

Abstract

Prior research suggests that Corporate Environmental Performance (CEP) enables businesses to build strong corporate image and reputation, thus leading to improved firm financial performance. However, studies relating to the relationship between CEP and firm risk are scarce. This research intends to bridge the gap in the literature by examining whether CEP helps firms' to reduce their financial risk. The Ordinary Least Squares regression with fixed effects provides strong evidence that environmental performance is negatively associated with firm volatility and firm downside risk. Our results are robust after controlling for moderating effects such as financial, institutional and environmental management.

Keywords: Corporate Environmental Performance, Market Risk, Downside Risk

4.1 Introduction

Debates continue to rage about whether or not firms should engage in environmental responsible behaviour. A review of literature by Horváthová (2010) show that 55% of the studies find a positive relationship, 30% find a negative and 15% find no association between Corporate Environmental Performance (CEP) and Corporate Financial Performance (CFP). Meta-analysis undertaken by several researchers (e.g. see Dixon-Fowler et al., 2013; Endrikat, Guenther, & Hoppe, 2014) show similar results. A common feature in prior studies relating to the CEP-CFP nexus is that they all have used either accounting measures (based on profitability) or market measures (based on stock returns) as proxies for financial performance. However, firm risk is mainly used as a moderating factor only. There are conflicting findings in prior studies, for example, some studies claim that improved environmental performance creates competitive advantage which enables firms' to enhance wealth creation objectives (Clarkson, Overell, & Chapple, 2011; Hart & Ahuja, 1996; King & Lenox, 2001; Konar & Cohen, 1997; Russo & Fouts, 1997). On the other hand, some studies argue that CEP does not enhance company value and is a burden on the shareholders (Cordeiro & Sarkis, 1997; Hassel, Nilsson, & Nyquist, 2005; Morris, 1997).

The literature reviews (e.g. Endrikat et al., 2014; Orlitzky & Benjamin, 2001; Orlitzky et al., 2003) show that there are few studies of the impact of CEP and financial risk. Although, there is evidence that poor CEP poses risk for wealth creation. The risk arises from many sources, such as: bad reputation leading to lower goodwill and revenue; legal violations leading to significant fines and clean-up costs (Capelle-Blancard & Laguna, 2010; Lee & Garza-Gomez, 2012);

potential law suits from third parties affected by companies' operations, loss of environmental sensitive customer-base; dissatisfaction in employee expectations leading to brain-drain from the company (Dögl & Holtbrügge, 2013); and weak supply chain relationships. The findings of behavioural finance research show that investors are risk averse (Jianakoplos & Bernasek, 1998), thus indicating that investors at a minimum level wants to protect their investment. Therefore, environmental responsiveness is viewed by investors as providing an insurance-like effect on companies (Godfrey, 2005). For example, a company with a positive environmental sustainability perception indicates to its investors that there will be a lower risk premium on their invested capital. Companies may also be able to increase their financial leverage (acquire higher levels of debt financing) without paying higher premium (Sharfman & Fernando, 2008). Based on the above, it is assumed that improved environmental performance has the potential to enhance the financial market's expectations about the risk profile of the firm.

To study the wealth protection characteristic of CEP, we use the following proxies for market risk: firm volatility, systematic financial risk and downside risk. Utilising different measures of market risk is important because financial risk and return on investment are the essential factors from the company and financial markets standpoint. If the financial market recognises enhancement in resource consumption but did not see any difference in riskiness, the cost of financing for an investment would not change (Sharfman & Fernando, 2008). Alternatively, if a change in observed riskiness leads to a decrease in cost of financing, companies would experience a decline in overall costs, thus leading to enhanced turnover and profitability.

Salama et al. (2011) argue that understanding the impact corporate environmental performance has on risk reduction is significantly important for advancing theories regarding the social aspect of corporate strategy and for providing practical implications for firm management. First, CEP represents a special type of firm expenditure that potentially appeals to a broader range of stakeholders and thus provides a multi-faceted protection mechanism to shield firms from potential risks. Extending this protection to volatility, systematic risk and downside risk illustrates that CEP's unique and far reaching characteristics. Second, unlike other pure profit oriented investments, CEP has a distinctive "attribution" characteristic that enable stakeholders such as consumers, employees and shareholders to build a stronger relationships with the firm. Third, extant research emphasizes examining CEP impact on a firm's immediate performance such as consumer metric benefits. Those benefits, although important, cannot reflect the fundamental health of the firm. For example; corporate environmental performance increases financial benefits but at the same time consumes a significant amount of financial and human capital. Volatility, systematic risk and downside risk represents an essential indicator of a combination of gains and costs of firm investment. Thus, linking corporate environmental performance and volatility, systematic risk and downside risk is a more reliable way to demonstrate corporate environmental performance actual contribution. Fourth, volatility, systematic risk and downside risk represents a forward looking performance indicator of a firm. Confirming CEP link to these proxies of risks further extends the understanding of its long-term nature and helps the firm's planning process.

In the next section, we review relevant earlier work followed by a description of the data and method in section 3, results are presented in section 4 followed by discussion in section 5. The final section concludes the study.

4.2 Background and Hypothesis Development

Prior research shows that different stakeholders (shareholders, government regulators, consumers, employees and the general public) are increasingly interested in corporations' environmental performance (Dixon-Fowler et al., 2013; Dobler, Lajili, & Zéghal, 2014; Endrikat et al., 2014). Part of this interest is motivated by the positive relationship between CEP and CFP. For example, CEP promotes innovation and operational efficiency (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013; Porter & van der Linde, 1995); improves firm competitive advantage (Hart, 1995; Russo & Fouts, 1997); increases company environmental reputation and in turn employee commitment (Dögl & Holtbrügge, 2013); enhances firm legitimacy (Hart, 1995); and reflects strong organisational and management capabilities (Aragón-Correa, 1998). All or some of the factors stated above also have potential to reduce firm financial risk and therefore, provide protection to the firm wealth (Godfrey, 2005).

According to Sarkis (2006), companies (either through different regulatory requirements or internally motivated proactive strategic benefits) have started to address sustainability and environmental issues as main management challenge. Companies' environmental management practices will continue to evolve as the generation of, environmental cost and liability is established (Karpoff, Lott Jr, & Wehrly, 2005). Capelle-Blancard and Laguna (2010) reported a drop of 1.3% in market value of firms after environmental incidents. They further state that this loss is substantially related to the seriousness of the accident as measured by the

number of casualties and by chemical pollution. For example, each casualty relates to a loss of \$164 million in firm market value, whereas a toxic release relates to a loss of \$1 billion in firm value. Similar results are also evident in the case of 2010 Deepwater Horizon oil spill. According to Lee and Garza-Gomez (2012, p. 73), the total cost¹ of the 2010 Deepwater Horizon oil spill was estimated to be approximately \$251.9 billion² as of September 19, 2010 when the well was permanently sealed. Therefore, an impact of an unanticipated event in a competitive marketplace could force a company to substantially lose its market share and/or liquidate.

The Deepwater oil spill event of 2010 is a reflection and reminder for businesses to be adept at addressing issues that protect natural resources and implement strategies that focus on balancing economics, environmental, political and social constraints. In the contemporary world it is expected that environmental concerns will be key issue affecting business deals and transactions (Cuddihy, 2000). Large, unforeseen environmental liabilities could be a significant competitive disadvantage. Therefore, the benefits from sustainable practices could lead to the creation of new opportunities and at the same time avoid liabilities that could lead to their competitive disadvantage in the market. Cuddihy (2000), argue that companies continually need to balance their socially desirable needs with that of the pursuits of financial survival, profitability, and growth.

¹ Based on a market-based measure, the change (or loss) in market capitalization (Lee & Garza-Gomez, 2012)

² It consists of \$68.2 billion to British Petroleum, \$23.8 billion to eight partners and \$183.7 billion to other firms in the oil and gas industry. Big companies like BP could withstand the effect of this loss. Most firms do not have the same financial strength and market share like BP, and then it becomes more difficult to cope with unforeseen events.

In order to implement the concept of sustainable development, environmental accountability must be amalgamated into policies, procedures and key commerce practices. Businesses can enhance environmental protection by tackling the environmental drivers in their operations through risk management. This will allow companies to deal with the social and environmental risk in their operations, but more importantly, companies will be able to translate these liabilities into monetary terms so that they can be more easily integrated into financial transactions. Furthermore, improvements in environmental risk management will offer many complementary advantages. It will create conditions that help companies anticipate and/or avoid incidental expenditures caused by environmental damages and minimise the cost of compliance with regulation in the future (Karpoff et al., 2005; Sarkis et al., 2010). Based on the above, we propose that companies that have lower levels of toxic substances release would face lower risk of violating regulations especially relating to the environment issues. Therefore, we propose the following hypotheses:

H_{1a}: There is negative relationship between environmental performance and firm financial risk (volatility).

H_{1b}: There is negative relationship between environmental performance and firm systematic financial risk.

Investment in CEP has a tendency to create opportunities to protect firms from unexpected events such as environmental incidents and law suit cases. Therefore, such CEP activities provide legitimacy in terms of decreasing regulatory violations and also minimises the chance of being sued by different stakeholders. CEP usually emphasises downside risk as opposed to upside opportunities. Based on the above, we propose a second hypothesis as follows:

H_2 : *There is negative relationship between environmental performance and downside financial risk.*

4.3 Data and Method

The sample for this study consists of ASX listed companies that filed both toxic release data to the Australian National Pollutant Inventory and annual reports to SEC for the period 2001-2010. After excluding financial services sector, transport sectors and companies that do not report for more than three years, our final sample contains 76 firms. The distribution across industry and sector is given in Table 4.1.

Table 4.1 Industry break up of sample

Code	Industry Name	Sub Sector	Sub Total	Total
1	Basic Materials	Industrial Metals & Mining	7	
		Mining	32	
		Chemicals	4	43
2	Consumer Goods & Services	Food Producers	4	
		Beverages	3	
		Travel & Leisure	1	
		General Retailers	1	9
3	Health Care	Pharmaceuticals & Biotechnology	1	
		Health Care Equipment & Services	2	3
4	Industrials	Construction & Materials	6	
		General Industrials	1	
		Industrial Engineering	2	
		Industrial Transportation	1	
		Support Services	1	11
5	Oil & Gas	Oil & Gas Producers	7	
		Oil Equipment & Services	1	8
6	Utilities	Gas, Water & Multi-utilities	2	2
Total Number of Companies				76

4.3.1 Independent, Dependent, and Control Variables

Independent Variable

Prior management literature on CEP uses company-level measures of environmental sustainability performance based on Pollutant Release and Transfer Registers (PRTRs). For example, Horváthová (2012) examined environmental performance effects on financial performance using the Czech PRTR. A number

of studies have also used the United States PRTR data to analyse environmental performance and its impact on financial performance (Cohen et al., 1997; Connors et al., 2013; Gerde & Logsdon, 2001; Hart & Ahuja, 1996; Khanna et al., 1998; King & Lenox, 2002; Ragothaman & Carr, 2008). The majority of these studies have used gross weights of chemical emissions as a proxy for environmental sustainability performance. According to Toffel and Marshall (2004), summing annual chemical emission of all substances for a company in a given year is a poor proxy for environmental performance as the potential harm caused by a specific substance depends on different number of factors. For example, shareholders' understanding of the toxicity of different materials and their potential impact on environment and public health is equally important. If shareholders believe their actions will improve the surrounding environment and their health, this may be enough of an incentive to act (Stephan, 2002). Furthermore, very few authors have considered the relative risk of chemicals as assessed in USEtox³ in their studies (Bosworth & Clemens, 2011) or used a ratio that divides the total emitted amount by the reporting threshold, if emissions are higher than the threshold (Horváthová, 2012).

