Determinants of Environmental and Financial Performance of the Australian Electricity Generating Firms: A Structural Equation Modelling (SEM) Approach

Shima Forughi

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Determinants of Environmental and Financial Performance of the Australian Electricity Generating Firms: A Structural Equation Modelling (SEM) Approach

By:
Shima Forughli
Master of Accountancy-Research

This thesis is presented as part of the requirement for the conferral of the degree:
Doctor of Philosophy

University of Wollongong
School of Accounting, Economics and Finance

July 2019
Certification

I, Shima Foroughi, declare that this thesis submitted in fulfilment of the requirements for the conferral of the degree of Doctor of Philosophy, from the University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

____________________

Shima Foroughi

30th July 2019
Abstract
The Australian electricity sector currently accounts for around one third of Australia’s emissions and is the largest single source of emission in the country (ACIL Allen Consulting, 2015). Given this, unsurprisingly there has been a significant interest in the way electricity manufacturers are attempting to improve their environmental performance. This study develops and presents a structural equation model to show the structural relationship between key variables that contribute to the environmental performance, financial performance and market performance of Australian electricity producers. The study then empirically test the model with a view to examine: (1) the relationship between firm efficiency, internal operations and the environmental performance, (2) the relationship between the firm efficiency and financial performance, (3) the relationship between the environmental performance and financial performance, (4) the impact environmental standards have on the relationship between the environmental performance and financial performance, (5) the relationship between the financial performance and market performance, and (6) the relationship between environmental performance of firms and their financial performance in different geographical regions. The data for this study was drawn from 13 Australian electricity producing companies for the period from 2006 to 2017.

The structural model built to examine the relationship between the environmental performance, financial performance and market performance of Australian electricity producers incorporated firm efficiency as a latent variable which was measured using Data Envelopment Analysis (DEA) and fitted into the model through reflective measures of technical efficiency, scale efficiency and allocative efficiency. The other key latent variables used in the model were: Internal Operation (reflected by size, risk, retention ratio and technology indicators), Environmental Performance (reflected by indictors of firms’ 5-year environmental performance), Financial Performance (reflected by return on assets, return on equity, gross profit margin and net profit margin indicators), Market Performance (reflected by the market indicator of price-earnings ratio), Environmental Standards (reflected by the dummy variable of firms’ following environmental standards) and Reginal Dummy (reflected by dummy variable of region of firms’ operation). In building this model, the study utilised the theoretical underpinning of three key theories: Resource based view (RBV), stakeholder theory, and Legitimacy theory.

The results of the study showed that firm efficiency is a significant factor that had assisted firms in enhancing their environmental performance directly as well as indirectly through the mediating effect of internal operations. The improved environmental performance
of firms was found to have significant positive relationship with firms’ financial performance and market performance. However, the relationship between the firms’ financial performance and market performance was found to be not significant, indicating that the improved financial performance has not translated into wealth creation of firm’s shareholders. The study also found that the firms’ full compliance with environmental standards helped companies achieve significantly higher environmental performance through reduction in emissions and as such improving both financial performance and market performance of firms. However, when the results were examined by regions, it was found that environmental performance of firms differs significantly in each of the six states indicating that regional factors play a role in determining the extent of the relationships examined in the study. Finally, the result of the study revealed that the relationships between firms’ environmental performance and both financial performance and market performance are significantly positive in the long-run indicating that the actions taken by these firms to enhance sustainable performance is likely to deliver long-term financial benefits.

This study provides insights for Australian electricity producers to undertake actions to improve the firm’s environmental performance leading to better financial and market performances. As shown in the study, from the stock market investor’s perspective, the combination of financial and environmental information can lead to decisions with proper future growth, whereas regulating authorities and managers can adopt useful policies for sustainable development. The positive impact of environmental performance of electricity generating firms on their future financial performance and market performance should provide incentives for the firms to bear the initial high costs of improving technical efficiencies within their factories as such an investment lead to better financial outcomes for the firms. The transition of the electricity generation from coal-fired approach to renewable source approach will be essential for Australia to address its international commitments. However, while taking decisive actions in implementing this long-term goal, Australian electricity can incorporate new technologies that enhance their internal business operations to take advantage of the mediating effect it has on firm performance. In order to enhance the electricity generation technology from traditional coal-fired production to the green production, firms could be benefited by the relevant financial and investment policies affecting their size and capital structure. These types of policies support the capital-intensive productions and indirectly enable the technical transition and replacement of aged coal-fired plants by the renewable sourced green plants. The capital investment decisions that firms are making in this regard need to be supported by public financing.
Acknowledgment

This research has been conducted with the support of the Australian Government Research Training Program Scholarship.

I do owe gratitude to my supervisor, Dr Anura De Zoysa, who has always been more than a supervisor to me. Through immense support and good-hearted advices, he has eased my academic journey during all my years in the University of Wollongong. The completion of this thesis would have never been possible without his valuable and detailed feedback on both theoretical and technical aspects of this study.

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I would like to express my heartily and sincere thanks and regards to the fabulous academicians of the School of Accounting, Economics and Finance for all their help and support. I am deeply thankful to Associate Professor Corinne Cortese, Associate Professor Lee Moerman, Mrs Fariba Ahmadi, Dr Parulian Silaen, Dr George Mickhail, Dr Stephanie Perkiss, and Dr Sanja Pupovac for all their kind-hearted support and valuable advices.
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I would love to be uniquely thankful to my lovely aunt and her beloved husband, Mrs. Mati and Dr. Soghrat Nazem, for their treasurable love, support and advice in every aspect of my life. They have always been there for me with the beautiful feelings of love and security.

My sincere gratitude, respects and love goes to my wonderful parents, Mrs. Shahla and Dr. Ali H. Forughi, who have always been the source of inspiration in every aspect of my life. Their endless love, kindness, patience and sacrifice supported me to persuade my wishes and live my dreams. Words fail me in the expression of my debt and love to my parents.

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<th>Description</th>
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<td>ABS</td>
<td>Australian Bureau Of Statistics</td>
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<tr>
<td>AC</td>
<td>Anticipation</td>
</tr>
<tr>
<td>AGL</td>
<td>The Australian Gas Light Company</td>
</tr>
<tr>
<td>AIC</td>
<td>Akaike's Information Criterion</td>
</tr>
<tr>
<td>AIC3</td>
<td>Modified Akaike's Information Criterion with Factor 3</td>
</tr>
<tr>
<td>AIC4</td>
<td>Modified Akaike's Information Criterion with Factor 4</td>
</tr>
<tr>
<td>AIC4</td>
<td>Modified Akaike's Information Criterion with Factor 4</td>
</tr>
<tr>
<td>ALCOA</td>
<td>Aluminium Company of America</td>
</tr>
<tr>
<td>Allocative EF</td>
<td>Allocative Efficiency</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>APA</td>
<td>Australian Pipeline Trust (APT) And Its Controlled Entities</td>
</tr>
<tr>
<td>AVE</td>
<td>Average Variance Extracted</td>
</tr>
<tr>
<td>BIC</td>
<td>Bayesian Information Criteria</td>
</tr>
<tr>
<td>CAIC</td>
<td>Consistent Akaike's Information Criterion</td>
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<tr>
<td>CB-SEM</td>
<td>Covariance-Based SEM</td>
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<tr>
<td>CC</td>
<td>Creative Culture</td>
</tr>
<tr>
<td>CRS</td>
<td>Constant Return To Scale</td>
</tr>
<tr>
<td>CSA</td>
<td>Covariance Structure Analysis</td>
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</table>
CSP     Corporate Social Performance
CSR     Corporate Social Responsibility
DC      Detection Culture
DEA     Data Envelopment Analysis
DMU     Decision-Making Unit
EBIT    Earnings Before Interest and Tax
EDL     Energy Developments Pty Limited
EF      Efficiency
EM      Expectation- Maximisation
EM      Expectation Maximisation
EN      Entropy Statistic (Normed)
EP      Environmental Performance
ES      Environmental Standards
FIMIX-PLS    Finite Mixture Partial Least Squares
FMP     Financial and Market Performance
FP      Financial Performance
GHG     Greenhouse Gas
GPM     Gross Profit Margin
HQ      Hannan Quinn Criterion
Hydro elec Hydro-Electric Corporation
<table>
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<th>Abbreviation</th>
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<tr>
<td>IO</td>
<td>Internal Operation</td>
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<tr>
<td>LnL</td>
<td>Log of the Likelihood</td>
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<td>LP</td>
<td>Linear Programming</td>
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<tr>
<td>MANOVA</td>
<td>Multivariate Analysis of Variance</td>
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<tr>
<td>MDL5</td>
<td>Minimum Description Length with Factor 5</td>
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<tr>
<td>MP</td>
<td>Market Performance</td>
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<tr>
<td>MPSS</td>
<td>Most Productive Scale Size</td>
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<tr>
<td>NEC</td>
<td>Normalized Entropy Criterion</td>
</tr>
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<td>NEM</td>
<td>Australian National Electricity Market</td>
</tr>
<tr>
<td>NFI</td>
<td>Non-Fuzzy Index</td>
</tr>
<tr>
<td>NIRS</td>
<td>Non-Increasing Returns to Scale</td>
</tr>
<tr>
<td>NPM</td>
<td>Net Profit Margin</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>NT</td>
<td>Northern Territory</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OLS regression</td>
<td>Ordinary Least Squares</td>
</tr>
<tr>
<td>PE</td>
<td>Price-Earning</td>
</tr>
<tr>
<td>PLS-GAS</td>
<td>Partial Least Squares Genetic Algorithm Segmentation</td>
</tr>
<tr>
<td>PLS-POS</td>
<td>Partial Least Squares Prediction-Oriented Segmentation</td>
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<tr>
<td>PLS-SEM</td>
<td>Partial Least Square Structural Equation Modelling</td>
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Chapter 1
Introduction

1.1 Introduction

More than two-thirds of energy produced in Australia is exported and this makes the Australian energy industry the foremost contributor to its economy. Coal accounts for around 40% of energy production and for more than 80% of electricity generation. The highest portion of the carbon pollution belongs to electricity production which is found to be 35% of the whole greenhouse gas emission within the country (Engineers Australia 2017). It is possible for the electricity sector to replace its conventional production approaches by the clean and advanced production technologies. Therefore, it may be reasonable for the Australian electricity sector to transit from the coal-fired electricity production to the renewable sources for the electricity production by replacing the aged power plants with the new ones with higher efficiency and less environmental pollution (Engineers Australia 2017). Considering this situation of the country and the significant role of the electricity sector in economy as well as in greenhouse gas emission, it is important to analyse the link between the environmental performance (EP) and financial performance (FP) of the electricity producers in the Australian power industry.

The present chapter will provide an outline of the whole thesis by discussing the logics and intentions of initiation and accomplishment of such a study. The background of the research will be discussed through section 1.2 followed by the issues being addressed by the study in section 1.3. The significant factors motivating the author to do this research will be pointed out through section 1.4. Objectives and research questions will be presented in section 1.5 followed by the introduction of theoretical background and methodology in section 1.6 and 1.7 respectively. Prospective contributions of the study will be discussed in section 1.8 and research limitations will be addressed in section 1.9. Thesis structure will be presented in section 1.10 and the chapter will be summarised in section 1.11.
1.2 **Background of the Study**

As a result of the heavy dependence of the Australian electricity generation on coal, Australia has become one of the foremost carbon dioxide (CO2) emitters among developed countries in the world. Although the Australian energy generation requires a transition from coal to green components, companies resist this change due to the higher associated costs (Nelson, Bashir et al. 2017).

The studies on the relation between financial performance of firms and their environmental effects have produced mixed results. Some studies suggest a positive impact of the environmental activities of firms on their financial outcomes while others presented negative or neutral relationships between environmental performance and financial performance of organizations. However, they all complain about the lack of consensus on the methodology and results, a point which will be elaborated in the present thesis.

Inspired by the previous literature, the present study will investigate the relationship between environmental performance (EP) and financial performance (FP) of firms in the short- and long-run. We propose that while becoming environmentally friendly will negatively affect the financial performance of the firms, it will positively contribute to their FP after a few financial periods. To accomplish this study, the sample consists of the 13 firms during the period of 2006-2017.

The firms in the sample are operating in the Australian electricity generation sector which forms a significant part of the Australian economy. The major resource of electricity generation in the Australian electricity sector is fossil fuels and it will stay the same. This makes Australian electricity generation the most polluting industry in the country. Due to the characteristics of this industrial sector, Australia will need transition plans and policies in order to be able to meet the national and international commitments of emission reduction along with the community concerns (Engineers Australia 2017; Shahbaz et al. 2017). According to Energy
Australia (2017), the main requisite of this transition is to replace fossil fuels by the renewable resources in larger part of electricity generation though it is likely that such a transition may not be financially viable for the firms. These and related issues will be discussed in Section 1.3.

1.3 Statement of the Problem

So far, several studies have been conducted on the relationship between corporate social responsibility and its financial performance such as the early studies by Porter (1991), Jaggi and Freedman (1992), Blacconiere and Patten (1994) (Misani and Pogutz 2015 and Chen et al 2015). However, the interest in the investigation of this relationship has recently increased (Saeidi et al. 2015) the search for theoretical improvements to hypothesise if “it pays to be green” (Misani and Pogutz 2015, p.150). Various methodologies are applied in the literature on the basis of different theories. These differences in the applied methodology and theoretical background produced different outcomes obtained by the majority of the studies (positive, negative or neutral) (Saeidi et al. 2015).

Those supporting a positive relationship between environmental and financial performance argue that the improved reputation achieved by improved environmental activities and reporting will lead to the higher number of investors and stakeholders and hence, to enhanced financial performance (Chen et al. 2015, p.446). The authors (not unlike the neoclassical economists) believe that spending resources and energy to improve their environmental performances will raise operational costs of the firms and hence, the products price which will impose negative effect on their financial performance (Chen et al. 2015, p.446). Furthermore, various probable factors (internal or external) affecting the environmental and financial relationship were missed through the previous studies which led to the misleading and unreliable results. Not having considered the “complicated” nature of this relationship
previous studies have led to the reconstruction of the hypothesis into “when and how it pays to be green” (Misani and Pogutz 2015, p.150).

To provide a reliable answer to the above query derived from the literature, we will examine the relationship between environmental and financial performance of firms with lagged period longer than those of the firms discussed in the literature to find out the effect of environmental performance on financial performance in both short- and long-run. In addition, the present thesis will propose a modified approach of the structural equation modelling (SEM) (which considers the influential hidden factors within a broader theoretical frame) to investigate this relationship.

The grounding studies to the present research include Liu (2020), Lin, Yang et al. (2009), Horváthová (2012), Delmas, Nairn-Birch et al. (2015) and Nollet, Filis et al. (2016) who concluded that being socially responsive imposes negative impact on the firms’ financial performance in the short-run but positive impact in the long-run. Next section will elaborate the significant factors of this analysis which motivated authors to commence this study.

1.4 Motivation and Significance of the Study

Review of the prior literature on the relationship between environmental performance and financial performance of firms highlights the lack of consistency in their methodology and results. The influential financial and environmental variables are not sufficiently applied by these studies in the development of their measurement model. Some factors are missed in the studies such as those of Saeidi et al. (2015), Misani and Pogutz (2015), Gonenc and Scholtens (2017), Lioui and Sharma (2012), Tzouvanas et al. (2019), Yang et al. (2018), Latan et al. (2018), Maso et al. (2018). This issue will be discussed thoroughly in the literature review chapter of the current thesis. The applied environmental data by the previous literature are mostly collected via surveys or environmental ranking authorities which are biased (Salama 2005, Elsayed and Paton 2005, Giovanni and Vinzi 2012, Marie et al. 2014, Saeidi et al. 2015).
In addition, the longest time span of the previous studies has been less than 3 years period while it is recommended to analyse the EP-FP relationship within a long term rather than short (Horváthová 2012, Lin et al. 2009, Nollet et al. 2016 and Delmas et al. 2015).

On the other hand, Australia is a major producer and exporter of coal and energy and known as one of the world’s foremost polluting countries. Therefore, the Australian energy sector is a vital sector in the Australian economy while being responsible for a large portion of the environmental pollution in Australia as a result of the GHG emissions from the electricity generation (Shahbaz et al. 2017; Nelson et al. 2017). Considering all these, the present study intends to highlight the impact of environmentally friendly activities on the improvement of financial performance of the electricity generating companies in Australia.

There have been wide-ranging discussions on the impact of environmental activities on financial performance of firms. According to the debates of classic economy, these types of investments are not as beneficial to the firms as to the society and therefore, firms usually under-invest in the environmental performance. In addition, it is argued that the enforcement of environmental standards by governments will create a trade-off between the societal benefits and organizational costs. However, some studies (for instance Porter 1991, Porter and Van der Linde 1995a, b, Konar and Cohen 2001, Horváthová 2012) claim that following environmental regulations by firms may lead to higher profitability in long-run due to benefits derived from customer satisfaction or reduction in the production costs. Such studies address the environmental investments as a “win-win” approach for societies and firms (Elsayed and Paton 2005).

Although there are numerous studies in this context, there is no consensus on the appropriate methods and variables to increase the accuracy of the findings which is itself a result of the lack of agreed-upon theories related to this analysis and inaccurate measurements. There are either qualitative (e.g. application of environmental management system) (Chen et
al. 2015, Lucas and Noordewier 2016, Rodrigues-Fernandez 2016) or quantitative measures (e.g. environmental ratings, emission amounts or indicators of GHG) (Salama 2005, Elsayed and Paton 2005, Lioui and Sharma 2012, Saeidi et al. 2015, Gonenc and Scholters 2017, Delmas et al. 2015, Lee et al. 2015, Kim 2015, Ernhart and Lizal 2002, Giovanni and Vinzi 2012, Horváthová 2012, Hatakeda et al. 2012, Misani and Pogutz 2015, Nollet et al. 2016) of environmental performance applied in the literature. However, another important issue is the dangerousness levels of different pollutants included in the applied measures of environmental performance which can lead to the ambiguous results.

The above-mentioned research gaps, which are revealed through reviews of previous studies, will be bridged by the present thesis by expanding the investigation period to 11 years, applying short-term (Accounting-based factors) and long-term (Market-based factors) indicators of financial performance plus the introduction of an environmental index as a measure of environmental performance of firms. The longer time-span (2006-2017) of the present study and the large lagged period analysis (5 years lagged period) to exhibit a longer trend of the EP-FP relationship will provide more precise analyses and results compared to the literature. It will exhibit a wider trend of the relationship between environmental performance of the Australian electricity producing firms and their financial and market performance.

In addition, considering the lack of suitable theoretical framework in the context of the relationship between environmental performance of firms and their financial performance which has been resulted in the inconsistency of theories and results within the literature, the present research will attempt to propose a broad theoretical background in order to include the majority of the influential factors (the largest number of variables among the literature) in the context of the EP-FP relationship. Such an inclusive theoretical framework will maximise the accuracy and reliability of the analysis and results providing a stronger evidence on the significance of the firms’ environmentally concerned operations to their future financial state.
Furthermore, as observed through the review of literature, this relationship has not been conducted in the Australian context. Thus, considering the crucial importance of GHG emissions in Australia and higher possibility of emission reduction by the electricity sector, this study will evaluate the relationship between the environmental performance and financial performance of the Australian electricity producers. The present study aims to apply improved methodological frameworks and models to analyse the environmental performance and financial performance of firms with results of higher accuracy. To do so, an index which normalises the amount of emission along with a modified measurement model to evaluate the relationship between environmental performance and financial performance of firms in the sample are proposed. Our theoretical background will be introduced through the next section.

1.5 Theoretical Foundation

The present study on the relationship between firms’ environmental performance and financial performance is based on the Porter Hypothesis (Porter 1991; Porter and van der Linde 1995) which argues for the importance of strict environmental regulations in the improvement of firms’ environmental performance. The environmental regulations will lead to the reduction of environmental pollution (resulting from waste or improper resource utilisation) which will reduce the production cost and increase the firms’ efficiency (Porter and van der Linde 1995; Lundgren 2015). This hypothesis is the ground of the legitimacy theory which concerns not only about the legitimate image of the firms but also the significant impact of the environmental regulations on firms’ environmentally-friendly operational approaches (Magness 2006). In fact, firms’ environmentally friendly operation will improve productivity and impose positive impact on their financial performance (Wagner, Van Phu et al. 2002; Porter and van der Linde 1995). According to this hypothesis, there is a causal relationship between environmental regulations and firms’ financial performance which is also affected by innovation and results in increased revenue as well as cost reduction (Rassier and Earnhart 2010). Also, impact of
innovation on the firms’ financial performance is grounded on the resource-based view (RBV) theory which concerns about the importance of firm’s competitiveness on its survival with the consideration of its resources (Salem et al. 2012). Accordingly, firms’ stakeholders are considered to be a vital source of business sustainability. Therefore, to manage the firms’ relationship with stakeholders and their strategies towards addressing the stakeholders’ expectations, needs and concerns are influential in firms’ competitiveness and vitality which is underlined by the stakeholder theory.

According to the above discussion, the arguments of the Porter Hypothesis form the basis of the present study on the relationship between environmental performance of the Australian electricity producing firms and their financial performance grounded on the Resource-based view (RBV) theory, stakeholder theory and legitimacy theory as the theoretical framework.

1.5.1 Resource-based View Theory

The resource-based view (RBV) theory argues for the relationship between firms’ resources and their competitiveness and highlights the importance of effective competency of businesses on its survival considering the uneven distribution of resources. In other words, the RBV theory lies on the assumption that businesses can gain competitive advantage on the basis of their resources and capabilities and this will result in different financial performance among different firms. While highlighting the significance of the available resources to the firms’ financial operation, the RBV theory provides a suitable ground for the analysis of firms’ environmental performance and its relationship with financial performance by acknowledging the importance of resource utilisation concerning environmental issues (Salem, Hasnan et al. 2012).

The present study will be supported by the results obtained by the work of Clarkson, Li et al. (2011), Darnall, Henriques et al. (2008), Busch, Stinchfield et al. (2011), Galdeano-
Gómez (2008) and Nakao et al. (2007) which confirm the significance of firms’ efficiency and technological level to their environmental performance and financial performance on the ground of RBV theory. Some studies refer to firms’ communication with their stakeholders, which is the basis of the stakeholder theory (Salem et al. 2012), as one of the crucial resources influencing firms’ financial performance.

1.5.2 The Stakeholder Theory

According to the RBV theory discussed in previous sub-section, resources available to the firms’ operation are significant in their competitive advantage and financial performance. Other than innovation, the previous literature has addressed “employee involvement, effective communication practices and stakeholders’ integration” (Salem et al. 2012, p.113) as substantial resources contributing to firms’ efficiency and financial performance. In other words, another source of firms’ competitiveness is their relationship with stakeholders and the strategies in managing the concerns of their stakeholders as the foundation of the stakeholder theory (Salem et al. 2012).

On the basis of the stakeholder theory, the stakeholders’ trust and attitude towards firms impose significant effect on their profitability and sustainability. Therefore, firms’ financial performance will be affected by their environmental performance when dealing with different groups of stakeholders which is also confirmed through the previous literature such as Semenova, Hassel et al. (2010), Salama (2005), Gonenc and Scholtens (2017) and Heras-Saizarbitoria, Molina-Azorin et al. (2011). In fact, the trust and reliance of stakeholders are crucial to the firms’ survival compelling them to publicly report their operations to enhance their legitimate image which is also grounded on the legitimacy theory (Aggarwal 2013); (Magness 2006).
1.5.3 The Legitimacy Theory

Businesses can achieve legitimacy when their operational approaches are allied with social values underlying the legitimacy theory. In other words, the concern of legitimacy theory is to maintain the firms’ legitimate image through their approach to deal with expectations of community. The firms should reveal their responses to the social and environmental concerns and values in order to improve and sustain their relationship with stakeholders and attain the stakeholders’ trust (Sulaiman, Abdullah et al. 2014; Magness 2006).

Addressing the substantial determinants of the firms’ disclosure of the environmental activities on their financial prospect supported by the stakeholder theory, the relevant studies based their investigation of the relationship between environmental performance of firms and their financial performance on the legitimacy theory (Magness 2006; Ghomi and Leung 2013; Juhmani 2014).

1.5.4 Measurement Model Grounded on the Theoretical Framework

Based on the discussion through this section, the present analysis of the relationship between the environmental performance of the Australian electricity generating firms and their financial performance will be conducted by means of a measurement model created on the basis of the discussed theoretical background. The proposed measurement model will investigate the relationship between firms’ level of efficiency and technology and their environmental performance and financial performance based on the RBV theory, the impact of firms’ environmental performance on their financial and market performance based on the stakeholder theory and the impact of firms’ environmental standards on their financial performance based on the legitimacy theory. As will be elaborated through Chapters 3 and 4, the proposed measurement model is consisted of the variables according to the proposed theoretical foundation. The impact of technology (Tech variable) and efficiency (EF variable) on firms’ financial performance will be measured on the basis of RBV theory. The influence
of stakeholders reflected by the market performance (MP variable) will be evaluated in relation to firms’ environmental performance (EP variable) and financial performance (FP variable) based on stakeholder theory. The impact of application of environmental standards (ES variable) on firms’ environmental and financial performance will be assessed on the ground of legitimacy theory. Next section will state the main objectives and questions of the present study.

1.6 Objectives and Research Questions

By accomplishing this research, the authors aim to provide an understanding about the financial advantages of environmentally friendly operations in order to persuade firms to develop more environmentally friendly approaches. To do so, the present research will analyse the impact of environmental performance of the Australian electricity producing firms on their financial and market performance. As a result, we expect to provide suitable policy implications and recommendations for the environmental authorities (with the focus on the Australian electricity producing firms) on the basis of the prospective results.

Along with the above-mentioned practical implications, the present research intends to contribute to the existing literature by proposing a broader and more suitable theoretical background in order to apply a modified methodology to perform the EP-FP analysis. The applicable theories to ground the analysis of EP-FP relationship will enable the measurement model on the basis of the modified methodology to include a broader range of significant and influential variables in the context of the relationship between environmental performance and financial performance.

As a part of the methodology, we introduce an index for the measurement of the environmental performance which is expected to be different from the applied environmental measures. As will be described through Chapter 4 of the present thesis, Horváthová (2012) has recommended to normalise the firms’ environmental emission based on the level of
harmfulness of the emitted pollutants according to their threshold level. Inspired by this research and in order to increase the accuracy of our measurement of the firms’ environmental performance, we will advance the index by normalising the pollutants emissions by the risk score\(^1\) of the environmental pollutants emitted by each firm-each year in the sample. The proposed index will be useful to measure the environmental performance of any type of economic unit.

The present study will specifically answer the following questions via the proposed model.

1. What is the relationship between the efficiency, internal operation and the environmental performance of Australian electricity generation firms?
2. What is the relationship between the efficiency and financial performance of Australian electricity generation firms?
3. What is the relationship between the environmental performance and financial performance of Australian electricity generation firms?
4. What impact do environmental standards have on the relationship between the environmental performance and financial performance of Australian electricity generation firms?
5. What is the relationship between the financial performance and market performance of Australian electricity generation firms?
6. Does the relationship between environmental performance of firms and their financial performance vary in different geographical regions?

To be able to answer the above research questions and fulfil the objectives of the current research, we will construct the methodology on the ground of the proposed theoretical

\(^1\) Obtained from Scorecard which is a free-public information service and non-profit organisation to identify and highlight the most polluting companies based on their environmental records.
background and in line with the previous literature. Section 1.7 will provide an introduction to the proposed methodology.

1.7 Methodology

According to the reviewed literature (Chapter 3 of the present thesis), the present study hypothesised that the firms’ efficiency level is an influential factor in their internal operation, environmental approaches and hence, their financial performance and market value (alternative hypotheses number 1, 2, 4 and 5) according to Heras-Saizarbitoria et al. (2011) and Marie, Ibrahim et al. (2014). Therefore, we will analyse the efficiency level of Australian electricity producers by means of Data Envelopment Analysis (DEA) method and the obtained results will be applied as a variable in the proposed measurement model.

To examine the relationship between environmental performance of the Australian electricity producing firms and their financial and market performance, the present study will propose a measurement model by means of the Structural Equation Modelling (SEM). According to the elaboration of methodology in Chapter 4 of the present thesis, this technique is found to be the most suitable to evaluate the causality of relationships in such context due to its capability to investigate the relationships among various variables (constructs and indicators) with different roles (dependent and independent) in the form of one measurement model. This method is specifically appropriate in the context of performance measurements and the involving factors (Hartmann, Klink et al. 2015; Tomarken and Waller 2005; Hair et al. 2014).

1.7.1 Data Envelopment Analysis (DEA)

In order to increase the precision of the efficiency measurement affecting the firms’ environmental performance impact on their financial performance, the present study will employ the non-parametric approach of Data Envelopment Analysis (DEA) instead of ratio analysis. The reason for superiority of the DEA approach to other methods of efficiency
measurement (in the context of our study) lies in its capability to deal with specific features of samples and variables like discretionary and nondiscretionary inputs, categorical variables and ordinal relationships as well as constructive development of an empirical production function (Seiford and Thrall, 1990). Furthermore, the DEA approach is suitable for productivity measurement and the decomposition of efficiency into its different components (Coelli et al. 2005).

DEA technique captures the frontiers to identify the best practice decision-making unit (DMU) to compare every single DMU with the best practice in order to determine efficiency scores for all firms. The efficiency level of DMUs is dependent on their location against the efficient frontier resulting in efficiency score range of 0 to 1 (Sathye 2001).

1.7.2 Structural Equation Modelling (SEM)

Unlike the majority of the literature on the EP-FP analysis which applied regression approach as a methodology, the present study will employ the structural equation modelling (SEM). The reason for applying this technique is its capability to answer a set of interrelated research questions in a single, systematic, and comprehensive analysis by modelling the relationships among multiple independent and dependent constructs concurrently (in one single measurement model) while different approaches of regression analysis can only measure one layer of linkages between independent and dependent variables at a time. In other words, SEM is capable of evaluating the interacting dependent and independent variables (i.e. they could interact with both direct and indirect relationships) and this capability arises from employing factor and multiple regression analysis approaches. In addition to the ability to measure complex relationships, this method can evaluate the influential factors on the hidden/latent variables (known as constructs) along with observable ones (known as indicators) (Hartmann et al. 2015). This characteristic of SEM makes it the most suitable in the context of present study considering that performance is a latent variable which cannot be directly measured.
(Lemstra, Voogt et al. 2015). The latent variables are measurable by means of SEM in relation to other constructs as well as their influential indicators via one measurement model estimated by SEM (Tomarken and Waller 2005).

The discussed methodology in this section will be elaborated on in Chapter 4 of the present thesis. Next section will address contributions of our research on both theoretical and methodological grounds.

1.7.3 Sample and Data
As mentioned earlier, the purpose of the present study is to investigate the impact of the efficiency and financial performance of the Australian electricity producers on their environmental performance. Therefore, the Australian electricity companies owning power generation plants are selected as the target sample. However, due to some mergers and acquisitions incurred among these companies as well as limitations in the availability of financial and environmental data\(^2\) throughout the study period, our sample includes AGL, Alcoa, Cs Energy, EDL, Ergon Energy, Horizon Power, Hydro electric Corporation, Origin, Power and Water Corporation, APA Group, Snowy hydro and TWPS. Although some of these firms generate a portion of their electricity by means of green/renewable resources, the major resource of power generation used by these companies are coal-fired ones.

Also, the environmental emission data reported by these companies will be accessed through the National Pollutant Inventory (NPI) website of the Australian Department of Environment and Energy.

1.8 Expected Contribution of the Study
Previous studies on the EP-FP relationship indicate that the environmental performance of firms will have effects on their financial performance in future. In other words, the

\(^2\) These limitations are discussed in detail through section 1.9 of the present chapter.
environmental performance does not have immediate effect on the financial performance of firms but will positively affect the firms’ financial performance after a few financial periods following the start of environmentally friendly activities (Harvathova 2012; Lin et al. 2009; Nollet et al. 2016; Delmas et al. 2015). However, the investigation period of all these studies is maximum 3 years with 2-years lagged period while the timespan of the present research is from 2006 to 2017 (the maximum timespan within the literature) with 5-years lagged period of EP-FP analysis. This expanded timespan and longer lagged-period analysis provide a wider and more precise trend of the relationship between environmental performance and financial performance of the Australian electricity producing firms. In fact, our research contributes further evidence on the future outcomes of EP-FP relationship of firms to the literature by conducting the analysis via a more inclusive measurement model expecting higher reliability level of results which will exhibit this relationship within a longer time period.

The present study is the first to evaluate the impact of firms’ efficiency and internal operation based on the Resource-based view (RBV) theory, environmental standards and regional factors based on the legitimacy theory on the relationship between the firms’ environmental performance and their financial performance and market performance based on the stakeholder theory. Another contribution of this analysis will be the examination of the EP-FP relationship by means of factors and variables grounded on the incorporation of the above-mentioned theories (RBV, legitimacy and stakeholder theories), which will fill the gap in the literature.

For the first time through the investigation of the effects of firms’ environmental performance on their financial performance, we will measure the effect of regional factors separately for every single Australian state and territory in which the firms in the sample operate. To do so, two measurements will be proposed with and without the regional factors while the previous studies have measured the effect of regional factors as a dummy variable.
Therefore, the present study will contribute to the literature through highlighting the influence of operational condition on the firms’ environmental performance and hence, financial and market performance.