In this paper we are using Australian PRTR data⁴ as a proxy for CEP. Unlike the majority of the extant literature we do not aggregate all different chemical without considering their toxicity. We use the toxic weighting scores presented in Muhammad et al. (2014). It is a composite toxicity measure that not only accounts for chemical toxicity to the environment but also for effects on human health and the consequences of large-scale population exposure to the substances. According

³ USEtox characterization factors are consensus based, include more chemicals, and account for the exposure pathways air, water, ground (Bosworth & Clemens, 2011)

⁴ Australian PRTR keep record of 93 different chemicals for over 4000 facilities (NPI, 2013)

to Muhammad et al. (2014) the Toxicity Risk Score (TRS)⁵ of a given substance is multiplied to the emission level (E) in kg in order to get a Weighted Average Risk (WAR) for a chemical. This process is repeated for all chemicals to calculate WAR at facility level and finally a company level WAR is estimated by adding all facilities in a given company.

$$WAR_{facility} = \sum_{i=1}^{93} (TRS_i * E_i)$$

This kind of toxicity score is important because there is evidence that despite reducing the mass of chemical emissions to air and water, toxicity from chemical emissions may have increased through waste transfers (Harrison & Antweiler, 2003; Muhammad et al., 2014). This has important implications for commerce, governments and other stakeholders. The use of a toxicity weighting score has far-reaching advantages over the use of mass emissions to express environmental information because it reduces the cost of information acquisition and increases participation by all stakeholders affected by emission outputs (Muhammad et al., 2014). To normalise the weighted average risk of company, we followed Stanwick and Stanwick (2013) method and divided WAR by total assets of the company and are using it as proxy for CEP.

Dependent Variables

According to Oikonomou et al. (2012), choosing a single variable that measures market risk for a firm is not straight forward. Prior researchers' have used a number of different methods to understand and define the notion of risk. Some have defined risk on the basis of probability, chances of occurrences or projected

⁵ Toxicity Risk Score=(Human Health Hazard + Environmental Hazard) X Exposure (Muhammad et al., 2014)

future values. Others define it on the basis of undesirable events or danger. Some viewed risk as being subjective and epistemic, dependent on the available knowledge, whereas others grant risk an ontological status independent of the assessors (Aven, 2012). We consider risk in the similar light as prior researchers and use firm market risk or volatility (measured by standard deviation), systematic risk (measured by beta) (Salama et al., 2011) and downside risk (Bawa & Lindenberg, 1977; Harlow & Rao, 1989; Oikonomou et al., 2012) as dependent variables.

CEP influences investor's risk perception regarding firm which may negatively affect stock price. Higher stock price volatility is considered as risk and is not good for a companies' risk profile because investors will demand a higher return on their investment irrespective of the level of the firm's revenue. This will cause cost of capital to rise and consequently negatively affect projects which otherwise would have been profitable for the company. This will also limit company competitiveness and profit making opportunities. The variation in stock return is market risk and is measured by its standard deviation (SD). SD is determined as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (R_i - \bar{R})^2}{n-1}}$$

Where R_i is the actual return and \bar{R} expected return of investor.

Many studies use the relative volatility of a given firm to the market returns or to the broad market changes as a measure systemic risk which is represented by the beta coefficient (β). The beta coefficient is a significant determinant of the firms' discount rate in several valuation models. Despite some critiques (e.g. Ang, Hodrick, Xing, & Zhang, 2006; Goyal & Santa-Clara, 2003), it is still the most

widely used measure of systematic risk due to its simplicity and validity. Following Oikonomou et al. (2012) and Salama et al. (2011), we also employ the Sharpe (1964) Capital Asset Pricing Model.

$$\beta_{im}^{CAPM} = \frac{E[(R_{it} - \mu)(R_{mt} - \mu_m)]}{E[(R_{mt} - \mu_m)]^2}$$

where β_{im} is the firm i beta when the market proxy is m , μ_i is the average value of return of firm i , R_m is the observed return of market proxy at time t and μ_m is the average value of those returns.

We also used downside risk for our study. Traditional risk measures like beta and standard deviation assumes the distribution of asset returns is symmetric and in such cases traditional risk measures and downside risk measures will produce the same results. However, several studies (e.g. Deakin, 1976; Ezzamel & Mar-Molinero, 1990; Ezzamel, Mar-Molinero, & Beech, 1987) have refuted the symmetrical or normal distribution assumption of the stock returns. Oikonomou et al. (2012) argue that distribution of asset returns is not symmetrical and therefore, the downside risk measures can capture the market sensitivity more than traditional risk measures like SD and beta. Such predicament is not new to economic and finance literature, for example, Kahneman and Tversky (1979) state that market participants give significant weights on losses relative to their gains in expected utility function. Similarly, Roy (1952) suggests that a rational investor would certainly try to minimise downside risk and a safety first principle will prevail. Echoing this Godfrey (2005) argued that corporate social performance will have an insurance-like effect on firms. Therefore, Oikonomou et al. (2012) argue that financial risk should be described as the probability of a downward

adjustment in the stock prices of socially and environmental negligent firms' instead of an overall uncertainty and fluctuation of those prices.

There is no agreement in finance studies about what are the most suitable definition and ways of estimating the downside risk. The core challenge in this debate is the minimum benchmark or return that investors should use to assess the performance of their investment. Risk will then be characterised by the downside deviation from set target. Following Oikonomou et al. (2012), this study uses two types of downside risk measures. First, similar to Bawa and Lindenberg (1977) we use the risk free rate for the target return. Second, similar to Harlow and Rao (1989), use mean market return as a cut-off point.

$$\beta_{im}^{BL} = \frac{E[(R_i - R_f)\min(R_m - R_f, 0)]}{E[\min(R_m - R_f, 0)]^2}$$

$$\beta_{im}^{HR} = \frac{E[(R_i - R_f)\min(R_m - \mu_m, 0)]}{E[\min(R_m - \mu_m, 0)]^2}$$

where R_i and R_m are the return on security i and market portfolio respectively and μ_i and μ_m are mean return of security and market portfolio respectively. R_f is the risk free rate (Government T-bills rate).

Control Variables

In order to control for the impact of environmental managerial system and other factors that may influence the relationship between firm financial risk and environmental performance, we included several variables in our estimated model.

The description of the control variables used in this study is given below:

ISO-14000 Certification: ISO certification represents both an internal management tool and a way of advertising an organisation's legitimacy among stakeholders (Boiral, 2007). Sometimes it is used as marketing tool for

international audience. These management system standards, also called meta-standards (Heras-Saizarbitoria & Boiral, 2013) do not guarantee a specific level of improvement in environmental performance as the requirements for obtaining ISO 14001 certification basically refer to the process and not to the outcome (Cañón-de-Francia & Garcés-Ayerbe, 2009). Also, this certification is awarded to the individual plants. It may not represent the overall company process and therefore we control for ISO 14000 certificates in our estimated model. If the company claim to have an ISO 14000 certification then it is equal to “1” otherwise “0”.

Crisis Management System (CMS): Companies exposed to greater public scrutiny are more likely to incur political costs associated with poor environmental performance (Al-Tuwaijri et al., 2004). Consequently, companies use public relation activity and hire lobbyist for green-washing instead investing in improving environmental performance. Therefore, we control for CMS. If the company report on crisis management systems or reputation disaster recovery plans to reduce or minimize the effects of reputation disasters then it is equal to “1” otherwise “0”.

Environmental Supply Chain Management (ESCM): ESCM can have significant implications for a firm's corporate reputation by shielding the firm from negative media attention and consumer boycotts (Hoejmose et al., 2013). To focus on the impact of CEP on financial risk, we are trying to control for potential factors that may affect this relationship. This notion aligns with Ullmann (1985) conceptual emphasis on including management's strategy in models examining firm social responsibility. ESCM is “1” if the company uses environmental criteria (ISO 14000, energy consumption, etc.) in the selection process of its suppliers or sourcing partners otherwise “0”.

Environmental Training (ETR): As discussed earlier Ullmann (1985), emphasised the inclusion of management strategy in models for analysing company social responsibility. Similarly, Telle (2006) claim that the companies that have reported positive environmental performance could be the result of omitted variable bias. To be consistent with earlier work we operationalise and control for ETR. The ETR is equal to “1” if the company trains its employees on environmental issues, otherwise “0”.

Regulatory Quality (RQ): Corporate environmental performance is influenced by institutional role. Institutional economists argue that institutions are fundamental to the effective functioning of market-based economies. Further, institutions can contribute to growth as well as environmental sustainability. Evidence shows that countries with *strong* regulations in place can control and minimise the harmful impact of toxic substances. For example, Gani (2013) find that regulatory quality is negatively and statistically significantly correlated with the emission levels. Thus this study controls for Regulatory Quality (RQ) in the estimated models. Regulatory quality is perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

Rule of Law (RoL): Firms working in governance regimes where there is high level rule of law spends more to mitigate the detrimental effects of their activities like pollution and toxic substances emission. The fear of being monitored and accountable for deed makes an important link between industrial production and environmental damage and impacts the political, social and economic relationship of a society (Gani, 2013). Rule of law reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the

quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

Size: Literature shows that firm size is negatively related to the financial risk of the company. Larger firms tend to be more risk averse as compared to smaller companies (Alexander & Thistle, 1999). Another line of argument is that larger firms' chances of default are lower than smaller firms because larger firms have more potential to sustain adverse economic shocks than smaller firm (Oikonomou et al., 2012). Following the norm in extant literature we also use log of total assets as measure of size.

Market to Book (M2B) ratio: Fama and French (1992) studied the cross-sections of expected stock returns and argued that the reciprocal of market to book value captures risk which is associated with the distress factor of Chan and Chen (1991). Particularly, companies having weak projections are indicated by lower share values and better book to market ratios (lower M2B ratios) than companies with sound projections (p. 428). Similarly, sound and stronger projection may lead to better flexibility in profitability and financial market performance. This "growth versus value" segregation of companies may describe why experts often believe the stock of a firm with low M2B to be a less risky investment, with book value seen as the minimum threshold of firm equity (Oikonomou et al., 2012).

Debt to equity (D2E) ratio: D2E measures firm leverage. A very high D2E ratio shows significant indebtedness which may challenge firm's ability to pay its creditors and as such, increases its viability. Following Oikonomou et al. (2012) we also control D2E ratio in our study.

Dividend Yield (DY): DY is calculated as dividend on company per share divided by the price per share. There is argument suggesting that stocks paying higher dividend yields are considered to be risky than stocks paying no or low dividends (Blume, 1980). Dividend yield has signalling effect regarding managements' perception and company prospects. Arguably, the management of a constantly high dividends paying company have no opportunities to reinvest their earnings. Contrarily, Beaver, Kettler, and Scholes (1970) state that lower dividend paying companies are more risky than the higher dividend yield companies because management has less uncertainty about future earnings.

Current Ratio (CR): CR measures firm liquidity. The current ratio is calculated by dividing a firm's book value of current assets by its current liabilities. It shows a firm's ability to pay its creditors and remain solvent in the short run. This ratio is widely used to assess a firm's liquidity risk.

4.3.2 Econometric Model

To study the relationship between company financial risk and environmental performance, the following generic regression model is used:

$$FR_{i,t} = \alpha_i + \beta_1 EP_{i,t-1} + \beta_2 x_{i,t-1} + \varepsilon_{i,t}$$

where $FR_{i,t}$ represents the measure of financial risk (SD (Standard Deviation), CAPM beta (Systematic Risk), BL beta (Bawa & Lindenberg), HR beta (Harlow & Rao)) and $EP_{i,t}$ represents the measure of environmental performance. $x_{i,t}$ represents control variables and $\varepsilon_{i,t}$ is the error term.

To control for the noise effect due to the outliers in the dataset, all the financial risk measures and financial control variables are winsorized at the 1% level (Oikonomou et al., 2012). To account for any missing values, we used linear

interpolation. Outliers and missing values treatment is important because: (i) we are using firm-year observations; and (ii) very high variations in observation and missing values have potential to sway the adjusted R^2 (goodness of fit) of the estimated models towards their direction (Baltagi, 2005).

Selecting the most suitable panel data regression model is vital in empirical studies. The effectiveness and reliability of the predicted constant and beta coefficients are characterised on the selection of the proper and suitable estimator, each having characteristic properties (Baltagi, 2005). It is to be noted that more than 50% of our sample companies are from the mining sector and this may bias our results towards large capital intensive Australian publicly traded companies. According to Baltagi (2005), “the fixed effects model is an appropriate specification if we are focussing on a specific set of N firms ... and our inference is restricted to the behaviour of this set of firms” (p. 12). On the other hand, the random effects estimation model is suitable when the companies in a sample are supposed to represent random draws from universe or a larger population (Baltagi, 2005, p. 14). The Hausman test strongly suggested the use of fixed effects model in our estimation.