To measure the impact of firms’ environmental performance on their financial prospect we will distinguish between the accounting-based measures (gross profit margin, net profit margin, return on assets and return on equity) and the market-based indicators (price-earnings ratio). Accounting based measures represent the firms’ short-term financial performance while the market measures indicate firms’ long-term financial performance. The proposed measurement model will be the first to separately evaluate the effect of firms’ environmental performance on both their financial performance and market performance resulting in a more accurate image of the effects of environmental performance on short-term and long-term financial performance.

The expanded theoretical framework of the EP-FP analysis (as discussed earlier in this section) will result in a broader measurement model to evaluate the relationship between environmental performance of the Australian electricity producing firms and their financial performance and market performance. In other words, based on the three theories of RBV, stakeholder and legitimacy there is a larger variety of the influential factors in this relationship, which will be included in the measurement model proposed by this study. The development of such an inclusive model to make the causal analysis based on the wider theoretical background will provide a more accurate results compared to the existing literature.

In order to evaluate the relationship between efficiency on firms’ environmental performance and financial performance, the Data Envelopment Analysis (DEA) will be applied. While the previous literature has examined the effect of efficiency on the EP-FP analysis (Galdeano-Gómez 2008), the present study will be the first to decompose the efficiency of the Australian electricity producing firms into the efficiency components through
the DEA approach which will show more clearly the effect of efficiency on the firms’ internal operation, environmental performance, financial performance and the relationship among these performance variables. Also, the efficiency will be applied as a mediation in the relationship between firms’ internal operation and environmental performance (i.e. the effect of internal operation on environmental performance of the Australian electricity producing firms will be measured directly and indirectly through efficiency).

Overall, the expected contribution of the present research as discussed through this section will be achievable by means of the proposed methodology i.e. the Structural Equation Modelling (SEM). As discussed through Section 1.6 of this chapter, SEM technique is more suitable in the context of the EP-FP analysis due to its capabilities in evaluating the causal relationships compared to the conventional regression analysis. While the majority of the literature has applied different approaches of the regression method, our study will be one of a few to apply the partial least square (PLS) approach of SEM to develop the measurement model. Therefore, our proposed measurement model is expected to be able to measure the causal relationships among number of variables with different roles (i.e. one single variable will be dependent on another variable while it will also be independent in another relationship for instance our environmental performance variable will be dependent on the efficiency while it is independent in its relationship with financial and market performance variables). In addition, the SEM technique is able to measure the mediating relationships along with the direct ones enabling us to find out the direct and mediating role of firms’ efficiency in the relationship between firms’ internal operation and their environmental performance to increase the precision of the role of efficiency in the context of EP-FP analysis. In fact, the proposed methodology by the present study will enable the measurement model to be developed by the application of various important factors on the ground of broader theoretical framework to back
up the expecting results and contribute the most accurate and reliable (with the least bias) results possible to the literature on the EP-FP analysis.

One of the major contributions of the present study will be the proposed measurement index for the environmental performance of firms. While the previous studies have applied environmental scores released by ranking authorities or qualitative data obtained via surveys as measures of firms’ environmental performance, the present study intends to introduce an index to measure environmental performance. This index will be obtained via the sum of normalised emission amounts of various pollutants (based on the dangerousness level of every single pollutant) in relation to firms’ production volume. In fact, the present study will provide the literature with the most accurate environmental performance measurement index applicable in developed and developing countries, on both national and international scale of environmental analysis.

However, like any other research, the present study has faced several limitations which will be elaborated through Section 1.9 along with the recommendations of future research avenues.

1.9 Limitations and Recommendations for Future Research

The first limitation of the present study to be addressed is that the focus of this research is only on one economic sector of one country (Australian electricity generation sector). However, the upcoming analysis and the methodology proposed through our research will be applicable to other types of economic sectors in Australia as well as other countries. We may recommend future studies to expand the context of EP-FP analysis as well as to conduct comprehensive studies.

As mentioned above, the investigated sample of the present research is the Australian electricity generating firms which are considered the most polluting economic sector (Engineers Australia 2017) and hence, it is crucial for this sector to reduce its greenhouse gas
(GHG) emission level. Therefore, the expected implications of our analysis might not be adjustable to inequivalent economic sectors and we recommend justified analysis in case of other types of samples.

In addition, the whole analysis will be on the impact of the environmental performance of the Australian electricity producing firms on their financial and market performance, which may also include the increase in the price of electricity. Therefore, further examination of the EP-FP relationship in the context of electricity consumers (residential, industrial and commercial sectors) will provide fruitful studies.

The Australian environmental data (regarding types and characteristics of pollutants and their level of emission) is released by the Australian National Pollutant Inventory (NPI). However, during our data collection, we realised that the information regarding some pollutants were missed for several firms and only the required information about Carbon Monoxide, Oxides of Nitrogen and Sulphur Dioxide have been completely released. Hence, these three pollutants are the only ones included in our environmental measurement index and we encourage future studies to apply all possible types of pollutants to their environmental measurement for which our proposed index is suitable (as discussed in Section 1.7 of this chapter). Also, the environmental data was released until the end of 2017 and we could not extend our analysis further to 2018.

A shortcoming of the required applicable financial data to measure the financial performance and market performance of firms were inconsistent (were not reported or available such as unpaid dividends in some years) for some of the Australian electricity producing firms and hence, will be missed from the analysis.

Also, we could not attain all the required financial data of some of the Australian electricity producing firms for whole of the investigation period which could be due to some mergers or acquisitions incurred through this timespan or operational discontinuance of some
firms (for instance, AGL merged with Alinta Limited and Acquired Loy Yang A power station). Due to these issues we ended up with a sample of 12 Australian electricity generating firms out of 20. Furthermore, while the financial data were acquired from the merged/single financial statements of the merged firms included in the sample, the environmental data were released separately for different power plant stations which forced us to manually compute and obtain the required environmental data.

Finally, we recommend further research on the investigation of the impact of regional factors on the firms’ environmental performance and its relationship with firms’ financial performance. It would be fruitful to increase the focus of the analysis on the policy implications on both national and regional levels considering the specific features and conditions of the environment in which firms operate.

Section 1.10 will exhibit the thesis structure.

1.10 Outline of the Thesis

This thesis is organised into six chapters which are briefly explained below.

Chapter one is the introduction and the first section of the chapter provides the background of the study. The problem will be stated in the following section followed with the significance of the study. The research questions, objectives and limitations of the research are presented through the following section.

The Australian electricity sector is elaborated in chapter two starting with the electricity generation sector and the Australian National Electricity Market (NEM). The climate change issues, the relevant policies and the impact of these policies on the electricity generation sector are also discussed in this chapter.

The related literature is reviewed through chapter three starting with the studies on the relationship between environmental performance and financial performance of firms divided in two sub-sections based on their obtained results. The studies providing the theoretical basis
to our research, is presented followed by the studies related to the applied methodologies for efficiency analysis as well as the assessment of EP-FP relationship. The chapter is concluded with the research gaps that led to the research questions to be answered via proposed methodology.

Chapter four begins with the hypotheses to be tested by the methodology to answer the research questions. The following sections cover the discussion of the Partial Least Squares Structural Equation Modelling (PLS-SEM) and the proposed model which is applied to measure the relationship between environmental performance and financial performance of the Australian electricity generation firms. These sections of the chapter include the definition of variables and proposition of the EP index to measure the environmental performance. Efficiency of the firms, a factor affecting the EP-FP relationship which is evaluated by the Data Envelopment Analysis (DEA), is also discussed in this chapter. Chapter four ends with the data collection sources and a brief introduction of the firms included in the sample followed by hypothesis testing section.

Chapter five presents the obtained results from the efficiency analysis by means of DEA followed by the evaluation of the proposed measurement model. The chapter finally presents the results obtained from the PLS-SEM analysis and hypothesis testing along with the answers to the research questions and ends by the main findings of the study.

The thesis is concluded through chapter six which summarises the chapters, answers to the research questions and the main results. The contributions made by the thesis are based on two grounds of theoretical and practical implications which will be pointed out in this chapter followed by drawing policy implications. The chapter will end by the discussion of the limitations of the present study and recommend pathways for the future research.
1.11 Summary

The present chapter intended to provide an introductory summary to the whole research. The chapter started with the background of the study which is a summarised explanation about environmental state of Australia and the production approaches of the Australian electricity producing firms. This section has also discussed the sample data and investigation period of the study. The issues to be addressed in the present study will fill the theoretical and methodological gaps revealed through the literature ended with the inconsistency of their analysis and results. To provide the existing literature on the EP-FP analysis with the most accurate and reliable results, the present study will apply a broader theoretical framework which will enable the authors to develop a more inclusive measurement model by means of a modified methodology. The introduction to the intended theoretical background and modified methodology were summarised in the present chapter followed by the contributory ground of the study. Finally, the organisation of the chapters presented in this thesis has been outlined in previous section. Next chapter will elaborate on the Australian electricity producing sector from various aspects.
Chapter 2
The Australian Electricity Sector

2.1 Introduction

Australia is one of the world’s largest carbon dioxide (CO2) emitter countries with the highest per capita CO2 emissions from fossil fuel among industrial and developed countries which is largely due to the dependence of electricity generation on coal. In 2014-15, more than half of greenhouse gas (GHG) emission in Australia was the result of electricity generation; the fact highlights the importance of transition of the Australian energy sector from fossil fuels to green production.

However, companies usually avoid becoming green because they are concerned about higher cost of the related technologies which will increase the production cost, higher retail price and finally, lower customer satisfaction (Shahbaz et al. 2017; Nelson et al. 2017; Maxim 2014).

Inspired by the literature, the present thesis proposes that environmentally friendly actions of firms will result in improved financial performance not immediately, but after a few accounting periods. Therefore, we will investigate Australian electricity generators during the 2005-2015 period to analyse their EP-FP relationship on the basis of an inclusive theoretical framework and methodology.

The purpose of this chapter is to illustrate the background of the Australian electricity generation sector, Australian National Electricity Market (NEM) as well as environmental policies undertaken in Australia to provide an overview of the firms in the sample. Section 2.2 provides an overview of the Australian electricity sector with particular focus on the electricity generation sector and the Australian National Electricity Market (NEM). In section 2.3 overall actions and policy approaches towards climate change is discussed. Section 2.4 explores the
Australian policies to encourage the low emission electricity generation. Section 2.5 summarises the chapter.

2.2 Australian Electricity Sector

The energy sector is a crucial component of the Australian economy (roughly 6 per cent of the economy in 2014-15) and the demand for the country’s energy resources is expected to rise slowly both domestically and internationally. Historically, there are three supply chain elements included in the Australian electricity sector which are “generation (power stations), transmission and distribution (poles and wires) and retail supply (marketing, customer services, risk management and billing)” (Nelson, Bashir et al. 2017, p.104). These sub-sectors have been combined together in “the vertically integrated government-owned state electricity commissions” throughout the 20th century (Nelson et al. 2017, p. 104). The electricity generation and retailing were separated from transmission and distribution sub-sector through the industry’s deregulation as a result of the Hilmer microeconomic reforms of the 1990s. Due to the monopoly features of the transmission and distribution after the deregulation, this subsector became a competitor with the generation subsector which was government-owned (Nelson et al. 2017). These two competitive subsectors will be distinctly discussed below.

2.2.1 The Australian Electricity Generation Sector

The installed generation capacity increased in the mid-1990s as a result of constructing large thermal power stations using coal and gas (low-cost resources) which led to considerable decline in real electricity prices. Local and distributed energy generation was significantly replaced by the centralised generation resulting in the expansion of the industry. Large volumes of energy were produced by the centralised generation and transported via the “transmission and distribution system” through “long distances” (Nelson et al. 2017, p. 105). The application of economies of scale caused a considerable decline of electricity prices until the late 1970s
while by the beginning of 1980s, prices rose significantly as a result of vast investments in new generation capacity by “the state-owned electricity commissions” (Nelson et al. 2017, p. 105).

The following four realistic approaches are proposed to be taken through the next few decades to reduce greenhouse gas emission by the electricity generation sector:

1. To improve the efficiency in the production and consumption of electricity (e.g. cleaner coal technologies);

2. "Capture CO2 emissions from fossil fuel led plants (especially coal) and permanently sequester the CO2" (Skoufa and Tamaschke, 2011, p.2610);

3. Increase the employment of nuclear power; and

4. Develop the application of renewable resources (Skoufa and Tamaschke 2011).

The fossil fuel options (number 1 and 2) are of ultimate significance to the majority of electricity systems including Australia and various researchers have been trying to highlight the importance of the impact of the GHG, CO2 in particular, on the environment (Skoufa and Tamaschke 2011).

To elaborate the response of the Australian electricity companies to climate change, Snell and Schmitt (2012) investigated the strategic response of 4 corporations operating in Australia which include China Light and Power Group (CLP), International Power (IP), Tokyo Electric Power Company (TEPCO) and Australian Gas Light Company (AGL).

Only AGL is basically Australian with investments and industrial activity inside Australia; CLP was established in Hong Kong, IP was founded in the UK and TEPCO is Japanese. All these corporations formally admitted the need to reduce GHGs in order to control climate change. They believe in the effect of climate change on environment and supported the actions on reduction of GHG. AGL claimed through its Sustainability Report in 2009 that “AGL recognizes that climate change is a critical issue facing the global community and accepts the
scientific consensus that greenhouse gases in our atmosphere need to be stabilized to minimize dangerous climate change” (Snell and Schmitt 2012, p.7).

CLP participated in the Climate Vision 2050 statement which admits the necessity of the carbon emission reduction. In addition, in 2007, CLP published an operation policy statement to launch a carbon reduction target by around 75 percent by 2050 (Snell and Schmitt 2012).

While all corporations are historically dependent on gas and coal for the functioning of their power generators, all corporations started to follow strategies of fuel efficiency and fuel diversification to reduce the carbon emission of their activity. They are increasingly using diversified fuels in their operations, comprising of traditional fossil fuels plus renewable alternatives. Some companies apply a portfolio management approach through which a diverse range of fuels are used to produce electricity. The objective of this approach is to diminish the overexposure risks to specific markets, type of contracts, fuel or technology (Snell and Schmitt 2012). The trend of the fuel diversification by the Australian electricity generators through the investigation period (2006-7 to 2016-17) is presented by Figure 2.1 as follows:
The diversification of fossil fuel-based assets and acquisition of less carbon-exposed generators are not necessarily due to the government carbon pricing policies. While all these corporations have included renewable energy sources in their portfolios, they still use coal-fired generation system. The main reason is that the use of fossil fuels would make their operations more profitable due to the competitive advantage of this type of fuel compared to alternative ones, although the coal-fired generators considerably increase the total carbon intensity of their operations (Snell and Schmitt 2012).

Furthermore, the growth plans of these companies reveal the expansion of their fossil fuel capacity while, their annual reports and public profiles underline their renewable schemes. For instance, TEPCO intends to double its coal-fired generation capacity during the next decade and has no plan to reduce its oil-fuelled generators (Snell and Schmitt 2012). IP pursued trade in emission credits which is included in emission’s trading scheme of the Europe (particularly in EU). In the time when there was no price on carbon in Australia, AGL, which is founded and operating in Australia only, was the first Australian corporation joining "the
Chicago Climate Exchange, the world's first carbon-trading scheme" (Snell and Schmitt 2012, p.8). AGL took this strategic decision as an anticipatory tactic to prepare for a global carbon-constrained environment in future (Snell and Schmitt 2012). Another strategy followed by these 4 companies on the way to become more competitive in a carbon-limited environment, is to develop new technologies to reduce carbon emission. They also have acquired considerable government support to apply different carbon-reduction technologies such as "carbon capture and storage, integrated coal gasification and combined cycle technologies” plus renewable energy technologies (Snell and Schmitt 2012, p.8). It is concluded that, these companies are becoming more environmentally responsible at the broad corporate level. However, through their investigation of individual facilities of these companies, Snell and Schmitt (2012) did not find any evidence of a coherent response provided by them. In fact, the power generators owned by these companies (especially those located in the Latrobe Valley in Victoria) are known as Australia's major CO2 emitters. "The primary reason for this is the high-water content of the lignite, which makes it a far less efficient fuel than black coal-fired and gas-fired plants found in other parts of the country" (Snell and Schmitt 2012, p.9). Considering the high dependence of the economic development on the energy sector, it may not be a feasible option to restrict the expansion of the energy sector (Maxim 2014). Therefore, it is essential to establish a balance between economic growth, quality of life and the manipulation of natural resources. “In response to this need, the specially appointed World Commission on Environment and Development published a report where the concept of sustainable development is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs” (Maxim 2014, p.284). Three basic dimensions are identified in the sustainability evaluation of the energy sector which include environmental, economic and social dimensions. Through the literature on the sustainability
and risk management, the historically oldest sustainability concepts are those concentrated on ecology (social and economic factors coming as secondary) (Maxim 2014).

As the main source of power generation by the Australian energy sector, fossil fuels are crucial to the economy (Shahbaz, Bhattacharya et al. 2017, p.1273). According to Engineers Australia (2017), 88 per cent of the total electricity generated in 2014-15 was from fossil fuel resources (mainly black and brown coal) and only 12 per cent of that was renewable energy. In addition, being the highest per capita greenhouse gas emitter among all OECD countries, “the fourth largest coal producer and the ninth largest coal consumer in the world”, Australia has been continuously dealing with the CO2 emission challenge (Shahbaz et al 2017, p.1273). However, the Australian government acknowledged that “fossil fuels, particularly coal will continue to play a vital role in providing Australia’s electricity supply” (Engineers Australia 2017, p.39).

Another noteworthy characteristic of the Australian electricity generation sector is aging power plants (established in the 1970s and the 1980s) which are close to the end of their commercial lives or already passed it but still working (around three quarters of the coal-fired power stations) and have greater MW generation capacity compared to the newer ones (Engineers Australia 2017). These aged power plants and their old technology could harm the electricity supply industry and even the whole national productivity. Therefore, the policy makers, states governments and investors need to decide about when to replace the aged plants as well as which type of technology to replace them with.

Since electricity generation sector is the largest source of GHG emissions in Australia (35 per cent of total GHG emissions in 2015), this sector is incompatible with the country’s international emission reduction commitments. Therefore, Australia requires “a transition plan to a new energy paradigm” in order to reduce emissions and stay internationally competent (Engineers Australia 2017, p.15).
Historically, a variety of energy resource bases have been used in Australia for electricity supply mainly coal and gas and recently, renewable energy resources (e.g. solar, wind, hydro, etc.). Engineers Australia (2017) believe that “Australia will need to reconsider its energy supply mix as a number of large capacity fossil fuel power stations reach the end of their economic lives, and Australia’s post Paris COP21 (United Nations Climate Change Conference in Paris 2015) commitments need to be addressed” (Engineers Australia 2017, p.9). In fact, the energy supply is required to be further diversified to enable the country to fulfil its emission commitments and avoid significant loss of generation volume. In addition, enhancing the renewable energy resources will result in assuring developments in the electricity sector, more efficient production technology and higher cost competitive products. Also, Australia is required to follow “energy efficiency policies” to instantly influence energy productivity and emission reduction (Engineers Australia 2017, p.9). Based on the Paris COP21 agreement, Australia is globally obliged to reach the “emissions reduction target of 26 to 28 per cent on 2005 levels by 2030” and this necessitates the replacement of aging plants and essential policies (Engineers Australia 2017, p.15).

2.2.2 Australian National Electricity Market (NEM)

A market competition for electricity generation and retailing was introduced by the National Competition Policy reform process during 1995 and 2010. The “power generation, transmission grid, distribution network and retail supply functions” owned by state commissions were disaggregated and, in some states, gradually privatised (Nelson, Bashir et al. 2017, p.105). The monopolistic behaviour and pricing were avoided by means of economic regulation of network businesses. The establishment of wholesale National Electricity Market (NEM) in 1998 which is an “energy-only market” was a fundamental microeconomic reform through which government policy strongly influences the electricity industry (Nelson et al. 2017, p. 105; (Nelson 2015). Currently, nearly “200 large public and private generators, the
five state-based transmission networks, 13 major distribution networks, and up to 30 electricity retailers in each of the five regions” are the major NEM participants (Higgs, Lien et al. 2015, p.174).

More than 90 per cent of Australian electricity demand is represented in the Australian National Electricity Market (NEM) which includes the states of New South Wales, Queensland, Victoria, South Australia and Tasmania. Of the distinctive characteristics of the NEM, we may point out "its large and largely north–south geographic coverage (around 5000 km from Port Lincoln in South Australia to Port Douglas in Queensland) and the prominence of coal fired generation, including significant very low operating cost brown coal (lignite) plant" (Forrest and MacGill 2013, p.123). In addition, the wholesale spot market has the following unique features:

- "It is energy-only with no capacity market or technical forward market;
- Is compulsory (gross pool) for all generators larger than 30MW, uses 5 minutes dispatch with 30 minutes averaged pricing;
- Requires participants to manage their own unit commitment and allows participants to rebid their price-quantity offers on a 5minutes basis; and
- It has extremely volatile prices by comparison with many other markets" (Forrest and MacGill 2013, p.123).

Because the generating plants are of different ages, locations, fuel sources and technologies, the production marginal cost could vary among different firms in the case of electricity generation (Graham and Williams 2003), Rukes and Taud, 2004 cited in Skoufa and Tamaschke, 2011). In addition, electricity demand differs based on the location, time of day and season of the year bearing in mind that electricity cannot be stored. Hence, different plant types (such as base load, intermediate load and fast start peaking plants) are required in order
to sustain the integrity of the electricity system and long-run marginal costs varies among plant
types (Skoufa and Tamaschke, 2011).

The electricity industry was based on the traditional public utility model which is a
centralized and regulated vertically integrated monopoly structure whereas, liberalization
introduces competition and concentrates on breaking up of vertically integrated monopolies;
specifically, in the generation area and the retail distribution end. To make liberalization of the
electricity sector successful, it is important to persuade "technological innovations as
distributed generation or intelligent networks whilst maintaining coherence within the current
and future institutional frameworks" (Skoufa and Tamaschke 2011, p.2606).

In order to provide a clearer image of the electricity pricing in Australia, we have made a
comparison among Australia and other members of The Organisation for Economic Co-
operation and Development (OECD) who continuously attempt to enhance global economic
and social wellbeing through relevant policy making (Department of Foreign Affairs and Trade
2020). Figure 2.2 illustrates the comparison of the electricity pricing for the housing sector in
the OECD countries as below:
As presented through the above figure, Australia’s electricity retail charges are relatively high rising prime ministerial concern three the same the United Kingdom (The Conversation 2017).

Economic and political incentives are the key factors in such transition (Skoufa and Tamaschke 2011).

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3 In 2017, the Australian prime minister placed a request to the ACCC to review the electricity retail prices the same as the British government who placed the most substantial review of the electricity industry as a whole in 30 years’ time span (The Conversation 2017).
Some assumptions associated with the reform process of electricity utilities from vertically integrated public utilities through the past two decades are:

- Higher economically efficient prices are attainable under greatly competitive conditions;
- To employ the newest and most efficient production methods is highly probable to happen in competitive markets than in non-competitive ones (Besanko et. al., 2007, Chao and Peck, 1998, Sioshansi, 2006, Joskow, 2002 and Porter, 1990 cited in Skoufa and Tamaschke, 2011).

Accordingly, "the resource costs of generation, transmission and distribution at each receiving node for each time period", are presented by the prices (Skoufa and Tamaschke, 2011, p.2607). So, price would reflect short-run marginal cost in the short-term period and in the long-run, the capacity could change. Therefore, if the plant is divisible and short-run marginal cost is larger than long-run marginal cost, capacity will be expanded. In fact, entry barriers and obligatory firms might have market power and therefore, the authority to raise prices beyond the long-run marginal costs without any decline in demand. However, in Australia, such market power is required to be inspected by regulators and the demonstration of a persistent market power may end in punitive actions (Skoufa and Tamaschke, 2011).

"The Australian NEM is regulated by several bodies and operates under the National Electricity Rules that are part of National Electricity Law (AEMO, 2009)" (Skoufa and Tamaschke, 2011, p.2607). In this market, station bids at regional reference nodes (RRNs) are applied based on “merit order dispatch” and demand is generally satisfied by higher bid stations (Skoufa and Tamaschke, 2011, p.2607). As part of the 2008 Australian NEM structure, each member state has one RRN, called QLD1 and VIC1 in the case of Queensland and Victoria.

When the volume of generation at the RRN is bigger than demand, the pool price in each trading period is determined by the bid of the most expensive generating plant. The
System Operator (previously known as the National Electricity Market Management Company) known as the Australian Energy Market Operator (AEMO), determines the level of electricity generation and matches supply and demand every half hour during a trading day. This approach of setting the spot prices is exemplified in Figure 2.3 as below on the basis of data released by the AER:


**Figure 2.3: Electricity Spot Pricing**

Generation firms may employ unregulated market-based instruments (e.g. financial derivatives) to contend with the price volatility in any trading period allied with the compulsory pool system (Skoufa and Tamaschke, 2011).
When available generation level at the RRN is lower than aggregate demand, the pool price will be determined by a preset "value of lost load". In addition, for the must-run directives like reserve requirements, AEMO provides generators with supplementary payments (AEMO, 2009 cited in Skoufa and Tamaschke, 2011). The similar system existed in the era before the mid-1990s (pre-liberalization era). However, after liberalization bids substituted merit-order dispatch based on marginal costs. An outcome of the liberalization for the whole electricity industry was the introduction of competition at the retail sales end (not the wires business) (Skoufa and Tamaschke, 2011).

The objective of Australia’s Renewable Energy Target (RET) is to modify the fundamental economics of electricity generation to make renewables more commercially desired. This will guarantee the switch to renewable energy sources and the less carbon intensive methods of electricity generation (e.g. renewable energy on both supply- and demand-side of electricity market) (Wright 2012).

As for all types of electricity generation, a transmission Network is required to connect the renewable energy power station to the distribution network and to end customers. Australia’s Network is evolved through the coal industry and thus, the transmission network is close to coal resources and far from the best renewable energy sources. Furthermore, "the present regulatory framework is geared toward irregular connection requests from large coal-fired power stations, but ill-suited to clustered generation, i.e. the connection of multiple smaller generations in the same area over time" (Wright 2012, p.80).

In order to simplify the construction of appropriately sized extensions to the network that will accommodate clusters of renewable energy generators in a geographic area over time, the Australian Energy Market Commission (AEMC), the rule-making body of the NEM, has created a rule change to the National Electricity Rules (NER). "This rule is planned to enable the exploitation of the economies of scale that flow from building an efficiently sized
augmentation, rather than a number of separate augmentations for each generator. Such augmentations have been termed ‘Scale Efficient Network Extensions’ (SENEs), though some have colourfully referred to them as ‘fields of dreams’ (ESAA, 2011)” (Wright 2012, p.80).

Of the distinctive characteristics of Australia’s network, the following items are noteworthy:

- "NEM is very long and thin, stretching 4000 km from the North of the country at Port Douglas in Queensland along the coast and West to Port Lincoln in South Australia;

- The NEM is one of the world’s longest interconnected power systems where electricity is traded across state boundaries

- Australia’s electricity system is, highly liberalized. This liberalization brings with it the delicate balance between market forces and regulatory oversight, and the difficulties involved in aligning Transmission Network Service Provider (TNSP) incentives and regulation with public good outcomes

- Australia’s best renewable energy resources are generally far from the Network or load centers. However, even where renewable energy resources are located close to the Network, connecting clusters of renewable energy generation in proximate locations is also challenging because “it is not desirable to establish many connections on a high voltage transmission line, nor is it the most economic outcome overall” (AEMO, 2010a). This is partly due to technical constraints and partly due to the high cost of transmission infrastructure. Thus, the notion that efficiencies can be gained in augmenting the network is also applicable to non-remote generation.

- Renewable energy resources, like coal and gas, can be conceptualized as being present in distinct ‘basins’. The most powerful winds in Australia blow offshore and on the Eyre Peninsula, 300 km west of Adelaide in South Australia, while the sun shines the strongest in the far northwest of New South Wales and in mid- to north-Queensland (Geoscience Australia and ABARE, 2010). The Network that the renewable energy
generators must connect to, however, is concentrated on the east and south-east coasts of the country, centered on the coal basins and load centres that necessitated its construction (Geoscience Australia and ABARE, 2010)” (Wright 2012, p.80).

However, reaching environmental goals was never of core decisions through the privatization of electricity utilities. Operational plants would be purchased by power corporations when the availability of fuel, cost and environmental requirements for every market were secured (Kaya and Yokobori, 1997 cited in Snell and Schmitt 2012). Therefore, fossil fuel-based electricity generation has been historically of the biggest competitive advantage in the market because of lower price of fossil fuels, their abundance compared to other energy sources and government policies supporting their continual exploitation (Goodell 2006, Diesendorf 2009 and Pearse 2009 cited in Snell and Schmitt 2012). Furthermore, fossil fuel prices were distorted through the externalization of GHGs and the real costs of fuel resources by companies (i.e. global warming and pollution) (Snell and Schmitt 2012).

2.3 Climate Change and Policy Responses

The environment’s limited ability to support the unrestricted development of humanity has been exposed during the last decades. In some of the largest developing economies, human health and life quality are vitally affected by air, water and soil pollution plus the climate change. The fossil fuel concentrated energy sector is a significant contributor to the global environmental degradation which is presumed to produce a 3.6°C increase in average temperature in the long run (Maxim 2014). It is crucial for basic materials and energy industries to consider the physical restrictions on materials and energy inputs and the disposal of wastes through the production processes. Therefore, it is now significant to ascertain if the economic sectors are willing to compete for some basic resources for the sake of long term planning and conductive policy making. In such process, the electricity sector will be affected more than other types of basic materials and energy industries because of the political sensitivity of some
of the key inputs and outputs (particularly water and CO2) and their physical stock volume (Turner and West 2012).

While various countries are launching mechanisms to price carbon emissions within the electricity industry, there are persistent doubts about long-run effects of climate change policies and influential level of carbon price on climate change (IEA, 2007; Newcomer et al., 2008 cited in Vithayasrichareon and MacGill 2013).

Carbon prices ought to be one of the key factors to motivate generation investment in renewable technologies and towards low emission. However, it seems to be challenging to make generation investment decisions in the electricity industry due to "uncertainties regarding climate change policies, increased uncertainties about future fossil fuels prices, fluctuating capital costs for generation plant and recent reductions in demand growth in many countries following the Global Financial Crisis (GFC)" (Vithayasrichareon and MacGill 2013, p.401).

Electricity producers are capital intensive corporations and therefore highly reliant on private financiers to recognize their growth plans and constant operations. More generally, investors started to react on national and international climate change policies highly aware of risks associated with “carbon-exposed assets” (Snell and Schmitt 2012, p.6). Many companies obtained fossil fuel-based energy assets but did not describe their decisions although joined the public agenda (Snell and Schmitt 2012).

In order to minimize capital risks, both power producers and their lenders increasingly expect the governments to provide financial security over carbon-exposed thermal power generators; however, securing constant investment for these assets is no longer assured (Snell and Schmitt 2012).

According to the literature if the rise of global temperatures could be held at lower than 2 degrees, there is hope to avoid the worst consequences of global warming (Snell and Schmitt 2012). This is achievable by significant decline in the concentration of GHGs entering
the atmosphere. A vital action through the climate change refinement is to replace "fossil fuel-based energy production with low or zero carbon energy sources" (Snell and Schmitt 2012, p.2). However, majority of the countries (even those with abundant sources of alternative energy) have found it extremely tough to develop clean energy systems and only a few are willing to and have the capability to make these essential changes. Various arguments have been raised for these failures, but the broadest ones are:

- the economic costs of evolution to establish cleaner technologies (Snell and Schmitt 2012);
- the weakness of alternative energy technologies in comparison with fossil-based fuels (Snell and Schmitt 2012); and
- the influential ‘lock-in’ of carbon-based systems that blocks government and non-government attainment towards building a low-carbon economy (Snell and Schmitt 2012).

The basis of the above-mentioned issues is the crucial response of corporations considering their vast political and economic influence and fundamental role in contributing to environmental change and degradation (Snell and Schmitt 2012). Therefore, in case of a fundamental and speedy justification to climate change, "the corporate sector will have to be an active agent of change" (Snell and Schmitt 2012, p.3).

In addition to governments’ increasing expectation from the corporations to be environmentally responsible, civil society has also enquired about these economic arrangements. There are higher levels of government regulations on the activities of corporations (as providers of essential services) while preserving important political impact on the societies. This influence is obtained due to the reliance of modern industrial, economic and social sectors on electricity supply (Snell and Schmitt 2012). “The introduction of private actors into the energy production and/or distribution system opened up a new dynamic that
required compromise and negotiation on the part of government and private operators over issues such as electricity pricing, upgrading of electricity infrastructure and the introduction of policy changes that may impact on the profitability of the energy sector” (Snell and Schmitt 2012, p.5). Regulators are always caught between governments and private energy producers since companies look for more promising pricing and regulatory arrangements. According to Andrew Reeves, Chairman of the Australian Energy Regulator, it is always essential to “strike an appropriate balance between the interests of network businesses and those of consumers” (Snell and Schmitt 2012, p.5).