In the above equation, we have used α_i as intercept notation depicting that intercept varies in cross section (firms) but is invariant in time series. It is important to note is that we have not explicitly used a set of industry dummy variables in our estimated equation because this part of cross-sectional heterogeneity is constant over time⁶ and is thus embedded in the intercepts. The estimation of robust standard errors is another important issue in panel data

⁶ We are assuming that a company does not significantly alter its business orientation during the study period.

estimation. If the residuals of the estimated model for a given company are correlated across years (time-series dependence) or the residuals for a given year are correlated across companies (cross-sectional dependence) then the standard errors of the estimated coefficients will be upward or downward biased (Baltagi, 2005; Brooks, 2002). In the latter case, the statistical significance of the results of the study will be overestimated and the conclusions drawn may be spurious (Petersen, 2009). There is reason to expect that time-series dependence may arise in the residuals of the estimated models since CEP is generally quite constant for the same company and environmental/social dimensions across time. Persistence and resolve in the application of CEP principles seems the most rational way to ensure the accrument of its long-run valuable economic impacts. The presence of fixed effects (dummy variables) in the specified models deals with this issue and leads to unbiased standard errors, as long as this time-series dependence is fixed and not time-decreasing (Petersen, 2009, p. 464). Contrarily, there are no particular grounds to anticipate that cross-sectional dependence will arise in the residuals of the fixed effects model. Moreover, the detection of such dependence is not an easy process considering both the two-dimensional nature of the residuals and the fact that cross-sections are randomly (alphabetically) stacked (Oikonomou et al., 2012; Petersen, 2009). Therefore, the robust function in STATA is used to estimate robust standard errors. To avoid simultaneity bias due to contemporaneous bi-directional causality among environmental performance and risk that will result in endogeneity problems, we used one year lag environmental performance and all control variables in our estimated fixed effects (Brooks, 2002; Oikonomou et al., 2012).

4.4 Results

Table 4.3 reports the basic descriptive statistics for the dependent and independent variables used in this study. The mean (median) of SD is 0.87 (0.35), suggesting that on an average basis companies' have 0.87 standard deviation. However, the median of SD is 0.35 which suggest that more than half of the companies in the sample have lower risk. The mean (median) of CAPM beta is 1.17 (0.98), suggesting that sample companies are more risky than the market. However, median 0.98 suggests that more than half of the companies are slightly less risky or equal to the aggregated market. When we compared mean (median) of the CAPM beta with the BL beta 0.77 (0.70) and HR beta 0.57 (0.30), the results indicate that the sample companies on an average basis are less risky than the market.

The average firm-year values of sustainability related variables are as follows: ISO (0.49), CMS (0.21), ESCM (0.22), and ETR (0.50). Median value of CMS and ESCM is zero suggesting that more than half of the companies have not adopted CMS and ESCM practices. The median value of ISO is 0.42 and the median value of ETR is 0.50, thus indicating that nearly half of the sample companies have ISO-14001 certifications and are providing environmental related trainings to their employees.

The average value of EP is -1.23, thus suggest that on average basis 1.23 units of toxic chemicals are released for every one unit of total assets by large companies. Since the median of EP -0.008, this suggests that environmental performance varies considerably from firm to firm. The average of size is 13.0, leverage ratio is 0.5, current ratio is 3.82, dividend yield is 2.01 and market to book ratio is 2.21.

Table 4.2 Descriptive Statistics for the Dependent and Control Variables

	COUNT	MEAN	MEDIAN	MIN	MAX
SD	760	0.872	0.345	0	23.01
HR	760	0.57	0.30	-7.93	21.2
BL	760	0.77	0.70	-6.1	3.9
CAPM	760	1.17	0.98	-5.81	10.6
ENVPER	758	-1.23	-0.008	-153.9	0
ISO	760	0.49	0.42	0	1
CMS	760	0.21	0	0	1
ESCM	760	0.22	0	0	1
ETR	760	0.50	0.50	0	1
ROL	760	1.76	1.75	1.70	1.84
RQ	760	1.64	1.63	1.44	1.77
M2B	760	2.21	1.61	-2.7	5.5
DY	760	2.01	1.10	0	16.4
CR	760	3.82	1.54	0	62.4
D2E	760	0.50	0.40	-7.64	11.0
SIZE	759	13.0	13.4	2.30	18.7

Table contains variable count, mean, median, minimum and maximum values for all variables. SD is the Standard Deviation of market value of share price, HR and BL refer to the Harlow-Rao and Bawa and Lindenberg betas, ENVPER refers to the weighted average toxic substance per unit of assets, ISO refer to ISO-14000 certificates, CMS refer to Crisis Management System, ESCM refer to Environmental Supply Chain Management, ETRAINING refer to Environmental Training, ROL refer to Rule of Law, RQ refer to Regulatory Quality, M2B refer to Market to Book ratio, DY refer to Dividend Yield, CR refer to Current Ratio, D2E refer to Debt to Equity Ratio and Size refer to log of total assets.

Table 4.4 reports the pairwise correlation coefficients of the independent and dependent variables used in this study. Overall, CEP is negatively related to different measures of risk. It supports the main hypothesis of our study that CEP and financial risk has negative relationship. An interesting observation is that ISO and CMS is negatively correlated to CEP. Several studies (e.g. Boiral, 2007; Cañón-de-Francia & Garcés-Ayerbe, 2009; Paulraj & Jong, 2011) have used ISO-14001 certification as a proxy for CEP. The negative correlation between CEP and ISO suggests that ISO-14001 certification should not be taken as similar to toxic substances release. The results show that the correlation between leverage ratio and market to book is high. Although, the correlation coefficient is 0.513 and is less than the rule of thumb level of 0.80 (Gujarati, 2004), therefore this relationship will not potentially affect our estimated model. Other pair-wise correlation coefficients reported in Table 4.4 are low and there are no obvious

Table 4.3 Correlation Coefficients

	SD	HR	BL	CAPM	CEP	ISO	CMS	ESCM	ETR	ROL	RQ	M2B	DY	CR	D2B	SIZE
SD	1															
HR	0.027	1														
BL	0.035	0.239***	1													
CAPM	-0.050	0.76***	0.232***	1												
CEP	0.0394	-0.0877**	-0.222***	-0.043*	1											
ISO	0.0731**	0.0437	0.0542	-0.00555	-0.0783**	1										
CMS	0.0210	0.0392	0.0126	0.00195	-0.00941	0.257***	1									
ESCM	0.127***	0.0570	-0.0677*	0.0248	0.0285	0.315***	0.389***	1								
ETR	0.0832**	0.0437	-0.0233	0.0214	0.0510	0.254***	0.150***	0.232***	1							
ROL	-0.0503	-0.0472	0.00308	0.0339	-0.0634*	-0.0478	-0.0239	0.00615	-0.0646*	1						
RQ	0.114***	0.112***	0.00360	0.0342	0.0727**	0.150***	0.112***	0.101***	0.161***	0.0836**	1					
M2B	0.0664*	0.0710*	0.0540	0.110***	0.0125	-0.0284	0.0731**	-0.0163	0.0687*	0.000662	0.00963	1				
DY	0.0681*	-0.109***	0.0259	-0.0752**	0.0967***	0.0702*	-0.0542	0.0556	0.0945***	-0.0318	0.0823**	-0.0923**	1			
CR	-0.111***	0.0530	0.124***	0.0748**	-0.116***	0.0495	0.00672	-0.0888**	-0.0790**	0.0308	-0.0423	-0.0569	-0.242***	1		
D2B	0.0329	-0.0160	0.000912	0.0360	0.0815**	-0.0151	-0.00997	0.0180	0.0800**	-0.00897	0.00766	0.513***	0.135***	-0.140***	1	
SIZE	0.353***	-0.117***	0.0463	-0.0841**	0.271***	0.0918**	-0.0147	0.139***	0.109***	-0.0238	0.0780**	0.0621*	0.453***	-0.356***	0.273***	1

Notes: (1) * denotes significance at 10% ($p < 0.10$), ** denotes significance at 5% ($p < 0.05$), *** denotes significance at 1% ($p < 0.01$)

concerns or anomalies in the data. Furthermore, we conducted multi-collinearity diagnostic (unreported) for variables in the model by using Variance Inflation

Table 4.4 Fixed effect regressions using Standard Deviation and CAPM as dependent variables

	SD			CAPM		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	-					
ENVPER	0.7569*** [-3.21]	-1.3770*** [-3.44]	-1.3752*** [-3.94]	-0.0063 [-1.57]	-0.0031 [-0.56]	-0.0034 [-0.65]
ISO			-1.9517 [-0.18]			-0.0604 [-0.55]
CMS			-16.0682 [-0.80]			-0.1285 [-0.88]
ESCM			36.4736 [1.64]			0.2031 [1.51]
ETRAININ G			8.0768 [0.85]			0.0535 [0.46]
ROL		-257.0295* [-1.96]	-257.0469* [-1.87]		1.1988 [0.89]	1.1539 [0.85]
RQ		193.3381** *	181.8646** *		0.5788 [1.14]	0.5666 [1.08]
M2B		4.6911 [1.33]	4.9061 [1.36]		0.05*** [2.66]	0.05*** [2.76]
DY		-8.3975*** [-2.70]	-8.4452*** [-2.68]		-0.0181 [-0.76]	-0.0185 [-0.78]
CR		0.2514 [0.37]	0.3765 [0.55]		0.0102 [1.37]	0.0113 [1.53]
D2E		-22.9090*** [-2.72]	-23.2896*** [-2.74]		0.0065 [0.14]	0.0025 [0.05]
SIZE		30.8174*** [6.79]	30.0504*** [7.39]		-0.0298 [-1.24]	-0.0327 [-1.37]
CONSTANT	88.375*** [13.00]	-163.7661 [-0.59]	-143.4601 [-0.51]	1.17*** [22.74]	-1.6011 [-0.61]	-1.4851 [-0.57]
N	682	682	682	682	682	682
R ²	0.16	0.1621	0.168	0.18	0.264	0.297

Notes: (1) * denotes significance at 10% (p<0.10), ** denotes significance at 5% (p<0.05), *** denotes significance at 1% (p<0.01); (2) Number in parenthesis below each coefficient show t-statistics

Factors (VIFs). The results show that the highest VIF is 1.57 and the average of VIFs is 1.26 suggesting that multi-collinearity may not be the problem in this study. The estimated value of the averaged fixed effects and slope coefficients are

provided in Table 4.5 and 4.6. Each of the dependent variable (SD, CAPM, BL and HR) is estimated using three models: Model one is estimated without control variables; Model two is estimated using winsorized financial control variables and Model three is estimated with all financial control variables and firm sustainability related variables (ISO, CMS, ESCM and ETR). Columns two, three and four in Table 4.5 represent models where standard deviation is dependent variable and columns five, six and seven represent models where CAPM beta is the dependent variable. Similarly, columns two, three and four in Table 4.6 represent models where BL beta is dependent variable and columns five, six and seven represent models where HR beta is the dependent variable.

In Table 4.5, overall, there appears to be negative and statistically significant relationship between CEP and standard deviation (volatility). This provides support to our main Hypothesis-1a. The results are robust after adding financial control variable (M2B, DY, CR, D2E and Size) and sustainability related variables (ISO, CMS, ESCM and ETR) in column 4 and 5 respectively.

The results reported in the last three columns of Table 4.5 show that the relationship between CEP and CAPM beta is negative but statistically insignificant in all three models. It suggests that there is no relationship between CAPM beta and CEP. Table 4.6 report the results for Bawa and Lindenberg (1977) (BL) beta and Harlow and Rao (1989) (HR) beta. Overall, our results show that there is a negative and statistically significant relationship between corporate environmental performance and BL beta. The results are consistent when financial control and firm sustainability related variables are used in model two and three, respectively. The results reported in the last three columns of Table 4.6 show that the relationship between HR beta and CEP. It shows that CEP is negative and

statistically significant in all three models meaning that downside risk metrics has a negative relationship with CEP.