According to some studies, energy corporations try to resist global climate change movements. In fact, the Global Climate Coalition, comprising of world’s most prominent oil and gas corporations, the coal industry and other main polluters are acknowledged to be keenly supporting research contradicting climate change and the Kyoto Protocol (Snell and Schmitt 2012). As well, several energy companies found to be involved in "green washing" which is referring to “making strong environmental statements without significant changes in their operations, environmental practices or positions on environmental regulation (Hart, 1997 and UNEP, 2008)” (Snell and Schmitt 2012, p.3). Companies tend to take environmental actions only when they are expected to be profitable (Snell and Schmitt 2012).

While, some researchers found an increasing number of companies supporting government environmental actions and willing to adopt renewable energy sources, others question the extent to which we could classify a company as being green and environmentally responsible. It is more difficult when a corporation owns numerous varied facilities across different countries. According to Pearse (2009) discussing “multinationals operating in Australia that a company can ‘wear green shorts when playing away, black shorts at home’” (Snell and Schmitt 2012, p.3).
Internationally as well as in Australia several proposals have been offered by government and non-government agents for electricity generators to switch to low-carbon production. “These proposals include: returning power generation to public ownership where organizational and technological changes are perceived to be more obtainable; encouraging or forcing the private sector to make the necessary change to cleaner forms of generation; or making other fuels or sources of energy more attractive and profitable for these organizations” (Snell and Schmitt 2012, p.6). On the other hand, companies’ motivation to a gradual transition (on their own terms not by the government approval) might challenge their planning plus threaten their asset value (Snell and Schmitt 2012).

The following section will discuss global obligations of the Australian Government and policy responses to achieve the committed targets with focus on the electricity generation sector.

2.4 Impact of Climate Change Policies on the Australian Electricity Generation

More than 93 per cent of total energy consumption in 2012 was related to fossil fuels (coal, gas, etc.) and CO2 emissions are mainly the result of fossil fuel power generation in Australia. Therefore, the country requires “a gradual shift from fossil fuel energy sources to renewable sources along with investment in energy saving technologies” plus green and efficient technologies in different economic sectors in order to reduce CO2 emissions from energy consumption (Shahbaz et al. 2017, p.1284). To achieve this goal, policies have been established by various government levels (Shahbaz et al. 2017).

Climate policy has been defined as what issues to be resolved by climate mitigation law and regulation and the consideration of policy solutions has been dominantly derived through the neoclassical economic studies assuming greenhouse gases as an “externality” to the effective markets (Pearse 2016, p.320). Therefore, new approaches of worldwide “environmental valuation and market-based solutions” of environmental protection have been
introduced to address these externalities (Markandya and Barbier 2013 as cited in Pearse 2016, p.321). Since 1990s, three major types of market-based climate policies, “voluntary carbon abatement programs, carbon taxation and emission trading” were commenced (Pearse 2016, p.321). Compared to the emission trading schemes, which comprises of forming markets in tradable credits, other policies are considered as “complementary” such as “efficiency programs” or “contradictory” like compulsory standards (Pearse 2016, p.321).

Garnaut (2008 and 2011b as cited in Pearse 2016), proposed an emission trading framework and complementary measures to encourage green technologies. He recommended that the higher efficiency of market instruments is more influential than direct regulations (Pearse 2016). Nelson (2015) has explained the Australia’s attitude towards climate policies as “erratic” through the past decade (Nelson 2015, p.257). Main political parties supported the national emission trading scheme known as ETS in 2007 but this support was disappeared in 2009. Later, an ETS was commenced in 2011 and cancelled in 2014 and consequently, the Commonwealth Government proposed a climate change policy known as “Direct Action”. However, “there is little political agreement about the best long-term policy approach” because of the features of climate science (Nelson 2015, p.257).

Through to the “cap-and-trade” ETS theory, the emission limit is created by the “cap” which is established within regulated trading periods with lack of carbon rights. In fact, the “cap-and-trade” ETS is theoretically expected to result in effective “allocation of emission rights” and cost-efficiency as a result of tradable carbon dioxide (Pearse 2016, p.321). High costs of emission reduction in perfectly operative markets might encourage polluting firms to buy surplus permits from low costs firms to take the advantage of this sale. On the other hand, “carbon offsets” are the other source of low-cost credits which are generated from emission reduction projects in various industries or states and sold into “cap-and-trade schemes” via legislated networks. “In most compliance schemes, credits are traded within the ‘cap’ and
arbitrage (the bids and offers) between buyers and sellers is theorized to produce net gains for all involved (welfare) creating an equilibrium carbon price at the margin” in order to reflect “the optimal level of the externality” (Pearse 2016, p.321).

This approach is not sufficient when taking into account “the power inequality of emissions-intensive industries” particularly, the fossil fuel energy sector in which the power concentration is neglected by the economic theory and carbon price design models (Pearse 2016, p.321). In theory, firms are price takers functioning based on marginal costs of production while consumers are expected to make decisions to form energy production patterns. But, price discrimination happens through the mark-up pricing by powerful firms in the energy sectors. Consumer energy demand is inelastic especially in the existence of costly or inaccessible energy alternatives and these all will result in inequalities and inadequacies in coal governance (Pearse 2016).

According to the Department of Environment (2015), to achieve the 2020 emissions reduction target and “decarbonisation of the economy”, the government needs fundamental policies to make significant changes in industry and trade structure, “stabilizing population growth to combat economic activities and invest in low-carbon technology” (Shahbaz et al. 2017, p.1274).

Since then, at least 6 substantial government policies are designed by the commonwealth and State Governments to encourage investments in renewable energy and diminish GHG emissions which have strongly modified investment decisions. As a result of these policies, volumes of new plant capacity have considerably increased. However, there is a concern about the design of the policies setup in increasing investment in new generation capacity to be functional in one of “the world’s most competitive energy-only gross pool electricity markets” (Nelson et al. 2015, p.25). Sections 2.4.1 and 2.4.2 will elaborate on the
most current policies designed and undertaken in order to encourage renewable energy generation.

2.4.1 The Renewable Energy Target (RET)

A 20 percent Renewable Energy Target (RET) was established by policy makers in 2009 expecting annual 2.5 per cent increase in electricity generation from 230 TWh in 2009 to 300 TWh by 2020. However, according to the Energy Supply Association of Australia (esa 2013), electricity generation was found to be declined by 4 percent in 2012 which was 221 TWh while, more than 6000 MW of new renewable energy was generated during the past decade. Derived by the RET scheme and community concerns about increasing emissions from coal fired power generation, several renewable power stations (like wind, solar, geothermal, etc.) projects are planned. Despite the expectations of policy makers, the demand in electricity has been declined and resulted in obviously uncompromising investment conditions due to “barriers to exit for incumbent aged thermal plants” (Nelson et al. 2015, p.26). The renewable energy generation is compulsory via legislation by the Commonwealth Government but is not financially viable anymore based on the present policy settings. Although, established targets require considerable growth and obligation, total revenues are significantly declined to less than the marginal cost of renewable plant entry in the long term due to the decreasing effective real prices of electricity and its very low wholesale prices due to the Large Scale Renewable Generation Certificates (LGCs). All these issues are the results of policy uncertainty such as a circle associated with an influential disparity of the RET. In addition to the firms’ expectations about modification of the target, LGC prices and investments delays, there is “very little time left to meet the target” by 2020 (Nelson et al. 2015, p.26). To overcome this concern, policy makers should make slight alteration in the target to prevent an evident policy failure which will end to another source of effective inconsistency.

There are two elements creating the Australia’s legislated RET which are as follows:
1. The electricity retailers are required to obtain an increasing part of their electricity sales from renewable energy generation every year and for every megawatt-hour generation, a certificate is created by eligible large-scale generators (LGC). The purpose is to reach the national “target of 33000GWh in 2020” (Orton and Nelson 2015, p.64). Figure 2.4 presents the current annual target based on the 2015 legislative amendments\(^4\) as below:

**Figure2.4:** Large-scale Renewable Energy Target (LRET) (GWh), 2009-2030

![Graph showing the LRET (GWh) from 2009 to 2030](http://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/LRET-2001-2030-Annual-targets-and-renewable-power-percentages.aspx)

Source: Clean Energy Regulator, Australian Government 2019

2. According to the Small-scale Renewable Energy Scheme (SRES), electricity retailers need to acquire a specific percentage of their annual “sales from small-scale distributed energy system” (Orton & Nelson 2015, p.64). At the time of installation, certificates presume 15 years generation. There is no upper-limit target assigned by the scheme and the number of system installations (STC) within the period is considered as the annual

targets (Orton & Nelson 2015). The annual SRES target is presented through the Table 2.5 as follow:

**Figure 2.5: SRES Nominal Target ($M), 2011-2021**

![Graph showing SRES Nominal Target ($M), 2011-2021](source: Clean Energy Regulator, Australian Government 2019)

A full exemption is provided to a series of “emission-intensive trade-exposed industry sectors under the scheme,” required by the legislative amended RET from 2015, and this changes the rate of “scheme compliance costs to non-emissions intensive industries and the residential and commercial sectors” (Orton & Nelson 2015, p.64). The exempted part of total demand in the NEM will rise “from an around 13%-16% for the period of 2012-2014 to an estimated 18%-19% for the period of 2015-2020” (Orton & Nelson 2015, p.64). The residential and commercial segments of the NEM expect a big contribution by renewable energy by additional small-scale and large-scale RET compliance to the previous renewable generation capacity by 2020 (Orton & Nelson 2015).

### 2.4.2 The Emissions Reduction Fund

Through “the Carbon Credits (Carbon Farming Initiative) Act 2011, the Carbon Credits (Carbon Farming Initiative) Act 2011 and Carbon Credits (Carbon Farming Initiative) Act
2015”, a voluntary scheme known as the Emissions Reduction Fund was endorsed. The purpose of the Fund was to encourage people and organisations to reduce their emissions via new technologies and practices (Clean Energy Regulator 2017). According to this scheme, Australian carbon credit units (ACCUs) is earned by participants for emission reductions which can also be sold to either the government or the secondary market (Clean Energy Regulator 2017).

There is pressure on conventional coal and gas power plants by the increasing number of emerging renewable electricity generation options (such as wind, hydro, waste gas, biomass, solar PV and thermal plants) and storage technologies since Australia is committed to “strong emission reduction targets” (Engineers Australia 2017, p.29). There are long-term based investment decisions in conventional baseload generating capacity rather than short-term because of their long-term nature. Therefore, investors may feel uncertain due to the ambiguity in current policies which make them inadequate to reach emission reduction targets unless there would be more funding or development “into an emissions trading scheme for Australia to reach this target” (Engineers Australia 2017, p.39). Furthermore, variety of climate change policies and targets settled in different states and territories magnified the confusion about the prospective revenues and costs and hence, affect “generators’ decision to remain in the market in the hope that it could benefit from little or no changes to government policy” (Engineers Australia 2017, p.39). Meanwhile, the existing policy scenarios positively affect renewable energy producers.

To efficiently develop climate change movements and to be able to reach the Paris targets, there is a necessity for a real action and plan. According to the Engineers Australia, it is time to develop a “transition plan” which offers the best alternatives to consumers, environment and economy as well as reducing uncertainty to attract potential investors. In fact,
the future of the Australian electricity generation could be outlined by the interference of the
government policy which is clarified through a national transition plan.

However, the Government lacks the desire to intervene and change the technology
from the coal and gas plants to new technologies and believes that it should be left to the energy
market to decide about the transition. They stated that to untimely push new technologies by
the policy interventions lead to the risk of “higher cost and lower efficiency than if the product
found its way onto the market by a competitive basis” (Engineers Australia 2017, p.40).

Referring to the significance of zero/low emission technologies in the reliable
electricity production while reducing emission, Engineers Australia suggests making changes
by the government to establish sustainable markets through required funding and infrastructure
for the related technologies. These all necessitate new policies, research and development
programs, technology placement and attract possible “competitive market forces” (Engineers
Australia 2017, p.40).

2.5 Summary

Australia is known as one of the foremost pollution-intensive countries in the world due to the
high consumption level of fossil fuels which are the basis of the electricity generation.
Therefore, energy sector is both a fundamental economic sector in Australia and the main
source of national GHG emissions. Considering the country’s global and domestic
commitments to emission reductions, the power generation is required to become more
diversified. For further developments in the electricity sector, it is necessary to enhance the
renewable energy resources which will also result in more efficient and higher cost-competitive
products. Energy efficiency policies are requisites for the electricity sector to transit from the
conventional power plants to the new and low emission renewable plants.

In response to community concerns and to fulfill Australia’s international
commitments, various policies and frameworks were designed and proposed at different
government levels. The Renewable Energy Target (RET) scheme was launched in 2009 and several renewable power plants projects were planned. On the other hand, the Emissions Reduction Fund was endorsed in 2011 which is a voluntary scheme offering organizations with carbon credit units on the basis of their emission reductions.

Although, renewable energy generation is compulsory by the legislation, it is not financially viable because of the policies ambiguity which will result in investors’ uncertainty. These concerns plus very little time left to reach some climate change targets makes it necessary for the government to design and endorse enhanced policies and frameworks to encourage the transition of power generation from coal-fired plants to the renewable ones.

Next chapter will elaborate the related literature in 3 sections categorised as the literature on the relationship between environmental performance and financial performance of organizations, theoretical background and methodology.
Chapter 3
Literature Review

3.1 Introduction

The purpose of this chapter is to review the literature on the studies that have been conducted to examine the relationship between environmental performance and financial performance (EP-FP relationship) of organizations in order to identify the research gaps that the present study aims to address. In reviewing the prior literature, attention is also given to examine the theoretical framework and methodologies used in the prior studies as the present study aims to utilise an improved theoretical framework and methodology in examining its underlying research issues.

This section is followed by Section 3.2 which presents a review of studies conducted to examine the relationship between the environmental performance and financial performance of organisations in various industries. A review of the theoretical frameworks used in prior studies is then presented in section 3.3. The variables used in the present study based on the relevant literature will be developed through section 3.4. This is followed by a review of the studies that used Data Envelopment Analysis (DEA), a method of analysis also used in the present study, in section 3.5. Section 3.6 reviews the methodologies used in prior studies to identify their relative strengths and weaknesses. Based on the review conducted in previous sections, section 3.7 identifies the research gaps in the literature review and it is followed by a summary of the chapter in section 3.8.

3.2 The Relationship between Firms’ Environmental Performance and Financial Performance

Studies have been conducted to examine the relationship between environmental performance and financial performance (Porter 1991; Jaggi and Freedman 1992; Blacconiere and Patten 1994; Misani and Pogutz, 2015). However, these studies have produced mixed results, identifying the relationship between the two as positive, negative or neutral. The studies that
have produced these inconclusive results have been conducted using varied theories and methodologies in different contexts (Saeidi, Sofian et al. 2015) making it difficult to compare the results of a particular study with those of others. This highlights the need for examining this relationship with a more advanced methodology and a theoretical framework that are able to explain this relationship soundly.

The studies that have found a positive relationship between environmental performance and financial performance in some companies argued that such companies have been able to achieve improved financial performance because their improved environmental performance resulted in high reputation and improved image of the company. Chen et al (2015), finds that the companies known to have high reputation and good image can enjoy operational efficiencies by relatively easy access to funds for the investment in environmental activities. On the other hand, the neoclassical economists believe that spending resources and energy to improve the environmental performances will increase the operational costs of the firms and will consequently lead to increase in prices of the product they produce and as a result will impose a negative effect on their financial performance. Given the fact that the EP-FP relationship is influenced by large number of factors (internal or external) as indicated by the review of literature in this chapter, it is clear that this relationship is more complicated than it has been explained in many of the prior studies (Saeidi et al. 2015). Therefore, the present study aims to design a new research framework on the results of the literature review conducted in the following sections in order to examine the underlined research issues using a rigorous research methodology. Section 3.2.1 of this chapter reviews the studies that found a positive, negative and neutral EP-FP Relationship while the following section (3.2.2) reviews the studies that are found to have a negative in short-run but positive in long-run EP-FP Relationship.
3.2.1 EP-FP Relationship: Positive, Negative and Neutral

Considering the dimensions of sustainability which are “economic accomplishment, social justice and environmental stability”, Chen et al. (2015) examined the relationship between environmental and financial performance in the Swedish manufacturing sector. This study also included 5 subsectors of the manufacturing sector in order to compare environmental performance among various subsectors and regions. The results of this study indicated that the environmental performance has a positive relationship with financial performance of firms while the environmental disclosures are not significantly different among various subsectors in the manufacturing sector of the economy.

Referring to the severe environmental degradation, Li et al. (2017) have examined the effect of environmental responsibility of energy intensive firms on their financial performance in China for the period of 2012 to 2014. Their obtained results indicate a significant positive impact of firms’ environmentally friendly actions on their financial performance. They have also found out the government regulations imposes positive moderating effect on the EP-FP relationship of these firms. The authors believe that “strict government regulation” (e.g. financing disapproval and fines resulting in their deteriorating financial performance) forces companies to be more cautious and therefore, attentive to environmental issues (Li et al. 2017). The financial performance of firms is measured by ROA (return on assets\(^5\)) and their environmental responsibility is the weighted score\(^6\) of environmental factors extracted from environmental databases\(^7\). However, the study suffers from a short time span which according to the authors, is not able to precisely evaluate the influence of firms’ environmental responsibility and its consequences on their financial performance (Li et al. 2017, p.1332). In addition, the analysis has been conducted across various industries each of which is of

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\(^5\) Return on assets (ROA) is a short-run indicator of financial performance.
\(^6\) Scores assigned by authors to environmental factors creating qualitative environmental measurement.
\(^7\) Global Reporting Initiatives (GRI) sustainability reporting guidelines (Li et al. 2017, p.1327).
different pollution threshold due to the different nature of their activities. Therefore, the obtained results could not be accurately explained and generalised for all firms in the sample.

Tzouvanas et al. (2019) examined the effects of the firms’ environmental performance on their financial performance differently based on the profitability level of each firm. Their sample is consisted of manufacturing firms operating in various European countries during the period of 2005 to 2016. ROA and ROE are the variables presenting the firms’ financial performance and to measure the environmental performance, the authors have computed the logarithm of the greenhouse gas emission amounts of every firm divided by its total assets along with the ISO 14001 standards. Their analysis resulted in positive relationship between environmental performance and financial performance of firms specially the highly profitable firms. The study also highlights the heterogeneity of this relationship in different conditions such as regional and economic factors (across countries). In conclusion, the study recommends further improvement of the measurement model to “dynamic and non-parametric” approaches (Tzouvanas et al. 2019, p.19).

Lee, Min et al. (2015) conducted a micro-level analysis to evaluate the relationship between environmental performance and financial performance of the Japanese manufacturing industry. The authors measured the environmental performance by CO₂ emissions (their main independent variable) and financial performance by Tobin’s q and ROA. This study concluded that society is sensitive to environmental performance and hence firms with negative environmental performance are penalized by the market (Lee et al. 2015, p.10). Accordingly, the authors argue that the higher investment level of green technology will enhance the financial performance of firms. They also found that Kyoto Protocol is effective guide for improving innovation in environmentally friendly activities in companies and therefore will positively impact the financial performance of firms.
Saeidi et al. (2015) developed a more inclusive and complex model incorporating a number of variables that have not been considered in prior studies. These variables included market share growth, sales growth, ROE, ROS, ROI, net profit margin as the financial performance measures and scale of CSR dimensions as measure of the environmental performance. Although a number of studies that have examined the FP-EP relationship (for example, Lucas and Noordewier (2016), Salama (2005), Kim (2015) has focused on the industries in developed countries, this study contributed to the literature by examining EP-FP relationship in the context of a developing country i.e. Iran. However, due to the lack of database to gather required data, this study conducted a survey to obtain information from manufacturing companies. It used a structural equation modelling (SEM) to test the study’s hypothesis which aimed to examine EP-FP relationship. The study identified an indirect positive relationship between the environmental and financial performance of organisations through companies’ competitive advantage achieved by high quality of products and services at lower costs (Saeidi et al. 2015, p.347).

Looking for the answer to the question of “when and how it pays to be green”, Misani and Pogutz (2015) studied the link between environmental performance and financial performance through the “process and outcome dimensions of environmental performance” (Misani and Pogutz 2015, p.150). They define environmental processes as the firms’ actions to overcome environmental issues and environmental outcomes refer to “firms’ impact on the natural environment” (Misani and Pogutz 2015, p.150). The focus of the study is on carbon emissions, carbon management and regulatory and stakeholders’ impact on the firms’ environmental processes and its interaction with financial performance. Their specified non-linear model includes one-year lagged period for financial performance as an alternative. The results of the study showed that firms’ highest financial performance is achieved when their carbon emission is at the medium level (neither high nor low). It also found that stakeholder
management resulted in moderated environmental performance and thereby strengthened financial performance.

To test the relationship between environmental and financial performance of similar organizations, Gonenc and Scholtens (2017) conducted a study in international fossil fuel firms (chemicals, coal and oil and gas) by using both qualitative and quantitative data. The study, which is based on the stakeholder theory, found that environmental performance is positively related to the financial performance.

Lucas and Noordewier (2016) empirically examined the relationship between the firms’ environmental performance and financial performance within and across industry contexts to find out how long the environmental practices at firm level take to deliver the expected outcome. They attempted to highlight the context of the relationship between the environmental performance of firms with their financial performance on the basis of the dirtiness level of industry and industry’s actions to prevent the pollution. The sample of the study included cross-sectional data obtained from 941 publicly traded manufacturing US firms and environmental performance is measured qualitatively based on firms’ environmental ratings in terms of 6 elements. The study identified that the firms’ environment management practices positively affect their financial performance and this impact is bigger in case of polluting companies than the clean ones. The authors found the lack of a precise environmental measurement in the dataset as a limiting factor of the study. Furthermore, this research is a cross-sectional study investigating FP-EP relationship only for a one financial year.

Referring to the lack of a common measurement method to measure the environmental performance and its relationship with financial performance, Rodrigues-Fernandez (2016) attempted to evaluate the impact of firms’ environmental performance on their financial

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8 “Pollution prevention programs, energy efficiency programs through alternative fuels, use of recycled materials, development of beneficial green products and services, engagement in internal or external environmental communications, or any other significant environmental initiatives” (Lucas and Noordewier 2016, p.27).
performance and vice versa (bi-directional relationship). The study indicated a positive relationship between environmental performance and financial performance of the firms in both directions. The study highlighted the vital role of social and environmental legislations on the improvement of both environmental and financial benefits.

Kim (2015) identified the lack of attention given to account for endogenous relationship in the modelling of the EP-FP relationship (for example, Griffin and Mahon (1997), Konar and Cohen (2001)) and lack of longitudinal data analysis as possible reasons for mixed results produced by the prior studies (such as Papagiannakis and Voudouris (2009)) on the EP-FP relationship. To overcome these shortcomings, this study employed longitudinal data analysis in the context of heavy-polluting manufacturing firms to measure the causal relationship of EP-FP in both directions. In this study, the EP is measured as the transformed natural log of total toxic releases and FP measured using in both accounting- and marketing-based performance measures (the ratio of earnings before interest and tax to sales plus Tobin’s q). The obtained results presented positive relationship between the environmental and financial performance. However, the study concluded that this causal EP-FP relationship is influenced by the consistency of the FP measures as well as the characteristics of the firms in the sample (such as the type of industry or level of environmental dirtiness). Therefore, the author strongly recommends applying a more reliable performance measure to test the causality of such relationship.

Considering that the prior studies have not established a clear relationship between the environmental performance and corporate financial performance and that the results of many of these studies are inconclusive (for example, Balabanis et al. (1998), Edwards (1998) and Toms (2000), Salama (2005)) conducted a study on the relationship between the firms’ environmental performance and financial performance to address some of the issues that he identified led to these outcomes. In this study, the author attributed the imperfections of the
econometric modelling of the prior studies to the inconsistencies with the results. For example, the ambiguity of outliers caused major issues for the OLS and associated methods (Salama 2005). Based on the review of prior literature, the author hypothesized that corporate environmental performance and its subsequent financial performance are positively related and the results of the study confirmed this relationship. The study highlighted the importance of gaining high reputation for leadership in environmental affairs to satisfy the needs of the environmental stakeholders. The study suggests that the corporations are better able to assign resources into the environmental schemes by regaining trust with stakeholders and investors.

Using unbalanced panel of 429 Czech firms, Earnhart and Lizal (2006) examined the impact of environmental performance of a firm and its ownership structure on its financial performance, The results indicated that better environmental performance could result in improved financial performance within 1 and 2 lagged periods. The authors claim that in the existence of economies of scale, the increased production level by firms will reduce their level of pollution. Therefore, “a firm with high absolute emissions and high production might be more environmentally friendly than a firm with lower absolute emissions but very small production” (Earnhart&Lizal 2002, p17).

Using data on GHG emissions in 2006, Hatakeda et al. (2012) investigated the relationship between environmental and financial performance in Japanese manufacturing organisations via a regression analysis. Due to the lack of data on environmental investment disclosed in financial reports, the authors conducted interviews (surveys) for a part of their research which resulted in a positive relationship between environmental performance and financial performance of firms. This study was subject to a number of limitations. The data obtained from the survey could have been biased as it is likely that respondents overestimate the benefits of GHG emissions reduction. In addition, small and medium sized firms were excluded from their sample because of the severe uncertainty in decision-making or weak
governance in those firms, which resulted in a sampling bias. This study identified the lack of control for the heterogeneity of environmental protection activities by organisations as a limitation of prior studies. Firms may be willing to adopt ISO 14001 which is applied as a dummy variable in prior studies (such as Dasgupta et al. (2000), Potski and Prakash (2005), Arimura et al. (2008), Russo and Harrison (2005)). However, the effectiveness of this standard in reducing GHG emissions has never been discussed throughout prior studies. Presented by the empirical results, adoption of ISO14001 (as a dummy variable) significantly affects the relationship between firms’ environmental performance and their financial performance.

Considering the argument that environmental strengths and weaknesses have an impact on corporate financial performance, Lioui and Sharma (2012) conducted a study to examine the direct negative impact of the firms’ environmental “strengths and concerns” on their financial performance. They have also tested the firms’ advantages of the environmental R&D activities. The results of the study found a positive relationship between the interaction of the environmental strengths and concerns and research and development (R&D) and corporate financial performance. It concluded that the positive relationship represents the potential advantages to the firm through more efficient R&D activities on environment activities.

Another study that examined the relationship between the environmental and financial performance of firms was Elsayed and Paton (2005). They conducted a static and dynamic panel data analysis for this purpose. Referring to the importance of this relationship, they stated that a positive relationship between the two variables could be a support for the environmental investment in order to achieve the ‘win-win’ solution for society. But this theory is indecisive in estimating the impact of environmental performance on the financial performance of a firm.

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9 The ‘win-win’ scholars (Porter 1991, Porter and Van der Linde 1995a, b) believe that the environmental improvement and protection can be beneficial to both the firm and society (Elsayed and Paton 2005). This theory is explained in more detail in the theoretical framework.
The authors started their analysis by the estimation of static panel data regression models of firm performance as a function of environmental performance. The results of the study suggested a strong significant effect of the one-year and two-year lagged environmental performance on financial performance during the 1994-2000 time span. The authors believe that these different results could be due to the existence of unobservable firm effects (such as heterogeneity effects instead of dynamic ones) that have important impact on the financial performance. This study obtained a neutral impact of environmental performance on financial performance which is compatible with “the theoretical work in which firms invest in environmental initiatives until the point where the marginal cost of such investments equals the marginal benefit” (Elsayed and Paton 2005, p 410). The summary of this literature discussed above is presented in Table 3.1. The following section presents a review of the studies that have found a negative relationship between environmental performance and financial performance in the short but a positive relationship in the long run.

**3.2.2 EP-FP Relationship: Negative in Short-run but Positive in Long-run**

Deviating from the prior studies conducted to examine the EP-FP relationship, Horváthová (2012) proposed a more precise and comprehensive method to examine the inter-temporal effect of environmental performance on financial performance. Through this improved method, firms’ EP was evaluated based on the weight of different pollutants relating to their “dangerousness” to environment. The study examined the idea of “better environmental performance may be beneficial for firms since pollution is a sign of economic inefficiency” (Horváthová 2012, p.91). The results of the study showed that firm’s decreased emissions deplete company profitability in the 1-year lag period while they improve company profitability in the 2-year lag period. The conclusion that could be drawn from this study was

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10 The reasons are: (1) the win-win situations seem to be rare in reality; (2) based on this theory, the EP-FP relationship would be neutral (Elsayed and Paton 2005).
that “it takes more than one accounting period for firms to benefit financially from decreasing pollution” (Horváthová 2012, p.96).

Referring to the lack of consensus about the positive impact of environmental performance of businesses on their financial performance, Liu (2020) has investigated US public firms during the sample period of 2005-2014 to assess the “bidirectional causal relationship” between environmental performance of firms on their financial performance (Liu 2020, p.328). The variable for environmental performance is the ESG (Environmental, Social and Governance) rating scores obtained via environmental indicators ESG database of Bloomberg. To measure the firms’ financial performance, the author has applied ROA and the measurement model controls for industry-level of firms based on their capital expenditure, infrastructure, manufacturing equipment as well as research and development expenditure. The findings of the study revealed a positive effect of the firms’ environmental performance on their future financial performance. However, the sample included only large firms which might make the results not descriptive for small or medium firms. In addition, the sample is compiled from various industrial sectors and consisted of firms with different operational natures and hence, different threshold for environmental pollution. Therefore, the author recommended an EP-FP analysis throughout a sample of firms with different sizes to increase the accuracy of the results. Finally, the proposed measurement model does not evaluate the impact of environmental standards and regulation on the EP-FP relationship of firms.

Lin et al. (2009) identified the model misspecification as a major reason for inaccurate and inconsistent results obtained by literature on the EP-FP relationship. The authors applied a variable representing firms’ investment in technical capital which improved knowledge and innovation of production. The results of the study did not identify a relationship between R&D investment and improved environmental performance and the firms’ financial performance in the short run but identified a positive relationship between the variables in the long-run. The
study concluded that being socially responsible makes firms publicly acceptable in the competitive environment leading to their “sustainable corporate brand building” in the long-term (Lin et al. 2009, p.61) which result in improved financial performance in the long run.

Nollet et al. (2016) examined the linear and nonlinear relationship between the environmental performance and financial performance of all companies listed in the S&P stock market index. They hypothesised that environmental performance has a positive linear relationship with financial performance and tested the hypothesis using Accounting based (ROA and ROC) and market-based criteria (annual excess stock returns) to measure corporate financial performance. Their linear analysis presented no significant relationship between corporate environmental performance and its financial performance. In conclusion, the results of this study showed a negative EP-FP relationship in the short-run and a positive EP-FP relationship one in the lug-run.

To examine the impact of environmental performance on the financial performance in both short and long term, Delmas et al. (2015) conducted a longitudinal study exploring the impact of changes in institutional conditions on 1095 firms’ profitability strategies according to a process-based view of environmental issues during the period of 2004 to 2008 in the United States. The study applied ROA to measure the short-term financial performance and Tobin’s q to measure the long-term financial performance. These are not considered as perfect indicators for measuring the performance as they are unable to capture all performance dimensions (such as the intangible assets replacement value). Therefore, the authors recommended the addition of other financial measures in order to increase the precision of the EP-FP analysis. The results confirmed that improved environmental performance will result in lower short-term financial

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11 The US stock market index (The Standard & Poor’s 500) including 500 large companies (Pandit and Rubenfield 2016).
performance and improved long-term financial performance through positive investor attitude towards the future market performance of firms.

The following table will summarise the above literature to highlight their importance to the present study and the gap to be filled.
<table>
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<th>Authors</th>
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<td>Lin et al. (2009)</td>
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<td>Nollet et al. (2016)</td>
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<tr>
<td>Delmas et al. (2015)</td>
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<td>Li et al. (2017)</td>
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</tr>
<tr>
<td>Authors</td>
<td>Country</td>
<td>Data</td>
<td>EP Variables</td>
<td>FP Variables</td>
<td>Methodology</td>
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<td>Log (total GHG/MV)</td>
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<td>Saeidi et al. (2015)</td>
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<td>Positive</td>
</tr>
</tbody>
</table>

12 Market Value (Tzouvanas et al. 2019, p.7)
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</tr>
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<td>Salama (2005)</td>
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<td>Robust regression</td>
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<td>Positive</td>
</tr>
<tr>
<td>Liou and Sharma (2012)</td>
<td>USA</td>
<td>17000 firms; Period 1991-2007</td>
<td>CSR ratings from KLD STATS Inc</td>
<td>ROA, Tobin’s q</td>
<td>Regression</td>
<td>Size, R&amp;D/sales, Risk</td>
<td>Negative</td>
</tr>
</tbody>
</table>
3.3 Theoretical Background

Prior studies that examined the relationship between environmental performance and financial performance have utilised a number of theories to explain the relationship between the two variables. In this section, the main theories that have been used by prior studies are reviewed.

3.3.1 Porter theory

The theoretical background of the relationship between environmental performance and financial performance is considerably influenced by the Porter Hypothesis discussed in Porter (1991) and Porter and Linde (1995) (Wagner, Van Phu et al. 2002). According to the Porter hypothesis, firms’ competitiveness will be improved by efficient strict regulation which will result in positive relationship between environmental performance and financial performance of firms (Wagner et al. 2002). According to this theory the waste or improper utilisation of resources and energy potentials is a result of pollution. Therefore, pollution reduction will increase firms’ productivity and this will be possible by the environmental regulations (Porter and van der Linde 1995).