Table 4.5 Downside risk using BL beta

	BL			HR		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
ENVPER	-0.9972* [-1.68]	-1.1252* [-1.93]	-1.1122* [-1.90]	-0.0198** [-2.42]	-0.0167** [-1.98]	-0.0163* [-1.92]
ISO			2.8145 [0.79]			0.0372 [0.21]
CMS			3.914 [0.88]			-0.1134 [-0.50]
ESCM			-10.0225** [-2.55]			0.3578 [1.61]
ETRAINING			-1.6678 [-0.52]			0.0939 [0.54]
ROL		-15.6057* [-1.74]	-13.5167* [-1.69]		-3.5850* [-1.83]	-3.5136* [-1.79]
RQ		6.6101* [1.62]	7.7468* [1.69]		3.105*** [3.70]	2.910*** [3.40]
M2B		1.0522*** [2.75]	0.9988*** [2.63]		0.0517* [1.91]	0.0533* [1.95]
DY		0.431 [1.18]	0.4239 [1.09]		-0.0617* [-1.72]	-0.0622* [-1.73]
CR		1.0146*** [2.84]	0.9654*** [2.70]		0.0036 [0.29]	0.0044 [0.36]
D2E		-2.2881* [-1.89]	-2.1645* [-1.76]		-0.0562 [-0.54]	-0.0582 [-0.56]
SIZE		2.7308*** [3.20]	2.8742*** [3.18]		-0.0568 [-1.57]	-0.0662* [-1.81]
CONSTANT	-0.4447 [-0.30]	-25.4811 [-0.27]	-31.7333 [-0.35]	0.546*** [6.88]	2.523 [0.70]	2.7064 [0.75]
N	682	682	682	682	682	682
R ²	0.3492	0.3884	0.2958	0.2717	0.2468	0.2516

Notes: (1) * denotes significance at 10% (p<0.10), ** denotes significance at 5% (p<0.05), *** denotes significance at 1% (p<0.01); (2) Number in parenthesis below each coefficient show t-statistics

4.5 Discussion

Overall, there appears to be negative and statistically significant relationship between CEP and different measures of firm risk (SD, BL and HR). This provides support to our main Hypothesis-1a and Hypothesis-2. According to Orlitzky and

Benjamin (2001), high firm risk that has arguably been caused by low CEP not only increases probability of civil or/and criminal legal proceedings but may also increase chances of state regulatory actions against the polluters. This means that being a good corporate citizen tends to reduce firm risk. Similarly, Godfrey (2005) argue that CEP does not represent an oxymoron but can contribute towards the positive moral capital among a broad base stakeholders. CEP not only enhances shareholder wealth but also improves risk management and provides protection to the wealth. This study findings are consistent with that reported by prior studies with similar data set but different methodologies and very general purpose¹ such as Horváthová (2012); Khanna et al. (1998); King and Lenox (2001) and (King & Lenox, 2002), but contrasts with the findings of Connors et al. (2013) and Telle (2006). Such mixed results suggest that further exploration is necessary. Telle (2006) argue that the mixed results reported in literature may be because of number of reasons including omitted variable bias, the difference in measurement of economic and environmental variables, difference in the characteristics of sectors and the sample firms, difference in regulations and regulatory quality of the countries. Although we control for firm heterogeneity in our Model one but to control for other financial variables, rule of law (ROL) and regulatory quality (RQ), we estimated Model two. The results reported in Model two remain robust. Al-Tuwaijri et al. (2004) and Ullmann (1985) suggested that while investigating the CEP-CFP nexus, researchers should include variables such as management strategy in their estimated models. Consistent with this line of argument, we included several environmental sustainability related variables such as ISO, CMS, ESCM and ETR and reported results in Model three. The results

¹ The prime focus of these studies are “Does it pays to be green?”

remain robust after firm sustainability related variables. None of the coefficient of ISO, CMS, ESCM and ETR has t-statistics value greater than 1.65 in any of the estimated models (except ESCM in BL beta model). It suggests that overall there is no relationship between firm risk and other sustainability factors (ISO, CMS, ESCM and ETR). This may be because such factors are not visible and insufficient as CEP reputations (Orlitzky & Benjamin, 2001).

To account for the potential existence of contemporaneous, reverse association between CEP and firm risk, we followed Oikonomou et al. (2012) and used lagged independent variables in our estimated models. Telle (2006) criticised extant literature empirical methods for incapability of illuminating the causal links between CEP and economic performance that may cause the issue of endogeneity. Therefore, these study results are robust. As mentioned earlier, our results provide support for hypotheses 1a and 2. Also, results show that firm total volatility (SD) and downside beta measures (BL and HR) are statistically significant. These results suggest that downside risk measures are better at capturing firm risks that arise from CEP compared to mean-variance risk measures like CAPM.

It is interesting to note that the goodness of fit statistics for our study is very much similar to the Corporate Socially Responsible (CSR) studies undertaken by Oikonomou et al. (2012); McGuire et al. (1988); and Salama et al. (2011). For example, the adjusted R^2 of the models using BL and HR beta are in range of 24.68% to 38.84% which is very close to the results reported by Oikonomou et al. (2012), that is, adjusted R^2 in the range of 27% to 35%. The adjusted R^2 in the study using systematic risk is in range of 18% to 29.70% which is comparable to the results reported by Salama et al. (2011), that is, 11.3% using fixed effects

model and 24.30% using random effects model. Our results are also comparable to the results reported by McGuire et al. (1988). The R^2 when systematic risk is used in our study is 13.1% and the adjusted R^2 when firm total risk is used is in the range of 16% to 16.8%. These results are comparable to McGuire et al. (1988) R^2 of 17.5%.

4.6 Conclusion

This study investigates the relationship between Corporate Environmental Performance (CEP) and financial risk for Australian listed companies from 2001-2010. Three financial risk measures including firm market risk, systematic risk and downside risk were used. The analytical procedure based on fixed effects estimation provides strong evidence that environmental performance is negatively and statistically associated with firm total volatility and to different measures of downside risk.

Our results show that downside risk is a better measure of firm risk especially when investors are not showing linear sensitivity to changes in prices. Therefore, we conclude that environmental performance (reduction in toxic emissions) provides wealth protection or an insurance-like effect on the firm. The results are robust after controlling for several moderating effects including financial, institutional and environmental management.

The findings from this paper have several implications. This paper enriches existing literature by providing positive empirical evidence that corporate environmental performance reduces firm market risk. Our empirical results provide an alternative to the view that previously existed, that is emerging challenges of corporate environmental performance has potential to impose new constraint on firm performance. Our results show that there is market incentive for

investment in environmental responsive practices. This has an important implication for governments. It is important to note that conventional sustainability and environmental policy tool usually depends on rigid legislations and regulations, which must be observed irrespective of cost, and they need standard process implementation. The majority of standards are based on available technology when the policies and regulations were formulated. Since the dynamics of environmental liability and accountability are constantly changing, many regulatory solutions become outdated, and there is not a uniform interpretation of environmental legislation. In addition, it increases the costs of compliance without necessarily improving the environment (Cuddihy, 2000). Considering the above argument, our results have implication for regulators and policy makers. As environmental performance has a negative impact on the firm financial risk, therefore, the benefits from market-based measure like firm risk and downside risk may be promulgated to the market participants so that they will adopt environmental responsive behaviour irrespective of legislations because it provide strategic advantages to firms. This will allow regulators to rely on a market-based enforcement mechanism that will be more efficient and encourage a greater degree of environmental improvement than through direct intervention by conventional laws and regulations (Salama et al., 2011).

Future research may examine the impact of toxic emission on idiosyncratic risk and also investigate if there is a reverse causal relationship driving this relationship.

Declaration about the role and contribution of Authors

I (Noor Muhammad) am chiefly responsible for the conceptualisation, review of literature and empirical analysis as well as the writing of this manuscript. Frank Scrimgeour supervised each step of this process. In particular, Frank Scrimgeour gave conception advice on this work and commented on all versions of the manuscript. Krishna Reddy and Sazali Abidin gave conception advice and edited the final paper.

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Chapter 5

Corporate Toxic Substances Release and Financial Performance in Australia: Short and Long Run Causality Analysis

Abstract

We analysed the long term and short term using panel data causal relationship between firm financial performance and environmental performance. The results show that environmental performance is cointegrated to all four measures of financial performance. Our results also indicate that environmental performance and financial performance have bi-directional causality both in the short run and in long run. Our findings have important implications and suggest that both environmental performance and financial performance are moving side by side i.e. improved environmental performance will enhance financial performance and good financial performing companies invest more money on environmental performance.

Keywords: *Financial Performance, Environmental Performance, Panel Causality*

5.1 Introduction

The nexus between corporate environmental performance (CEP) and corporate financial performance (CFP) is poorly understood. The search for a link between CEP and CFP has evolved into something similar to finding the “holy grail” (Endrikat et al., 2014). Despite many studies of the relationship between CEP and CFP, the overall picture is still not clear. Some studies have provided evidence of a positive relationship (P. Clarkson et al., 2011; Hart & Ahuja, 1996; King & Lenox, 2001; Konar & Cohen, 2001; Russo & Fouts, 1997; Wagner & Schaltegger, 2004), others have supported the conclusion of a negative relationship (Cordeiro & Sarkis, 1997; Hassel et al., 2005; Morris, 1997) or yielded insignificant results (Cohen et al., 1997; Graves & Waddock, 1999).

Several explanations for the apparent inconsistency have been proposed, involving both methodological and theoretical issues (Ruf, Muralidhar, Brown, Janney, & Paul, 2001). These explanations address different aspects, describing (1) the lack of a sound theoretical foundation (Aragon-Correa & Sharma, 2003; Ullmann, 1985); (2) the lack of a clear idea of the direction of causality (Ambec & Lanoie, 2008; Surroca et al., 2010; Waddock & Graves, 1997); (3) the inconsistency of defining and measuring the constructs of interest (Busch & Hoffmann, 2011; Griffin & Mahon, 1997; McWilliams, Siegel, & Wright, 2006); and (4) the use of misspecified models due to omitted variables and a lack of consideration of moderating or mediating influences (Russo & Minto, 2012; Telle, 2006).

The extant literature on the relationship between these performance constructs shows inconclusive results. One of the most critical issue is determining the direction of causality (i.e., whether CEP influences CFP, whether CFP influences

CEP, or whether there is a bidirectional relationship) (Ambec & Lanoie, 2008; Molina-Azorín et al., 2009). There are very few papers focusing on causality at the firm level. For example, Wagner et al. (2002) used simultaneous equation modelling to address the issue of causality. They find no evidence that CFP influences CEP but Nakao et al. (2007) used the Granger causality test proposed by Hurlin and Venet (2001) in their study. Nakao et al. (2007) acknowledged the limitations of data availability and used a simple version of the Hurlin and Venet (2001) method. They find that CFP positively influences CEP. Therefore, the research question “*is it corporate environmental performance that leads to better financial performance or better financial performing companies have the ability to spend more on environmental responsive initiatives?*” needs empirical investigation. This study analysed the causal relationship between environmental performance and financial performance at the firm level using ten years of panel data² from Australia. Thus, this paper contributes to the extant literature by studying long and short term causality using panel data.

The next section reviews existing theories and literature, section three explains data and method, section four provides results and the last section draws key conclusions from this study.

5.2 Literature Review

Conventional economic logic suggests a negative impact of CEP on CFP. Supporters of the trade-off theory, like Levitt (1958) or Friedman (1970), claim that companies’ that withdraw economic resources in favour of environmental activities are harming its financial performance, as the financial benefit from

² We are using the most recent statistical technique for panel data by Dumitrescu and Hurlin (2012)

environmental activities are believed to be less than their costs (Preston & O'Bannon, 1997; Waddock & Graves, 1997). The narrow view of maximization of shareholder returns endorses the view that firms' environmental responsiveness conflicts with its primary objectives. Thus, expenses on environmental activities beyond the legal requirement are considered philanthropy and contradict profit-maximization (King & Lenox, 2002). These neoclassical views have been increasingly challenged by different researchers who offer alternative explanations for a significant positive impact of CEP on CFP leading to a "win-win" state (Porter & van der Linde, 1995). Along these lines the Natural Resource Based View (NRBV) and the instrumental stakeholder theory provides the most notable theoretical frameworks.