According to this hypothesis, “the firms’ performances are positively affected by environmental regulation” (Lundgren and Marklund 2015, p.229). The effects of the environmental regulations on firms’ performance and efficiency will end in the lower costs and increased profits (Broberg et al. 2013). In other words, the hypothesis argues about the causality of the relationship between environmental regulations and financial performance which could contain three influential approaches through innovation, cost reduction and revenue raise caused by innovation and enhanced financial performance (Rassier and Earnhart 2011).

The present study is grounded on the Porter Hypothesis in the investigation of the relationship between environmental performance affected by the regulations and the financial performance of the Australian electricity firms. The following sub-sections will explore the theoretical background of this analysis.
3.3.2 Resource-Based View

The resource-based view theory broadly elaborates on the relationship between resources and competitiveness of the business and its fundamental assumption is to help corporations to compete effectively in the existence of uneven distribution of resources across corporations (see for instance, Barney (1991), Barney (1995), Priem & Butler (2001), Wernerfelt (1984) and Duncan et al. (1998) as cited in Salem et al. (2012, p.112)). In fact, this theory highlights the importance of the corporation’s resources in its competitiveness while ignoring critical environmental factors. Furthermore, it is not always only one resource that is effective in improvement of competitiveness; multiple sources are, in fact, required for a greater performance. Therefore, alternative resources which affect business capabilities (e.g. environmental issues’ resources) are required to be investigated (Salem, Hasnan et al. 2012).

The underlying assumption of the RBV theory is the difference in financial performance of firms because of their resources’ heterogeneity and hence, corporations obtain competitive advantages based on their capabilities and resources. Based on this theory, “only pro-active environmental governance is a source of firm performance, which is unique to the firm and difficult to obtain by competitors and this pro-active environmental management can be represented by eco-efficiency” (Salem et al 2012, p. 114). Therefore, the RBV theory is acknowledged as a basis to achieve competitiveness via resource utilization allied with environmental issues (Salem et al. 2012).

In fact, firms’ attempt towards environmentally cautiousness is relied upon their accessible resources (tangible and intangible). The capability resulted from the resources and the ability to resource allocation enable firms to obtain “sustainable competitive advantage” and therefore, increased productivity (Kang and He 2018, p.581). On the basis of RBV, not all firms are able to strategically become environmental-friendly due to their diverse level of resources and capabilities in resource coordination and allocation. Kang and He (2018)
concluded that innovation and “environmental orientation” of the firms significantly enable them to settle their corporational issues (Kang and He 2018).

According to RBV, diverse levels of resources and capability will result in generation of new resources, exclusive capabilities of firms and therefore their survival/sustainability. Also, this theory emphasizes that the approach of exploitation of the resources (valuable and scarce ones in particular) and areas of the investment of capabilities are more vital than the volume of resources in obtaining competitive advantage and sustainability. The RBV theory is also developed throughout the natural environment referred to as the “Natural RBV”. According to the natural RBV, the sustainable competitive advantage will be achievable by waste and emission reduction along with viable operating developments towards minimizing environmental harms (Fernando et al. 118, p.419). This theory confirms that firms’ financial performance will be significantly affected by the optimally application of their unique resources and capabilities which is absolutely dependent on their level of efficiency. In fact, RBV analyses the firms’ efficiency in the conversion of its resources into “valuable capabilities” and hence, to achieve and strengthen competitive advantage (Fernando et al. 118, p.419). Other than the internal capabilities, the RBV acknowledges the firms’ reputation as another valuable resource enabling firms to obtain other resources and competitive advantage followed by improved financial performance (Partanen and Goel 2017).

Considering the above discussion and compared with the other options available in the literature, this theory was found to be the most suitable to link between the financial performance and environmental performance of corporations. The most reliable literature including Clarkson et al. (2011), Darnall et al. (2008), Busch et al. (2011), Galdeano-Gómez (2008) and Nakao et al. (2007) found positive relationship between environmental performance and financial performance of organizations based on this theory which are being discussed as follows.
To examine the effect of environmental activities of 4 most pollutant industries in the United States on their financial performance, Clarkson et al. (2011) analyzed the sample within 1990-2003 period based on the resource-based view which presented a positive relationship. Combining the Institutional theory and resource-based view theory, Darnall, Henriques et al. (2008) accomplished a survey study to comprehend the relationship between the environmental management systems adopted by firms and their financial performance in OECD countries which was found to be positive. Busch et al. (2011) combined a contingency approach with the resource-based view in order to analyze the relationship between the financial and environmental performance of firms which was found positive in the long-run but negative in the short-run. Galdeano-Gómez (2008) made a panel data analysis on the relationship between environmental and economic performance of 56 farming-marketing firms in Spain from 1997 to 2002. The study revealed positive effect of environmental performance on market value and profitability of firms based on the RBV theory. Nakao et al. (2007) found a positive relationship between environmental performance and financial performance of 278 corporations in Japan during 1999 to 2003 based on stakeholder theory and the resource-based view.

However, Hart (1995 as cited in Salem et al. 2012, p.112) acknowledged the resource-based theory as an inadequate basis to detect vital competitive sources due to its neglecting of the environmental issues which are becoming more significant because of various challenges faced by firms such as improving technology and productivity and cost reduction. On the other hand, Freeman (2010 as cited in Salem et al. 2012) discussed that organizations are required to manage the objectives and interests of their stakeholders to retain them (Sarkis, Gonzalez-Torre et al. 2010). Therefore, in order to enhance and strengthen the theoretical background of the present study, we will ground the study with stakeholder theory along with the resource-based view. Next section will explore the literature on the stakeholder theory which has been used in the prior studies to examine the EP-FP relationship.
3.3.3 Stakeholder Theory

There are four organizational resources recognized to be common throughout environmental studies summarized as “innovativeness, employee involvement, effective communication practices and stakeholders’ integration” (Salem et al. 2012, p.113). Emphasizing the necessity of further research on the stakeholders’ integration, some studies discussed that retaining stakeholders keen on the organization depends on the way corporations manage their stakeholders which denotes to stakeholder theory (Salem et al. 2012, p.113).

Stakeholder theory recommends improvement of the relationships with stakeholders and hence, improving the firms’ competitiveness by including stakeholders’ concerns in business strategies (Salem et al. 2012, p.113). This theory is developed “as a new narrative to understand and reconceptualize” business related issues including “responsibility, ethics, environmental policy and sustainability” rather than the conventional business goal of profit maximization (Benites-Lazaro and Mello-Théry 2019, p.254; Abolghasemi et al. 2018). As defined by Freeman (1984 as cited in Zhang min et al. 2018), stakeholders are consisted of all parties who can affect firms to achieve their goals and be affected by firms’ achievements (Zhang min et al. 2018). Therefore, the stakeholder theory claims that the firms’ relationship with their stakeholders is vital in determination of their resources and capabilities to create “sustainable wealth” (Benites-Lazaro and Mello-Théry 2019, p.255). In fact, stakeholder theory is constituted of characteristics which make it the initial theory in the operational research to affirm the vital impact of the firms’ relationship with their stakeholders on the firms’ financial performance (Abolghasemi et al. 2018; Gooyert et al. 2017). These characteristics are of the following aspects:

- Approaches taken by firms to interact with their stakeholders (descriptive aspect) which is found to be of the main concern by the previous CSR (corporate social responsibility) literature;
• Approaches taken by firms to satisfy stakeholders` expectations to enhance the firms` financial performance (instrumental aspect);

• Significance of managerial behavior in firms’ forming the relationship with stakeholders (managerial aspect) (Abolghasemi et al. 2018).

On the basis of the stakeholder theory, previous environmental literature has incorporated the impact of stakeholders` involvement through analytical analysis (Benites-Lazaro and Mello-Théry 2019). The following studies analyzed the relationship between environmental performance and financial performance of firms based on the stakeholder theory.

Emphasizing on the negative financial impact of environmental “misdeeds”, Yang et al. (2018) believe in the crucial impact of firms` environmental responsibility on the shareholders` attitude. On the basis of structural stakeholder theory, they studied the relationship between “corporate environmental strategy and the structure and power of networked shareholder activism”. The study concluded that shareholders` attitude could be a great practical instrument to evaluate firms` environmental friendliness and authors expect even further influence of shareholders on environmental approaches and activities through modern business strategies (Yang et al. 2018, p.725-726).

Herremans et al. (2016) conducted a field study on the Oil and Gas Industry in Canada to examine the role of sustainability reporting in the firms` relationship with their stakeholders along with the stakeholders` response to the firms` sustainability disclosure. The study resulted in the further theoretical understanding of stakeholder theory and resource dependence theory14, highlighting the significance of improved organization-stakeholders relationship by

13 Shareholders are a part of stakeholders and their important role in the firms` operational issues is considered through stakeholder theory (Yang et al. 2018).

14 The resource dependance theory highlights the importance of the process of obtaining and controlling the external resources in the corporation strategies and structure and hence, control of internal resources (Herremans et al. 2016).
means of sustainability report and disclosure. The authors recommended further research (in other industries) on the role of sustainability reporting in the organizational changes and improvement considering the stakeholders’ relationship with firms.

Emphasizing on the cruciality of firm-stakeholder relationship on the firms’ operational success, Kumarasiri (2017) has surveyed the role of “stakeholder pressure on climate change strategies” via management accounting practices in 18 large Australian companies (high carbon intensive and low carbon intensive companies). The study is conducted during the 2012-13 when the Australian government applied carbon tax on business operations (regulatory pressure by the government as a stakeholder). The author found this regulatory pressure (also referred to as an economic tool of carbon emission management) imposing direct negative financial effects on the high carbon intensive companies and indirect negative financial effects on low carbon intensive ones. This negative financial impact has been the result of the higher costs of energy which has also negatively affected stakeholders’ attitude (social pressure).

Semenova et al. (2010) examined the impact of environmental performance of 300 Swedish companies on their market value as well as its relationship with firms’ financial performance based on the stakeholder theory. Their study indicated positive relationship of the environmental performance of the firms and their financial performance and market value. Based on this theory, Heras-Saizarbitoria et al. (2011) investigated “the bi-directional relationship between ISO 14001 certification and financial performance” of “268 ISO 14001 certified companies” along with 7232 non-certified companies in Spain (Heras-Saizarbitoria et al. 2011, p.1 & 6). Their longitudinal analysis during 2000-2005 period represented possible positive relationship between environmental certification and financial performance of companies. Like Heras-Saizarbitoria et al. (2011), Salama (2005) found out a positive effect of firms’ environmental performance on its financial performance via OLS regression of panel
data for 201 British companies. On the basis of the stakeholder theory, Gonenc and Scholters (2017) found a positive relationship between environmental performance and financial performance of international fossil fuel firms through their homogenous analysis.

In summary, according to the stakeholder theory, there is a positive relationship between financial performance and environmental performance when different groups of stakeholders are concerned (Semenova et al. 2010). Also, the legitimacy theory and stakeholder theory are acknowledged as the most successful frameworks in describing the efficient level of environmental disclosure protecting identity and reputation of firms (Juhmani 2014). It is impossible to run business without stakeholders’ trust and reliance on corporations. Therefore, they should publicly report their operations to achieve a trustworthy image in the viewpoint of stakeholders (Aggarwal 2013). In fact, legitimacy theory claims that the perception of stakeholders about corporations’ responsibilities and their fulfillment level is shaped by the managerial disclosure (Magness 2006). Hence, our measurement model will include variables addressing features of legitimacy theory in addition to the RBV and stakeholder theory.

The Section 3.3.3 outlines the legitimacy theory which has been also used by a number of studies to explain the EP-FP relationship.

3.3.4 Legitimacy Theory

The focus of both legitimacy theory and stakeholder theory is the significant effect of transparency, disclosure and reporting on the relationship of the firms with their competitors, society and government (Luca and Prather-Kinsey 2018). Legitimacy is achievable when firms’ performance is well-suited with social values (Sulaiman, Abdullah et al. 2014). Therefore, legitimacy theory concerns about firms’ reaction to social expectations and anticipates that organizations operate in a way to protect a legitimate business image in a community to assure their survival (Sulaiman, Abdullah et al. 2014). Legitimacy is referred to the situation through which firms’ actions are in line with social expectations, values and
beliefs. In fact, legitimacy theory is a supplementary theory of the stakeholder theory which is more descriptively identifies the approaches taken by firms to address the social expectations and requirements aiming to act legitimately. This theory specifically and strongly explains the corporate social responsibility issues with different corporational pressures and social contexts (Sila 2018). Firms’ management responses to social values should be disclosed publicly in order to notify the stakeholder about firms’ environmental performance (for instance through annual reports) which enables them to make decisions about their business relationship with firms (Magness 2006, Sulaiman et al. 2014).

As a whole, legitimacy theory is the benchmark based on which the firms are evaluated for voluntary and legislative environmental disclosures, the impact of the environmental disclosures on firms’ GHG emissions and the GHG emissions reporting by companies compared to the actual level of emissions. In fact, this theory identifies firms’ environmental performance as a vital factor of their level of legitimacy and hence, credibility and financial performance (Perera et al. 2019).

Considering the above discussion, Maso et al. (2018) have incorporated both stakeholder and legitimacy theories to examine the relationship between the environmental performance and financial performance of firms operating in different industries and different countries within a 12-year sample period. Their analysis presented a positive association between environmental performance and financial performance moderated through the stakeholder management and environmental regulation. However, the authors recommended further study on the EP-FP relationship via an enhanced model to include risk level of firms with the focus on an individual industry in one country to increase the accuracy of the analysis.

On the basis of legitimacy view, Qian and Schaltegger (2017) have analyzed a panel data for the duration of 2008 to 2012 to investigate the impact of environmental disclosure by
firms on their “carbon performance”\textsuperscript{15}. The study resulted in significance of carbon disclosure in improving carbon performance by firms confirming their tendency towards legitimacy and carbon-reduction-compensation and therefore, “real carbon reduction” (Qian and Schaltegger 2017, p.376). However, the authors found this motivation is less strong in the heavy-polluting firms because of the weak relationship between carbon disclosure and carbon performance in those firms.

Referring to the significance of understanding the vital determinants of GHG disclosure and the basis of legitimacy theory supporting stakeholder theory, Ghomi and Leung (2013) conducted a content analysis of 151 firms in Australia from 2009 to 2011. Their results identified the positive association of GHG disclosure with firm size and corporate governance. However, voluntary environmental disclosure (such as disclosure of emissions in annual reports) does not provide sufficient level of data source to evaluate firms’ environmental performance. Specifically, larger firms with more financial and production resources are required to be scrutinized for releasing more information in order to legitimize their operations (Ghomi and Leung 2013).

To evaluate the relationship between the environmental disclosure and financial performance of Canadian gold mining companies in 1995, Magness (2006) essentially defined disclosure score to measure environmental disclosure comprised of both financial and non-financial components\textsuperscript{16}, the size of companies, financial performance and capital access strategies. This study resulted in neutral relationship between environmental performance and financial performance of the firms in the sample. The investigation period is the year of an environmental accident\textsuperscript{17} in this industry when stakeholders asked for information regarding the environmental issues. Thus, the author used the disclosure level of firms to assess the

\textsuperscript{15} Carbon emission intensity (Qian and Schaltegger 2017, p.370)

\textsuperscript{16} “Measures of financial versus qualitative, forward-looking versus historic, and mandatory versus discretionary items” (Magness 2006, p.559)

\textsuperscript{17} Omia accident: The failure of a dam at the Omai gold mine in Guyana (Magness 2006, p.547).
The study also claimed that companies are required to disclose greater information on their social and environmental activities “when stakeholder power is high” (Magness 2006). Discussing the extensiveness of disclosures, the study concluded with the necessity of following environmental regulations.

Juhmani (2014) investigated the effect of “firm size, profitability, financial leverage, firm age and audit firm size which are the variables defined based on the legitimacy theory, on the level of social and environmental information disclosures” of 33 companies listed in Bahrain Bourse during 2012. In fact, this study attempted to find the impact of financial factors of firms on their environmental performance disclosure according to the legitimacy theory. The study indicated positive impact of financial leverage and audit firm size on the disclosures level of environmental information, but no relationship between profitability and social disclosure. The results of the study indicated more than half of the listed companies in Bahrain included in the sample voluntarily disclose qualitative environmental information which is their strategy to legitimize their operations.

On the basis of the above theoretical framework consisted of RBV, stakeholder theory and legitimacy theory, the present study will apply the variables to explain the EP-FP relationship through the Australian electricity producing firms included in the sample and hence, provide solutions to research problems, as will be discussed through Section 3.4 as follows.

### 3.4 Variables explaining EP-FP relationship

As discussed above, the variables used in prior studies to measure key constructs varied significantly from study to study. As for the measurement of financial and environmental performance, the most commonly used measurements include ROA, ROE, net profit margin, sales revenue and Tobin’s q as measures of the financial performance of the firms in their
sample and CO₂ emission (in tonnes), environmental management system, environmental score, CSR index, total GHG emissions, level of disclosure and adopting ISO 14001.