The NRBV is the extension of Resource-Based View of the firm (RBV) (Barney, 1991; Wernerfelt, 1984) and was introduced by Hart (1995) by incorporating the natural environment into this framework. The NRBV considers addressing environmental issues can nurture the development of extraordinary and unique organizational resources and skills, leading to a better image, competitive advantage and higher economic performance (Chan, 2005; Hart & Dowell, 2011). The NRBV claims at least three key strategic capabilities: pollution prevention, product stewardship, and sustainable development. Each capability is built upon key resources and each capability is providing various sources of competitive advantage (Hart, 1995; Hart & Dowell, 2011). For example, pollution prevention can save expenditure on installing and operating end of pipe technologies and may reduce pollution and hazardous waste dumping expense, and cut compliance and liability costs (Hart & Ahuja, 1996; King & Lenox, 2002). Because the RBV focuses on the interdependence of resources and skills, competitive advantage and

superior CFP may not come from a single resource, rather from bunches of multifaceted resources (Hart & Dowell, 2011; Hoskisson, Hitt, Wan, & Yiu, 1999). Therefore, there are several ways through which CEP may be translated to CFP. For example, if firms implement environmental policy and adopt less pollution making technologies, it may as a result motivate them to adopt new processes that may increase efficiency (Sharma & Vredenburg, 1998; Surroca et al., 2010). It may also increase organizational learning to adopt new practices that may strengthen employee skills and involvement (Hart, 1995; Russo & Fouts, 1997; Waldman, Siegel, & Javidan, 2006; Weber, 2008). Moreover, better CEP can improve firm goodwill and reputation (Brammer & Pavelin, 2004; Hart, 1995; Surroca et al., 2010), which may make a firm an attractive place for working and consequently, provides potential competitive advantages (Schminke, Caldwell, Ambrose, & McMahon, 2014; Turban & Greening, 1997). Environmental activities can also lead to fundamental and beneficial changes with regard to decision-making processes and other aspects of organizational culture (Hillman & Keim, 2001; Sharma & Vredenburg, 1998). Hence, the reasoning of the NRBV allows a systematic examination of the CEP–CFP link by providing a rationale as to why proactive environmental strategies and management practices may constitute sources of competitive advantage and superior financial performance (Hart & Dowell, 2011).

Similarly, Instrumental stakeholder theory (Donaldson & Preston, 1995; Jones, 1995) provides another theoretical aspect to explain the positive impact of CEP on CFP. Different stakeholders attached different expectations to firms. Environmental responsiveness constitutes a fundamental part of stakeholder expectation and CEP may be considered an attempt to meet such expectations

(Buysse & Verbeke, 2003). Instrumental stakeholder theory states that fulfilling stakeholders' expectations pays-off in the form of higher CFP. A successful and balanced stakeholder management and meeting their expectation and claims, firms can obtain different sources of competitive advantage. For example better reputation, sustainable relationships with suppliers and customers, or enhanced efficiency by adapting to external demands in general (Bansal & Roth, 2000; Hillman & Keim, 2001; Orlitzky et al., 2003; Surroca et al., 2010). Corporations with better CEP can enhance their sales due to customer's willingness to purchase products from environmental responsible companies at a higher price including a premium for the environment (Hart & Dowell, 2011; Hillman & Keim, 2001). Additionally, CEP may change investor perceptions and lead to improved relations and thus may decrease the risk profile of a company (Busch & Hoffmann, 2011; Orlitzky & Benjamin, 2001; Sharfman & Fernando, 2008) and the cost of financial capital (Ambec & Lanoie, 2008).

It is important to note that instrumental stakeholder theory and the NRBV should not be taken as inconsistent or competing frameworks, rather they should be considered as complementary theories. It is the firm's organisational capability to encourage stakeholder integration (Aragon-Correa & Sharma, 2003; Hart & Dowell, 2011). Similarly, firms need to take advantage from the tangible and intangible resources through balanced stakeholder management (Russo & Minto, 2012). Additionally, stakeholders may play a role to motivate a firm to enhance efficiency and consequently encourage firms to identify new opportunities which may otherwise be ignored by management or whose benefits may have been underestimated or whose expenses may have been overestimated (Hart & Dowell, 2011; King & Lenox, 2002). Sharma and Vredenburg (1998) concluded that if

firms manage effective stakeholder integration, it may effectively reduce waste and better perform on its energy conservation programs and correspondingly enhance organisational capabilities. On the same lines Endrikat et al. (2014) state that combining the instrumental stakeholder point of view with the ‘resources and capability accentuation’ of the NRBV provides a solid theoretical basis to propose a positive link from CEP to CFP.

The majority of the CEP–CFP relationship studies are trying to explore the fundamental research question as to whether it pays to be green and therefore, run a causal link from CEP to CFP (Endrikat et al., 2014). On the other hand, there are researchers focusing on the possibility of the opposite causal link such as CFP affects CEP (Dooley & Lerner, 1994; McGuire et al., 1988; Ullmann, 1985). According to Waddock and Graves (1997), the slack resources hypothesis states that higher CFP accumulates (slack) resources which enable firms to invest in environmental responsive activities. Organizational slack can be defined as a “cushion of actual or potential resources which allows an organization to adapt successfully to internal pressures for adjustment or to external pressures for change” (Bourgeois, 1981, p. 30). It enables firms to make investments in resources and capabilities that are not likely to immediately pay-off but that are necessary to improve the speed and degree to which firms can adapt to their external environments (Bansal, 2005). As highlighted by the NRBV, by implementing environmental friendly policies firms can draw on different resources and capabilities. Consequently, organizational slack allows firms to direct more resources towards the improvement of CEP (Kock, Santaló, & Diestre, 2012) and permits firms the opportunity to seek innovative and environmentally sound solutions (Bansal, 2005; Russo & Fouts, 1997).

A tacit assumption of the slack resources hypothesis is that high levels of CFP result in available slack resources (Dooley & Lerner, 1994; Makni et al., 2009; Preston & O'Bannon, 1997). Thus a number of studies analysing the slack resources hypothesis are utilising CFP measures as proxies for slack (Clarkson, Li, Richardson, & Vasvari, 2011; Surroca et al., 2010). Nevertheless, it is pertinent to note that improved CFP does not always result in organizational slack. However, previous studies on organizational slack consistently regarded CFP as a sign of slack resources (Seifert, Morris, & Bartkus, 2004; Singh, 1986) and therefore slack is more likely to appear in superior CFP firms. Moreover, Daniel et al. (2004) provided meta-analytic evidence for a positive relationship between slack resources and CFP.

There may be a bidirectional relationship or 'virtuous circle' as Hart and Ahuja (1996) and Waddock and Graves (1997) term it because of the potentially reciprocal causal relationship. A possible theoretical explanation for such a bidirectional relationship is the integration of the reasoning of the NRBV (complemented by instrumental stakeholder arguments) with the slack resources hypothesis (Surroca et al., 2010). Without conjecture about where the circle begins, whether in the availability of slack resources (resulting from superior CFP), or in initial environmental activities (Waddock & Graves, 1997), CEP and CFP may reinforce each other and thus constitute a complex relationship involving causal mechanisms going from CEP to CFP as well as mechanisms in which higher levels of CFP lead to increased CEP. In other words, financially successful firms may have the resources necessary to improve their environmental performance, which in turn increases financial benefits that again can be ploughed

back into further improvements of CEP (Hart & Ahuja, 1996; Makni et al., 2009; Surroca et al., 2010).

Based on the former considerations and drawing on the rationale of the NRBV, the instrumental stakeholder theory, and the slack resources argumentation we derive the following hypothesis we seek to test:

Hypothesis 1: A higher (lower) level of CFP (CEP) Granger causes higher (lower) levels of CEP (CFP).

5.3 Data and Method

This section describes the data and method used in this study.

5.3.1 Corporate Environmental Performance (CEP)

Corporate Environmental Performance (CEP) measures used in previous studies differ considerably, which may constitute an important source of the inconclusiveness of previous empirical findings and may account subsequently for the failure to establish consensus (Busch & Hoffmann, 2011; Ilinitch et al., 1998; Telle, 2006; Ullmann, 1985). For example, environmental certificates like ISO-14001 (Ann et al., 2006; Paulraj & Jong, 2011; Wahba, 2008), perceptual measures like environmental strategy (Sharma & Vredenburg, 1998), environmental competitive advantages (Karagozoglu & Lindell, 2000; Marín et al., 2012), environmental management practices (Carmona-moreno & Céspedes-lorente, 2004; González-benito & González-benito, 2005; Marti et al., 2013) and integration of environmental performance issues into strategic planning processes (Judge & Douglas, 1998; Weber, 2005). These performance measures are not common across all countries and are influenced by the overall business, social and legal environment of respective countries. The desire to have similar and

comparable environmental databases was fulfilled after the United Nations Conference on Environment and Development (UNCED) at Rio de Janeiro in 1992, where countries agreed to maintain industrial chemical emission data on specific substances that have potential risk to the environment and public health (Fenerol, 1997). Later on, the Organization for Economic Co-operation and Development (OECD), in cooperation with the United Nations Economic Commission for Europe (UNECE) and the United Nations Environment Program developed and maintained the first Pollutant Release and Transfer Registers (PRTRs) database (PRTRs, 2012).

This database maintains records of chemicals released to the environment. Different countries use different nomenclatures for PRTRs: for example, the National Pollutant Inventory (NPI) in Australia, the Toxic Release Inventory (TRI) in the United States, the Pollutant Emission Register (PER) in the Netherlands, and the National Pollutant Release Inventory (NPRI) in Canada.

Several studies have used Pollutant Release and Transfer Registers (PRTRs) as a proxy for CEP. For example, Horváthová (2012) examined environmental performance effects on financial performance using the Czech PRTR. Similarly, there is a significant amount of literature using the United States PRTR to analyse environmental performance and its impact on financial performance (Cohen et al., 1997; Connors et al., 2013; Gerde & Logsdon, 2001; Hart & Ahuja, 1996; Khanna et al., 1998; King & Lenox, 2002; Ragothaman & Carr, 2008). The majority of these studies have used gross weights of chemical emissions to form a proxy for CEP. An aggregation of annual chemical emissions of all substances for a company in a given year is a poor proxy for environmental performance as the potential harm caused by a specific substance depends on number of factors

(Toffel & Marshall, 2004). There is added incentive when shareholders understand the toxicity of such materials and their potential impact on environment and public health. If shareholders believe their actions will improve the surrounding environment and their health, this may be enough of an incentive to act (Stephan, 2002). Very few authors have considered the relative risk of chemicals as assessed in USEtox³ in their studies (Bosworth & Clemens, 2011) or used a ratio that divides the total emitted amount by the threshold amount of emission (Horváthová, 2012).

In this paper we use Australian PRTR data⁴ as a proxy for CEP. Unlike the majority of extant literature we do not aggregate all different chemical without considering their toxicity. Rather, we use toxic weighting scores presented in the Muhammad et al. (2014) study. It is a composite toxicity measure that not only accounts for chemical toxicity to the environment but also for effects on human health and the consequences of large-scale population exposure to the substance. According to Muhammad et al. (2014) the Toxicity Risk Score (TRS)⁵ of a given substance is multiplied to the emission level (E) in kg in order to get a Weighted Average Risk (WAR) for a chemical. This process is repeated for all chemicals to calculate WAR at the facility level and in the end a company level WAR is estimated by adding all facilities in a given company.

$$WAR_{facility} = \sum_{i=1}^{93} (TRS_i * E_i)$$

³ USEtox characterization factors are consensus based, include more chemicals, and account for the exposure pathways air, water, ground (Bosworth & Clemens, 2011)

⁴ Australian PRTR keep record of 93 different chemicals for over 4000 facilities (NPI, 2013)

⁵ Toxicity Risk Score = (Human Health Hazard + Environmental Hazard) X Exposure (Muhammad et al., 2014)

This kind of toxicity score is important because there is evidence that despite reducing the mass of chemical emissions to air and water, toxicity from chemical emissions may have increased through waste transfers (Harrison & Antweiler, 2003; Muhammad et al., 2014). This has important implications for commerce, governments and other stakeholders. The use of a toxicity weighting score has far-reaching advantages over the use of mass emissions to express environmental information because it reduces the cost of information acquisition and increases participation by all stakeholders affected by emission outputs (Muhammad et al., 2014). To normalise the weighted average risk of company, we followed the Stanwick and Stanwick (2013) method and divided WAR by total assets of the company and are using it as proxy for CEP.

5.3.2 Corporate Financial Performance (CFP)

We employed two CFP measures from both accounting and market based methods. The two accounting measures are return on assets (ROA) and return on equity (ROE) whereas the market based measures are Tobin's Q (TBQ) and the market to book ratio (M2B).

The return on assets ratio is the proportion of earnings before interest and tax (EBIT) to total assets. ROA indicates the efficient use of firm's total assets and also an indicator of the amount of profit a firm generates for each unit of investment in assets (Palepu et al., 2010). We adopt a similar method to that used by Palepu et al. (2010) to measure of ROA as follows:

$$ROA = \frac{\text{Earning Before Interest and Tax (EBIT)}}{\text{Average Total Assets}}$$

Palepu et al. (2010) argue that to remove the effect of financing choice EBIT is a better option compared to net income in the numerator.

Return on equity is a comprehensive indicator of a firm performance because it measures the percentage of profit earned on common stockholders' investment in the firm. The most common method of ROE calculation is as follows (Livingstone & Grossman, 2002; Palepu et al., 2010):

$$ROE = \frac{\text{Income available to common shareholder}}{\text{Average common shareholder's equity}}$$

According to Palepu et al. (2010), the average common shareholder equity in the denominator ensures measurement unit consistency and also compensates for any rapid growth or changes in shareholders' equity. Therefore, higher ROE reflects an efficient use of shareholders' equity.

Tobin's q (TBQ) measures the market value of a firm relative to the replacement cost of its assets (Chung & Pruitt, 1994). If the TBQ value is greater than one, it indicates that a firm's assets could be purchased more cheaply than the firm itself and the market is overvaluing the company. If the TBQ ratio is less than one, it indicates that the market is undervaluing the company. The TBQ plays an important role in explaining diverse corporate financial phenomenon such as investment strategies⁶ contribution to firm value (Jose et al., 1986), common equity structure and its relationship with corporate value (McConnell & Servaes, 1990), acquiring firm investment opportunities that lead to different methods of payment in corporate acquisitions (Martin, 1996) and time series patterns of excellence (Jose, Lancaster, & Stevens, 2011) .

In this study, we adopted a simple approximation of TBQ developed by Perfect and Wiles (1994) in their study as follows:

⁶ Investment strategies are referred to research & development, promotion and diversification in multiproduct companies (Jose, Nichols, & Stevens, 1986)

$$\text{Approximate } Q = \frac{MVA + PS + D}{\text{Total Assets}}$$

where MVA is the product of a firm's share price and the number of common stock outstanding, PS is product of firm's preferred stock price and number of preferred stock outstanding and D is the total debt of the company.

The second market based financial measure used in this study is market to book ratio (M2B). We have used the following formula.

$$\text{Market to Book value} = \frac{\text{Market Value of Equity}}{\text{Book Value of Equity}}$$

The M2B ratio is an indicator of whether a company's stock price is undervalued or overvalued. The values for calculating CFP (ROA, ROE, TBQ and M2B) were collated from Datastream database and also crosschecked with the company annual reports. Companies that reported data for NPI and are listed on Australian Stock Exchange (ASX) for the period 2001-2010 are included in our sample. Our final sample includes and data for 76 companies. Table 5.1 reports the sample used in this study and the industry.

Table 5.1 Industry break up of sample

Industry Name	Sub Sector	Sub Total	Total
1 Basic Materials	Industrial Metals & Mining	7	
	Mining	32	
	Chemicals	4	43
2 Consumer Goods & Services	Food Producers	4	
	Beverages	3	
	Travel & Leisure	1	
	General Retailers	1	9
3 Health Care	Pharmaceuticals & Biotechnology	1	
	Health Care Equipment & Services	2	3
4 Industrials	Construction & Materials	6	
	General Industrials	1	
	Industrial Engineering	2	
	Industrial Transportation	1	
	Support Services	1	11
5 Oil & Gas	Oil & Gas Producers	7	
	Oil Equipment & Services	1	8
6 Utilities	Gas, Water & Multi-utilities	2	2
	Total Number of Companies		76

5.3.3 Econometric Model

The long and short term causal relationship between CFP and CEP in Australian listed companies are analysed for the period of 2001-2010. We used the Dumitrescu and Hurlin (2012) method for short run panel causality. Basically they test for causality using stationary VAR framework with fixed coefficients (Dumitrescu & Hurlin, 2012; Hurlin & Venet, 2001, 2008). The null hypothesis is the Homogenous Non Causality (HNC) hypothesis under which there are no causal relations for all units of the panel. The alternative is the Heterogeneous Non Causality (HENC) hypothesis. In this context the VAR models for the different companies are allowed to have a distinct lag structure and unconstrained coefficient under both the null and the alternative. The null hypothesis is no causality in any of the companies against the alternative hypothesis of causality for some non-negligible fraction of the companies (Dumitrescu & Hurlin, 2012).

We estimate the long-run causality using Fully Modified Ordinary Least Squares (FMOLS) and Panel Dynamic Ordinary Least Square (Panel DOLS) proposed by

Canning and Pedroni (2008) and Pedroni (2001). Before analysing our data for long and short run causality, we tested the stationarity of data by conducting unit root tests. We used panel method unit root tests similar to Im, Pesaran, and Shin (2003) and Levin, Lin, and Chu (2002) which allow for cross sectional dependence among companies in Australia. We tested the relationships between CFP (TQ, M2B, ROA and ROE) and CEP variables allowing for heterogeneity of the dynamic models for all the companies in the sample. Similar to Herrerias, Joyeux, and Girardin (2013), our study time series dimension is small thus we used only panel causality.

5.4 Results

5.4.1 Panel unit root tests

We have considered two unit root tests that are used widely for panel data. The first panel unit root test is based on Levin et al. (2002) and the second unit roots test is based on Im et al. (2003). Levin, Lin and Chu test assumes common unit roots for all panel members whereas the Im, Pesaran and Shin test allows for individual unit roots for panel members. Panel unit root test with individual intercept are shown in Table 5.2 and Panel unit root test with individual intercept and trend are shown in Table 5.3. The results of both tests reported in Table 5.2 and Table 5.3 lead to rejection of the null hypothesis of existence of a unit root and we can conclude that the variables are stationary $I(0)$.

Table 5.2 Unit Root Test with Individual Intercept

Method	TQ	M2B	ROA	ROE	CEP
Levin, Lin & Chu test	2.15*	0.64*	-141.81***	-169.65***	-141.81***
Im, Pesaran and Shin W-stat	-3.46***	-1.91**	-23.49***	-191.82***	-23.49***
ADF - Fisher Chi-square	160.15	157.93	256.1***	284.96***	256.10***
PP - Fisher Chi-square	238.16***	267.14***	447.54***	395.38***	447.54***

All tests statistics are asymptotically distributed as $N(0,1)$. *** rejects the null hypothesis of Unit Root at 1%, ** rejects null hypothesis at 5% level and * rejects the null hypothesis at 10% level.

Table 5.3 Unit Root Test with Individual Intercept + Trend

Method	TQ	M2B	ROA	ROE	CEP
Levin, Lin & Chu test	-15.70***	-32.65***	-42.61***	-9.72***	-150.57***
Im, Pesaran and Shin W-stat	-5.52***	-2.52*	-8.41***	-3.89***	-8.77***
ADF - Fisher Chi-square	287.99***	226.07***	288.53***	274.92***	254.35***
PP - Fisher Chi-square	422.18***	373.53***	479.33***	476.34***	386.94***

All tests statistics are asymptotically distributed as $N(0,1)$. *** rejects the null hypothesis of Unit Root at 1%, ** rejects null hypothesis at 5% level and * rejects the null hypothesis at 10% level.

5.4.2 Panel Cointegration tests

We used a similar method to Pedroni (2004) to undertake panel cointegration test because it is robust to bi-directional causality and also allows for both heterogeneous cointegrating vectors and short run dynamics. Pedroni's test is based on the following model:

$$y_{it} = \alpha_i + \delta_{it} + \beta_{1i}x_{1it} + \dots + \beta_{ki}x_{kit} + \varepsilon_{it} \quad 1$$

where there are K regressors, which are allowed to be endogenous. If the error term in the above equation is stationary then the dependent variable is cointegrated with the explanatory variables with a unit coefficient. To test the stationarity of the error term, Pedroni (2004) proposes seven tests using common time dummies to handle cross section dependence. The null hypothesis is of no cointegration for all companies. The pooled tests are specified against the

homogeneous alternative that the first order autocorrelation coefficient of the residuals is the same for all the cross section units and less than one. The group mean tests, based on cross-sectional averages of individual estimates of the first order autocorrelation coefficient of the residuals, are specified against the heterogeneous alternative.

The results of Pedroni (2004) panel cointegration are reported in Table 5.4. The tests are performed with the dependent variable chosen to be one of the CFP (TQ, M2B, ROA and ROE) and the independent variable as CEP. Wagner and Hlouskova (2009) evaluated the performance of panel cointegration tests and concluded that the tests applying the ADF principle perform better, whereas all other tests are severely undersized and have low power when $T \leq 25$. Since our sample size is small which signifies that the group ADF test has the best power properties. We reject the null hypothesis at the 1% level with the group and panel ADF tests and the group and panel Phillips and Perron test.

Table 5.4 Panel cointegration tests: CEP is independent variable

	TQ	M2B	ROA	ROE
Panel v-Statistic	1.81 **	4.75 ***	-11.54	-11.54
Panel rho-Statistic	0.13	0.99	5.98	5.97
Panel PP-Statistic	-13.56 ***	-15.58 ****	-14.92 ***	-14.92 ***
Panel ADF-Statistic	-11.83 ***	-17.23 ***	-8.77 ***	-8.78 ***
Group rho-Statistic	5.49	6.58	4.99	5.06
Group PP-Statistic	-16.83 ***	-14.22 ***	-19.77 ***	-20.18 ***
Group ADF-Statistic	-13.57 ***	10.40 ***	-18.33 ***	-18.36 ***

All tests statistics are asymptotically distributed as $N(0,1)$. *** rejects the null hypothesis of no cointegration at 1%, ** rejects null hypothesis at 5% level and * rejects the null hypothesis at 10% level. Common time dummies and a trend were included in the cointegrating regression.

5.4.3 Short and long run Causality

The short run causality tests (similar to that undertaken by Dumitrescu and Hurlin (2012)) are reported in Table 5.5 and 5.6. The following model is used to test for CFP and CEP causality.

$$y_{it} = \alpha_i + \sum_{k=1}^n \gamma^{(k)} y_{it-k} + \sum_{k=1}^n \beta^{(k)} x_{it-k} + \varepsilon_{it} \quad 2$$

where k refers to individual companies, t denotes time, and k is the number of lags. The individual effect α_i are fixed effects. For each company the error term ε_{it} are assumed to be *i.i.d.* $(0, \sigma_i^2)$ and independently distributed across companies.

Dumitrescu and Hurlin (2012) proposes a test for Homogeneous Non-Causality (HNC) between x and y :

$$H_0: \beta_i = 0 \quad \forall i = 1, \dots, N \quad 3$$

Where $\beta_i = (\beta_i^{(1)}, \dots, \beta_i^{(n)})'$. Under the alternative hypothesis, there is causality from x to y for at least one company:

$$H_1: \beta_i = 0 \quad \forall i = 1, \dots, N_1 \quad \beta_i \neq 0 \quad \forall i = N_1 + 1, N_1 + 2, \dots, N \quad 4$$

Where N_1 is unknown and $N_1 < N$.

The VAR model in (2) has heterogeneous unconstrained coefficients under both the null and alternative. Therefore, if the null of HNC is rejected, the causal relationships are allowed to be heterogeneous across companies. This is a very important feature of the test in our context since we can expect heterogeneity across companies. Dumitrescu and Hurlin (2012) examine the small sample properties of their test statistics and conclude that the power of their test substantially exceeds that of time series Granger causality tests for small values of

T even in presence of cross-section dependence (for example around 10). Dumitrescu and Hurlin (2012) test also requires stationarity of the x and y series. Variables used in this study do not have a unit root and are stationary (see Table 5.3). We reject the null hypothesis of HNC from CEP to four financial performance variables at 1% level and find feedback at the same level from all variables (see results in Table 5.6 and 5.7).

For testing long-run causality we used the Canning and Pedroni (2008) method. If y and x are cointegrated, Engle and Granger (1987) show that there exists an Error Correction Model (ECM) relating those two series. We estimate the error correction model for each company in two steps. We first estimate the long run cointegrating relationship between y and x using Fully Modified Ordinary Least Squares (FMOLS) and obtain the error correction term, $\hat{\epsilon}_{it}$. Second, we estimate the ECM:

$$\begin{aligned}\Delta y_{it} &= c_{1i} + \lambda_{1i}\hat{\epsilon}_{it-1} + \sum_{j=1}^p \gamma_{11ij}\Delta(y_{it-j}) + \sum_{j=1}^p \gamma_{12ij}\Delta x_{it-j} + \varepsilon_{1it}\Delta x_{it} \\ &= c_{2i} + \lambda_{2i}\hat{\epsilon}_{it-1} + \sum_{j=1}^p \gamma_{21ij}\Delta(y_{it-j}) + \sum_{j=1}^p \gamma_{22ij}\Delta x_{it-j} + \varepsilon_{2it}\end{aligned}\quad 5$$

For each company i, where ε_{1it} and ε_{2it} are the disturbance terms. Engle and Granger (1987) show that if y and x are cointegrated at least one of the adjustment coefficients $\lambda_{1i}, \lambda_{2i}$ must be significantly different from zero. Replacing the error correction term with its estimates does not affect the asymptotic properties of the estimators in (5) due to the super-consistency of the estimates for the cointegrating relationship.

$$\begin{aligned}\Delta y_{it} &= c_{1i} + \lambda_{1i} \hat{e}_{it-1} + \sum_{j=1}^p \gamma_{11ij} \Delta(y_{it-j}) + \sum_{j=1}^p \gamma_{12ij} \Delta x_{it-j} + \varepsilon_{1it} \Delta x_{it} \\ &= c_{2i} + \lambda_{2i} \hat{e}_{it-1} + \sum_{j=1}^p \gamma_{21ij} \Delta(y_{it-j}) + \sum_{j=1}^p \gamma_{22ij} \Delta x_{it-j} + \varepsilon_{2it}\end{aligned}$$

Finally, given the time series dimension of our panel we complement these tests with the Panel Dynamic Ordinary Least Square (Panel DOLS) estimates proposed by Pedroni (2001). Wagner and Hlouskova (2009) compares the performance of a number of panel cointegration estimators and report that in the case of a single cointegrating relationship the DOLS estimator outperforms all other estimators. The DOLS estimator is also found to be the least sensitive to cross-section dependence and cross-unit cointegration.

Long-run causality results are shown in Table 5.5 and 5.6. We find that long run causality run from CEP to CFP (TQ, ROA and ROE) in FMOLS estimates (column 3) and we also receive feedback from the same variables. Only M2B neither reject no causality nor give feedback in FMOLS estimates.

We find causality running from CEP to CFP (ROA and ROE) in Panel DOLS estimates (column 4) and we also receive feedback from the same variable. TQ and M2B neither reject no causality nor give feedback in DOLS estimates.

Table 5.5 Causality test: Summary (Y indicates rejection of non-causality at 10% level or less)

Variable causality (from → to)	Short-run causality Dumitrescu and Hurlin's test	Long-run causality FMOL	Long-run causality DOLS
TQ → CEP	Y	Y	N
M2B → CEP	Y	N	N
ROA → CEP	Y	Y	Y
ROE → CEP	Y	Y	Y
CEP → TQ	Y	Y	N
CEP → M2B	Y	N	N
CEP → ROA	Y	Y	Y
CEP → ROE	Y	Y	Y

Table 5.6 Short and Long Run Causality Tests

Variable causality (from → to)	Short-run causality Dumitrescu and Hurlin's test	Long-run causality FMOLS	Long-run causality DOLS
TQ → CEP	2.69166**	2.656714**	0.638421
M2B → CEP	2.55941***	0.200746	0.591408
ROA → CEP	34.3500***	6.092045***	4.057955***
ROE → CEP	24.5641***	7.440500***	1.735863*
CEP → TQ	3.76871***	1.993544**	1.442969
CEP → M2B	4.73961***	1.052067	1.058146
CEP → ROA	27.2***	4.759076***	-3.259085***
CEP → ROE	3.42737***	5.999849***	-3.253513***

All tests statistics are asymptotically distributed as $N(0,1)$. *** rejects the null hypothesis of no causality at 1%, ** rejects null hypothesis at 5% level and * rejects the null hypothesis at 10% level.

Due to small sample period (2001-2010), one lag was used in Dumitrescu and Hurlin test and Panel DOLS estimation.

5.5 Discussion and Conclusion

We analysed the causal relationship between CEP and CFP in Australian listed companies from 2001-2010. The results lend convincing support to the idea that there is a bi-directional relationship between CEP and CFP in both short and long run. Our results are in broad support of Nakao et al. (2007) that CEP has positive impact on CFP and vice versa. Our results are also supported by the Ambec and Lanoie (2008) argument that augmented expenses related to CEP could be compensated in the long run by increases in revenues through better access to certain markets, the possibility to differentiate products and sell pollution-control technology and the reductions of costs related to regulations, material, labour and capital market.

Makni et al. (2009) find that better CEP is linked to poor CFP in the short run. Our results are in contrast to the Makni et al. (2009) study that CEP appear too costly and do not seem to be considered as sound investment. Our results also do not support the Dooley and Lerner (1994) argument that firm expenses by top management are primarily in a fashion consistent with their own values rather than firm financial gains.

Our bi-directional causality results are consistent to the slack resources theory (e.g. Surroca et al., 2010; Waddock & Graves, 1997) that CFP give rise to slack resources which are later used to invest in pollution-control technology and provide competitive advantage. Our results support the Hart and Ahuja (1996) hunch that a 'virtuous circle' exists with regard to the relationship between pollution prevention and CFP, that is, firms can realize cost savings and plough these savings back into further emission reduction projects for a number of years before the investment/ savings balance turns negative. This view is also supported

by Bansal (2005) who find that organizational slack is relatively important in early periods, when firms are accommodating new changes in respect to sustainable development, but once the firm had moved along this path organizational slack was increasingly less important. The analysis also validates the method of Dumitrescu and Hurlin (2012) in testing for causality with panel data, as this is consistent with the recent high level of citation of the study.

Our results have significant implication for strategic managers as they need to decide where to invest company resources. This study suggests that there is no detrimental impact or penalty from allocating some resources towards CEP. In fact, it would seem that such investment might be beneficial, especially if they improve key stakeholder relations. This research indicates that good CEP may go beyond simple 'good deeds', in excess of normal strategic activity to incorporate range of stakeholder relations. The analysis has been successful because we have used a composite measure of CEP that has not been used in the past and because our measure does incorporate both human hazard and environmental hazard. The analysis and the results appeal to a broad range of stakeholders because it provides evidence of financially credible CEP and validation that public available waste emission data can be used as valid mechanism to measure CEP.

Chapter 6

Synthesis and General Conclusions

Corporate environmental performance (CEP) is a growing area of research and interest among academia, professionals and regulators. Firms are spending money and efforts trying to improve their environmental performance and management. A considerable amount of research has been conducted to address issues in this area. The primary goal of this thesis was to investigate in four essays (1) Corporate Environmental Performance (CEP), (2) CEP impact on Corporate Financial Performance (CFP), (3) CEP impact on Corporate Financial Risk (CFR) and (4) investigate the reverse causality relationship between CEP and CFP. The first essay is entitled “*Emission Indices for Hazardous Substances: An Alternative Measure of Corporate Environmental Performance*”. This essay explores a new alternative to measure CEP. The second essay is entitled “*The relationship between environmental performance and financial performance in periods of growth and contraction: Evidence from Australian publicly listed companies*”. This essay uses CEP measures developed in the first essay and empirically investigates whether or not CEP affects firm financial performance. The third essay is entitled “*The impact of corporate environmental performance on market risk*”. This essay also uses the CEP measure to explore the impact of CEP on firm financial risk particularly the impact on downside risk. The last essay is entitled “*Corporate toxic substances release and financial performance in Australia: short and long run causality analysis*”. This essay responds to one of the most popular call from the extant literature to investigate the causal relationship between CEP and CFP.

For academia, professionals and regulators, it is important to understand what constitutes company environmental performance and how publicly available chemical release information impacts on a firm and its investors? Hence, in Chapter 2, we first identify what constitutes firm environmental performance. We reviewed significant inter-disciplinary research and concluded that chemical release/emission can be used as a proxy for a firm measure of environmental performance. We also proposed that due to the variety of chemicals and different level of its toxicity, a risk factor should be calculated for all chemical releases on the basis of human, environment and exposure. Once a single risk factor is calculated for each chemical, then it should be multiplied by the level of each company chemical release that is reported to National Pollutant Inventory on yearly basis in order to calculate the weighted average risk factor for each company. Thus, the weighted average risk is a robust measure having the combined effect of level of toxicity and volume of chemical emissions.

Once we formulated the environmental performance index, we further investigated the nature of the relationship between environmental performance and financial performance of publicly listed companies in Australia. Throughout Chapter 3 it becomes apparent that the nature of the relationship between environmental performance and financial performance is positive. Therefore, this research contributes to our understanding of how environmental performance affects firm financial performance, including consideration of how this behaviour changes with economic conditions. The multivariate regression estimation shows a positive relation to return on asset (ROA) and Tobin's Q (TBQ). This research is of great relevance for entrepreneurs, managers, academics and society at large as the results are consistent with Buysse and Verbeke (2003) and Darnall et al.

(2010) studies that CEP is associated with actively managing the changing norms and making a trade-off among the interests of all stakeholders and also consistent with Hart (1995) natural resource-based view of the firm which is based on three interconnected strategies namely pollution prevention, product stewardship and sustainable development. This study is also supported by the Al-Tuwaijri et al. (2004) and Waddock and Graves (1997) notion that environmental performance and financial performance go parallel to each other. For example, in times of economic growth CEP and CFP had a positive relationship and during extraordinary circumstances like the financial crisis this relationship is insignificant.

Chapter 4 investigates the relationship between Corporate Environmental Performance (CEP) and financial risk for Australian listed companies from 2001-2010. Three financial risk measures including firm market risk, systematic risk and downside risk were used. The analytical procedure based on fixed effects estimation provides strong evidence that environmental performance is negatively and statistically associated with firm total market volatility and to different measures of downside risk. Chapter 4 results show that downside risk is a better measure of firm risk especially when investors are not showing linear sensitivity to changes in prices. Therefore, this study concludes that environmental performance (reduction in toxic emissions) provides wealth protection effect. The results are robust after controlling for several moderating effects including financial, institutional and environmental management.

Chapter 5 analyses the causal relationship between firm financial performance and environmental performance. The results lend convincing support to the idea that there is a bi-directional relationship between CEP and CFP in both short and long run. The results are in broad support of Nakao et al. (2007) that CEP has positive

impact on CFP and vice versa. The results are also supported by the Ambec and Lanoie (2008) argument that augmented expenses related to CEP could be compensated in the long run by increases in revenues through better access to certain markets, the possibility to differentiate products and sell pollution-control technology and the reductions of costs related to regulations, material, labour and capital market. This study results are consistent to the slack resources theory (e.g. Surroca et al., 2010; Waddock & Graves, 1997) that CFP give rise to slack resources which are later used to invest in pollution-control technology and provide competitive advantage. These results support the Hart and Ahuja (1996) hunch that a 'virtuous circle' exists with regard to the relationship between pollution prevention and CFP, that is, firms can realize cost savings and plough these savings back into further emission reduction projects for a number of years before the benefits balance turns negative.

6.1 Policy Implications

In the light of the results obtained in this work, some important policy implications can be extracted. First, firm environmental performance has an impact on investors' perceptions because of the chemical releases and environmental responsiveness. Thus, when a firm is perceived as environmentally responsible, it is also considered as fair in its policies. As a consequence, the benefits of a strong corporate image based on environmental performance may lead to diminishing investors' sensitivity to financial costs, provide legitimacy to a firm and enhances insurance like protection against possible legal actions. A suitable environmental performance strategy may help the company to be perceived as ethical and objective in all its activities. Second, market participants' perceptions of environmental performance have an impact on investors' attitudes

and behaviours towards the firm. Ethical strategies, corporate social responsibility and environmental performance determine brand loyalty, and therefore companies enjoy more goodwill and better financial performance due to effective strategies and communication in order to retain their customers.

Beyond the Australian listed companies, these results may also be compared with previous literature dealing with similar relations in other countries. Thus, this study shows that reduction in toxic chemical release has an influence on financial performance and financial risk, and both factors have significant effects on investors' satisfaction, commitment, and loyalty.

From a managerial point of view, the results of this work show the effectiveness of environmental performance to gain investors satisfaction, commitment, and loyalty. Thus, ethical behaviour in form of environmental performance not only benefits investors and specific firm but it also can benefit society at large. Environmental performance may provide value for the investors and consumer through the desire to belong to a specific community. There is a need for companies to engage in a specific environmental performance and corporate social responsibility programs that are meaningful to their stakeholders. Thus, companies should try to be identified with causes that are relevant to their stakeholders. In the same vein, companies should strive to be perceived as responsible in their policies and strategies. As shown in our results, investors will take environmental performance as phenomenon that enhances firm legitimacy and provides protection from potential legal action or possible law suits cases.

Moreover, companies should properly communicate their actions in relation to environmental performance and fairness in their policies. In order to gain credibility, firms need to communicate their policies, credit ratings or indexes

made by external organisations that provide evidence of the ethicality or green loving behaviour of the company. Further, it is believed that credibility is higher when a third party communicates that a firm is pursuing green policies than when the company directly communicates that it has green and environmentally responsible policies.

From a public policy perspective, the results of this work lead to certain implications. It is pertinent to note that stakeholders are concerned about the ethicality of companies. Since investors' perceptions determine their investment attitudes and behaviour. Therefore, investors have a regulating effect on corporate behaviour. In this way, there is a need to implement investor education programmes, where investors realise that they are the key to the process: their investment behaviour may determine corporate actions. In this way, it will also decrease regulator expenses on implementation and monitoring of environmental related laws because this role will be in a sense outsourced to the investors.

This fact also leads to another important implication; in this process, stakeholders in general and investors in particular should have suitable information about the environmental performance and policies of a company. Policy-makers should provide or ease investor accessibility to ethical records of companies. Independent ratings and reports made by third parties, enable investors to properly identify the most environmentally and socially responsible companies, what type of specific actions firms are developing, and how their strategies are implemented. Policies need to be designed to control and discourage abuse of green reporting and to prevent false or misleading claims. In this sense, it also raises questions such as: How much knowledge about the companies do investors think they have? How

accurate is their knowledge? What are the most influential sources of information? These questions should encourage future research in the field.

6.2 Limitations and Suggestions for Future Research

As with any empirical research, there are several limitations for our study. The primary limitation of this study is that the use of pollution emissions fails to quantify the measurement of environmental performance of firms in relatively low polluting industries and is therefore not representative of small, medium, private or not for profit firms. Thus, this study is biased toward high polluting industries like manufacturing and mining and this compromises the generalizability of the results. This study excluded financial sector companies, because of the nature of their operations which are different from those of non-financial sector firms. Financial firms like banks provide services to other industries. Therefore, the relationship between environmental issues, bank lending policies, and banks financial performance is potentially a rich vein for future research.

Also, given the large number of CEP measures and methods of measurement, our selection of toxic emissions and treatment for hazardousness by assigning risk factors may preclude generalisation to all measures of CEP and all assumptions underlying these measures. Our findings are conditioned by the toxic weighted index, and we do not assert that this hazardous weighting system is the only way to sum different toxic chemicals. Rather, we highlight an important issue among a number of factors that may influence firms CEP.

Next, while this thesis has provided useful insights into corporate environmental performance, financial performance and financial risk in Australian companies, the findings are based on research in a single country. It is suggested that future research may be done on corporate environmental performance beyond Australia.

This thesis utilises data from National Pollution Inventory (NPI) which has an objective that community/investor awareness will lead to pressure on polluters to reduce their emissions. The success of the NPI depends on the extent of engagement that the general population and investors have with the program. Future studies should aim to determine the extent of knowledge and use of the NPI that exists in the community and investment circles and to identify whether barriers exist which indicate a need to restructure aspects of the program to overcome these barriers. Further, the use of pollution emissions will not capture extraordinary environmental impacts, such as major oil spills and toxic gas releases. However, the goal of this thesis is to examine the consistency of the relationship presented over a 10 year time period. The objective of this thesis was not to examine the short term measurement of this relationship based on one time unique extraordinary circumstances.

Another limitation is the use of pollution emissions to measure environmental performance in all sizes of firms. Although we have addressed this issue to some extent by dividing the weighted average risk factor (chemical emission) by respective total assets, future research may explore other avenues to address this issue. While empirical researchers continue in their search for the comprehensive database of corporate environmental performance, it is pertinent to note that much can be learned about environmental performance by conducting surveys, interviews and archival research.

As this thesis has used data from operations within Australian territory and many (if not all) of the companies have subsidiaries or facilities abroad, there is evidence in the literature that some companies based in rich countries may be outsourcing pollution to developing or less developed countries (Pollution Haven

Hypothesis). On the contrary, there are companies that have only domestic manufacturing operations and pollute the domestic environment but part of their revenues are based on exports. Future research may address this issue by comparing pollution and revenue in the domestic market and control for foreign sales or subsidiaries.

Further methodologically, the findings from this thesis may be biased because of endogeneity. To minimise the impact of endogeneity one may use the Instrumental Variable (IV) approach in estimating models. Econometricians agree that finding a suitable instrument is a challenge and the only source for finding a good instrument is in the literature. Since the literature is so divided almost every study has used a different set of independent variables. To minimise the potential impact of endogeneity, this thesis used lagged independent variables in estimated models. Future research may test this thesis result using different econometric techniques including Instrumental Variable (IV) approaches. In addition, addressing causation over longer timeframes could certainly increase our understanding. To this end, the use of different assumptions and methodologies may better address this issue, such as a split time-series data set, or lagged or nested effects.

In short, this thesis suggests further academic research to explore the relationship between CEP-CFP that signifies a consistency and reliability of CFP that uses composite measures of CEP, that focuses on a similar type of industry, and that looks at the association of real CFP and CEP over longer time. These reasonable constraints should lead to improved understanding about these relationships, the impact of similar nature of operations or industry context on CEP, and better understanding of individual company sustainability related actions under different

CFP conditions. Further, it may allow investors to enhance their knowledge of these multifaceted relationships and provide suitable advice to practitioners on how to advance and determine CEP.

This study suggests that future research may incorporate individual firm efforts for mitigating the detrimental effects of their activities on environment. It may include investment in environmental related research and development or with regards to pollution efficient technologies. Both top management fiduciary responsibilities (compared to personal aspirations regarding the involvement in voluntary mitigation efforts) and cultural factors determine national differences on how individual managers will contribute to existing knowledge about corporate environmental performance.

Theoretically, this thesis calls for further explanation of CEP and firm sustainability activities as a long-run commitment. At a higher level investors need to identify and recognise the dynamics among CEP activities, corporate governance practices and overall organisation model, other key stakeholder priorities, and business performances, as these factors mature and evolve in the longer-run rather than quarter by quarter. The pragmatic question will be whether such dynamics are explained by different theories, including neoclassical approaches, dynamic capabilities, social constructionism, slack resources, the natural resource based view and others, and to what extent these different viewpoints shed further light on the observed phenomenon. At the micro level, the progress and evolution of attitudes and decisions regarding CEP policy calls for further study, again from a range of views including behaviours through which social processes implicated, for instance, in managerial level decisions about making tangible investments in sustainability related activities or efforts made to

further understand CEP as an internal firm process should help investors and assist firms trying to improve their standing in this critical area.

Finally, this thesis suggests future empirical research to focus on a few, key CEP and CFP performance indicators in order to improve internal validity and reliability of performance measures rather than generalizability. Since the toxic weighted index appears to differentiate between high and low environmental performers, further research using this database is warranted. The NPI database must be carefully analysed for any potential double counting due to inter- and intra-company transfers. On the financial side, consistency in measurement criteria will at least allow for comparison across industries and firms.

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Appendix

Appendix 1: European Union Risk Phrases

R-Phrase	Description
R1	Explosive when dry.
R2	Risk of explosion by shock, friction, fire or other sources of ignition.
R3	Extreme risk of explosion by shock, friction, fire or other sources of
R4	Forms very sensitive explosive metallic compounds.
R5	Heating may cause an explosion.
R6	Explosive with or without contact with air.
R7	May cause fire.
R8	Contact with combustible material may cause fire.
R9	Explosive when mixed with combustible material.
R10	Flammable.
R11	Highly flammable.
R12	Extremely flammable.
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R59	Dangerous for the ozone layer.
R60	May impair fertility.
R61	May cause harm to the unborn child.
R62	Possible risk of impaired fertility.
R63	Possible risk of harm to the unborn child.
R64	May cause harm to breast-fed babies.
R65	Harmful: may cause lung damage if swallowed.
R66	Repeated exposure may cause skin dryness or cracking.
R67	Vapours may cause drowsiness and dizziness.
R68	Possible risk of irreversible effects.

Appendix 2: Human Health Score

	Acute Toxicity	Chronic Toxicity	Carcinogenicity	Reproductive
Zero (0)	Adequate evidence for negligible effect	Adequate evidence for negligible chronic effect	Adequate evidence for negligible effect	Possible negative evidence
Low (1)	R20, R21, R22, R36, R37, R38, R65	Limited evidence or no evidence providing negligible effect	R40 (Category III)	R64, R63, R62
Medium (2)	R23, R24, R25, R34	R33, R42, R43	R45, R46, R49 (Category II)	R60, R61 (Category II)
High (3)	R26, R27, R28, R35	R39	R45, R46, R49 (Category I)	R60, R61 (Category I)

Appendix 3: Environmental Score

	Acute Toxicity	Chronic Toxicity, Persistence and Bioaccumulation
Zero (0)	Adequate evidence for negligible effect	Adequate evidence for negligible effect
Low (1)	R52	In absence of EC, Pacific Air and Noise (PAAN) criteria is applied
Medium (2)	R51, R54, R55,	In absence of EC, Pacific Air and Noise (PAAN) criteria is applied
High (3)	R50	R53, R58

Appendix 4: Exposure Score

	Point Source	Diffuse Source	Biodiversity
Zero (0)	No release to environment or no use in Australia	No production, generation or use	No bioavailable forms known in the environment
Low (1)	Low release or use	Minimum level production, generation or use	Rarely in bioavailable forms in the environment
Medium (2)	Release or use in moderate amount	Medium level production, generation or use	Bioavailable forms in the environment under certain circumstances
High (3)	High release and widespread release or use	High level production, generation or use	Widely bioavailable forms present in the environment

Appendix 5: Ranking of substances by Risk Factor

Substance	Risk Factor
1 Oxides of Nitrogen	13.50
2 Chromium (VI) compounds	9.60
3 Sulfur dioxide	8.50
4 Carbon monoxide	8.50
5 Dichloromethane	7.80
6 Cadmium & compounds	7.60
7 Particulate Matter 10.0 um	7.50
8 Sulfuric acid	7.30
9 Xylenes (individual or mixed isomers)	7.00
10 Arsenic & compounds	7.00
11 Lead & compounds	6.90
12 Benzene	6.70
13 Trichloroethylene	6.70
14 1,3-Butadiene (vinyl ethylene)	6.70
15 Glutaraldehyde	6.70
16 Total Nitrogen	6.40
17 Tetrachloroethylene	6.40
18 Polycyclic aromatic hydrocarbons (B[a]Peq)	6.40
19 Methyl ethyl ketone	6.00
20 2-Ethoxyethanol	6.00

Appendix 6: Ranking of substances by Emission Volume

Substance	Total (kg)
1 Sulfur dioxide	1274262608
2 Carbon monoxide	1059200000
3 Oxides of Nitrogen	215505568
4 Total Volatile Organic Compounds	77997716
5 Particulate Matter 10.0 um	57385569
6 Ammonia (total)	18051973
7 Ethanol	15844679
8 Particulate Matter 2.5 um	12463411
9 Fluoride compounds	5292358
10 Total Nitrogen	4073769
11 Hydrochloric acid	3994476
12 Toluene (methylbenzene)	2162038
13 Xylenes (individual or mixed isomers)	1731759
14 Dichloromethane	1171552
15 Ethyl acetate	1147417
16 Benzene	1098670
17 n-Hexane	1092351
18 Sulfuric acid	1018139
19 Formaldehyde (methyl aldehyde)	784640
20 Acetone	686221

Appendix 7: Ranking of Substances by Weighted Average Risk Factor

Substance	WARF
1 Sulfur dioxide	10831232166
2 Carbon monoxide	9003200000
3 Oxides of Nitrogen	2909325172
4 Particulate Matter 10.0 um	430391771
5 Ammonia (total)	72207894
6 Ethanol	39611698
7 Fluoride compounds	26461790
8 Total Nitrogen	26072125
9 Hydrochloric acid	17176249
10 Xylenes (individual or mixed isomers)	12122310
11 Toluene (methylbenzene)	10161578
12 Dichloromethane	9138106
13 Sulfuric acid	7432416
14 Benzene	7361089
15 Methyl ethyl ketone	4114157
16 Ethyl acetate	3786475
17 Acetone	3774213
18 Lead & compounds	3191296
19 Formaldehyde (methyl aldehyde)	2824705
20 n-Hexane	2730877