The control variables used in prior studies consisted of firms’ size, sales growth, debt to equity ratio\(^{18}\), firms’ age, risk, R&D expenditure, investment in environmental technology, ownership structure, corporate governance and regional dummies. All the studies included in the literature reviewed above (See Table 3.1 for a summary) examined the relationship between environmental performance and financial performance of firms by means of different approaches of the regression analysis.

As discussed above, the EP-FP relationship is grounded on the RBV theory which highlights the significance of resource utilisation considering environmental issues to increase the firms’ competitiveness (Salem et al. 2012). According to this theory, enhanced technology will result in more effective usage of resources by firms and higher efficiency improves firms’ environmental performance and financial performance (Cui, Lapan et al. 2016). Therefore, we will apply firms’ level of efficiency and technology in our model estimation to measure the impact of environmental performance of the Australian electricity firms on their financial performance reflected by the gross profit margin, net profit margin, ROA and ROE. This part of the analysis will answer the research questions number 1 and 2 by means of the RBV theory.

In addition to the RBV, the literature emphasized on the importance of the stakeholders’ attitude towards firms for the firms’ financial performance. This theory claims that the improved relationship of firms with their stakeholder will result in the increased competitiveness which will be achieved by incorporation of the stakeholders’ concerns in the firms’ strategies (Semenova et al. 2010). Based on this theory, stakeholders are concerned about the firms’ accountability. In other words, firms’ relationship with the stakeholders is one of the most vital factors in their value creation (Stankevičienė and Vaiciukevičiūtė 2016).

\(^{18}\) As the financial leverage ratio
Accordingly, our proposed measurement model will evaluate the impact of the environmental performance and financial performance of the Australian electricity producing firms on their stakeholders’ perspective presented by the market performance variable. The influence of firms’ environmental performance and financial performance on their market performance will reply the research questions number 3 and 5 on the ground of the stakeholder theory.

The firms’ relationship with their stakeholders is also the focus of the legitimacy theory which emphasizes the adequate level of environmental disclosure in order to enhance firms’ reputation and legitimise their operation (Juhmani 2014). In other words, this theory believes in the influence of the corporations’ social and environmental disclosure on the stakeholders’ trust. To measure this relationship, the impact of the application of the ISO14000 standard series by the Australian electricity generating firms on their environmental performance, hence on their financial performance, will be measured by means of our estimated model answering research question number 4 based on the legitimacy theory. Table 3.2 summarised the literature reviewed for the theoretical framework.

Finally, according to the above literature, efficiency level of firms is an effective factor in the relationship between their environmental performance and financial performance (Giovanni and Vinzi 2012; Marie et al. 2014). The present study will also evaluate the effect of efficiency on the EP-FP analysis of the Australian electricity generating firms. The estimated measurement model will incorporate the efficiency scores obtained from the data envelopment analysis (DEA) based on the literature reviewed through the next section.
# Table 3.2: Theoretical Background

<table>
<thead>
<tr>
<th>Theory</th>
<th>Authors</th>
<th>Country</th>
<th>Data</th>
<th>Analysis</th>
<th>Methodology</th>
<th>Control &amp; Dummy Variables</th>
<th>FP Variables</th>
<th>EP Variables</th>
<th>Results: EP-FP Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource-based View</td>
<td>Clarkson et al. (2011)</td>
<td>USA</td>
<td>1990-2003</td>
<td>Relationship between environmental and financial performance</td>
<td>Regression</td>
<td>Age of equipment</td>
<td>Total assets, ROA, Liquidity, Leverage, R&amp;D expenses/assets, Growth, Enterprise value, Capital intensity</td>
<td>Pollution propensity: emission volume scaled by the cost of sales</td>
<td>Positive</td>
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<td></td>
<td>Darnall et al. (2008)</td>
<td>OECD Countries</td>
<td>2003</td>
<td>Impact of environmental management systems on the financial performance</td>
<td>Multi-variate OLS Regression</td>
<td>Facility size</td>
<td>Profitability (survey), Growth performance (survey), Export orientation, Employee commitment</td>
<td>Environmental management system adoption (survey), Institutional pressures (survey), Environmental R&amp;D budget</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Busch et al. (2011)</td>
<td>USA</td>
<td>252 companies; 2001-2003</td>
<td>Relationship between environmental and financial performance</td>
<td>Regression</td>
<td>Size, Risk</td>
<td>Tobin’s Q, Investments in ESP and innovation, Industry membership</td>
<td>Environmental and social factors based on KLD database</td>
<td>Positive in the long-run; Negative in the short-run</td>
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<tr>
<td>Theory</td>
<td>Authors</td>
<td>Country</td>
<td>Data</td>
<td>Analysis</td>
<td>Methodology</td>
<td>Control &amp; Dummy Variables</td>
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<td>Results: EP-FP Relationship</td>
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<td></td>
<td>Nakao et al. (2007)</td>
<td>Japan</td>
<td>278 manufacturing companies; 1999-2003</td>
<td>Relationship between environmental and financial performance</td>
<td>Multiple Regression</td>
<td>3 industrial groups based on the firms' size of small to large.</td>
<td>Tobin’s Q and ROA</td>
<td>Scores published by the Nikkei Environmental Management Score Report</td>
<td>Positive</td>
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<td></td>
<td>Yang et al. (2018)</td>
<td>USA</td>
<td>364 companies; 2006-2014</td>
<td>Relationship between environmental and financial performance via responsiveness to shareholders' demand</td>
<td>Multinomial Logistic Regression</td>
<td>Size (sales), Network Variables, Activist Centrality</td>
<td>Financial slack (cash)</td>
<td>Request Urgency</td>
<td>Positive</td>
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<td></td>
<td>Herremans et al. (2016)</td>
<td>Canada</td>
<td>Oil and Gas Industry (11 companies); Duration of 15 years</td>
<td>Relationship between environmental and financial performance</td>
<td>Coding Scheme</td>
<td>Number of Employees</td>
<td>Total Revenue</td>
<td>Means of Sustainability Reporting</td>
<td>Positive</td>
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<td></td>
<td>Semenova et al. (2010)</td>
<td>Sweden</td>
<td>100 to 300 companies; November 2005- June 2008</td>
<td>Relationship between environmental and social performance on firms’ market value</td>
<td>Regression</td>
<td>Size, Industry dummies</td>
<td>Market value, Book value, Net income</td>
<td>The GES and KLD Environmental and social indexes</td>
<td>Positive</td>
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<td>Theory</td>
<td>Authors</td>
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<td>Methodology</td>
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<td></td>
<td>Salama (2005)</td>
<td>UK</td>
<td>201 British companies; 2000</td>
<td>Relationship between environmental and financial performance</td>
<td>OLS Regression</td>
<td>Size, Systematic risk, Industry effects, R&amp;D expenses/assets</td>
<td>Financial indexes</td>
<td>The corporate reputation index of Britain MAC</td>
<td>Positive</td>
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<td></td>
<td>Maso et al. (2018)</td>
<td>International</td>
<td></td>
<td>Moderating factors affecting the Relationship between environmental and financial performance</td>
<td>Regression</td>
<td>Size, Risk, Board size, Governance performance score, Stakeholder engagement, Stakeholder prioritisation</td>
<td>ROA, ROE</td>
<td>CSR index, Environmental score</td>
<td>Positive</td>
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<td>Theory</td>
<td>Authors</td>
<td>Country</td>
<td>Data</td>
<td>Analysis</td>
<td>Methodology</td>
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<td></td>
<td>Ghomi &amp; Leung (2013)</td>
<td>Australia</td>
<td>151 companies; 2009-2011</td>
<td>Relationship between financial and non-financial GHG disclosure with firm size and governance</td>
<td>Regression</td>
<td>Firm’s status in the industry, Corporate governance, Size, Age, Ownership concentration</td>
<td>No financial variable</td>
<td>GHG voluntary disclosure (survey)</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Magness (2006)</td>
<td>Canada</td>
<td>1995</td>
<td>Relationship between the environmental disclosure and financial performance</td>
<td>Regression</td>
<td>Size, Dummy variable: if firms obtained external financing</td>
<td>ROA</td>
<td>Firms’ disclosure factors</td>
<td>Neutral</td>
</tr>
<tr>
<td></td>
<td>Juhmani (2014)</td>
<td>Bahrain</td>
<td>33 companies; 2012</td>
<td>The effect of firm size, profitability, financial leverage, firm age and audit firm size on the level of social and environmental information disclosures</td>
<td>Regression</td>
<td>Size, Age, Audit firm size</td>
<td>Profitability, Financial Leverage</td>
<td>Level of social and environmental disclosure</td>
<td>Positive impact of financial leverage and audit firm size on environmental disclosure. Neutral relationship between profitability and social disclosure</td>
</tr>
</tbody>
</table>
3.5 Efficiency Measurement: Data Envelopment Analysis (DEA)

In prior studies (see for example, Giovanni and Vinzi (2012), Marie et al. (2014), Galdeano-Gomez (2008)) efficiency has been identified as a significant variable that have significant impact on the determination of environment and financial performance of companies. Considering the significant role that efficiency plays in firms’ performance, this section will review the studies that have considered firm efficiency a variable in the model designed to examine the EP-FP relationship. This section will also review studies that have used Data Envelopment Analysis (DEA) to measure firms’ efficiency as it has been the main method that prior studies have used to measure the firm efficiency.

DEA is a frontiers-based technique to identify the best practice for decision-making unit (DMU) in the sample of homogenous units. To determine the efficient and inefficient DMUs they will be scored 0 to 1 based on their location on the efficient frontier, above or below (Sathye 2001). To select the orientation of the DEA approach to either output- or input-orientation, the managers’ control level on the inputs or output quantities should be considered (Wheelock and Wilson 1999). The DEA technique and orientation approaches will be explored through Chapter 4 of the present study.

Halkos and Tzeremes (2009) conducted DEA analysis for a period longer than 11 years in order to capture “the efficiency trend over time” and to investigate the relationship between the electricity generation and economic growth, Their analysis is on the basis of 2 inputs, 1 output production based on the logic of efficiency ratio equal to a weighted sum of outputs over a weighted sum of inputs. The efficiency analysis revealed both positive and negative impact of the electricity generation on economic efficiency of various countries in the sample based on the level of service-orientation of the firms in developed and developing

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19 The advantages of DEA method over ratio analysis will be discussed in Chapter 4 of the present thesis.
countries. The obtained results highlight the importance of institutional structure as well as homogeneity of the firms/countries under investigation.

Çelen (2013) states that there is no constraint “on the functional form of the production relationship between inputs and outputs” which is considered the main benefit of this technique (Çelen 2013, p. 301). Therefore, the study applied input-oriented DEA assuming the variable returns to scale (VRS) to evaluate Turkish electricity distributors within a 7-year period. To include the effect of length of distribution line and transformer capacity in the analysis, the study considers capital as an input variable. The results indicated the significance of ownership structure plus the customer density (as an environmental factor) on the firms’ efficiency. However, the environmental variables (customers density and sales related ratios) applied in the study are not controlled by firms and changeable in the long run.

To evaluate the efficiency of electricity distribution and transmission utilities in Brazil, Pereira de Souza et al. (2014) applied input-oriented DEA approach. They emphasise that “only inputs or outputs that really contribute significantly to the performance of a DMU20 should be applied in the analysis (Pereira de Souza et al. 2014, p.171). Therefore, referring to the products as the “cost drivers”, the study applied operational costs as the input. The results indicated the important role of firms’ efficiency in their level of competitiveness in the market. Also, the authors concluded that the organisational characteristics and noncontrollable features influence the efficiency trend of the firms during the investigation period. However, the study does not consider the weight/multiplier of applied variables (according to the observations) and firms’ different contexts.

Worthington (2000) applied input-oriented index based on production approach of DEA method to measure the efficiency and productivity growth of fifteen Australian Building societies. Selected inputs are members’ funds, physical capital, labour and the number of full-

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20 DMU: Decision Making Unit
branch equivalent operations and outputs involve call deposits, term deposits, personal loans, residential loans, commercial loans and other financial investments. The author found that technological progress contributed to the productivity improvement.

Lyroudi and Angelidis (2006) employed DEA to investigate the firms’ efficiency in the ten latest members of the European Union during 1996 to 2002, the period before their entry in the EU. Labour, other operating expenses and total fixed assets are selected as inputs and total deposits, total customer loans and investments are outputs. The authors also analysed the relationship between the sizes of financial institutions and their productivity. According to the empirical results, financial institutions presented productivity growth.

Applying an input-oriented DEA model, Das and Ghosh (2006) assessed the efficiency of the Indian commercial banks. The production approach of the study included interest expenses, employee expenses and capital related operating expense as inputs and interest income, and non-interest income as outputs. The results indicated high inefficiency over the liberalization period which could be due to the underutilization of valuable resources as well as the scale of operations. The study concluded that the trend of efficiency and technological change could be the response of the industry to the deregulation forces.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Data</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halkos and Tzeremes (2009)</td>
<td>42 World and East Asian countries</td>
<td>The impact of electricity generation on countries’ economic efficiency; Period of 1996-2006</td>
<td>Total labour force and Agriculture labour force</td>
<td>Gross domestic product (market price)</td>
</tr>
<tr>
<td>Celen (2013)</td>
<td>Turkey</td>
<td>21 electricity distribution companies; Period of 2002-2009</td>
<td>Number of employees, Length of distribution line, Transformer capacity, Outage duration and Loss &amp; Theft ratio</td>
<td>Quantity delivered and Number of customers</td>
</tr>
<tr>
<td>Pereira de Souza et al. (2014)</td>
<td>Brazil</td>
<td>60 Electricity distribution utilities</td>
<td>Operational expenditure</td>
<td>Energy distributed, Units consumers and Network distribution length</td>
</tr>
<tr>
<td>Hirschhausen et al. (2006)</td>
<td>Germany</td>
<td>307 Electricity distribution companies; Year 2001</td>
<td>Labour, Capital and Peak load capacity</td>
<td>Number of customers</td>
</tr>
<tr>
<td>Sanhueza et al. (2004)</td>
<td>Chili</td>
<td>35 electricity distribution companies; Year 2000</td>
<td>Distribution added value, Total kilometres of lines, Unbilled energy, Number of workers and Salaries</td>
<td>Total energy sold, Coincident power during peak hours, Number of customers</td>
</tr>
<tr>
<td>Worthington (2000)</td>
<td>Australia</td>
<td>Building societies, 1993/4-1996/7</td>
<td>members’ funds, physical capital, labour and the number of full-branch equivalent operations</td>
<td>call deposits, term deposits, personal loans, residential loans, commercial loans and other financial investments</td>
</tr>
<tr>
<td>Lyroudi and Angelidis (2006)</td>
<td>AU</td>
<td>994 institutions; Period of 1996-2002</td>
<td>Labor, other operating expenses and total fixed assets</td>
<td>total deposits, total customer loans and investments</td>
</tr>
<tr>
<td>Das and Ghosh (2006)</td>
<td>India</td>
<td>Banks; Period of 1992-2002</td>
<td>interest expenses, employee expenses and capital related operating expense (Production approach)</td>
<td>interest income, non-interest income (Production approach)</td>
</tr>
</tbody>
</table>
3.6 The Statistical Analysis of EP-FP Relationship

As observed through section 3.2, majority of the literature on the investigation of EP-FP relationship have been accomplished via different approaches of regression analysis. Among the related literature, Lucas and Noordewier (2016), Rodrigues-Fernandez (2016), Kim (2015), Salama (2005), Ernhart and Lizal (2002), Hatakeda, Kokubu et al. (2012), and Lioui and Sharma (2012) found positive or negative EP-FP relationship. On the other hand, authors such as Elsayed and Paton (2005) and Esfahbodi, Zhang et al. (2016) found no association between environmental performance and financial performance of organizations.

Although regression-based analysis has been commonly applied through various fields of research, the Structural Equation Modelling (SEM) became more prevalent over the last two decades. This method is distinguished for its features specifically the capability to measure unobserved factors within relationships and the graphical illustration21 (Hair et al. 2014; Hox and Bechger 1998). This methodology has been explored through studies such as Tomarken and Waller (2005), Clayton and Pett (2008), Byrne (2001), Chang, Lee et al. (2009), and Chaudhuri and Chowdhury (2012). The most prominent SEM studies applicable to context of the present study are reviewed in the following sections.

To enhance the previous literature on the structural equation modelling, Giovanni and Vinzi (2012) attempted to build a model to measure the effect of environmentally friendly activities on the economic performance of firms. In fact, their comparative study provides a practical ground for analyses on the relationship between financial performance and environmental performance of firms to be measured by reflective or formative constructs22 within the structural model. They respond to arguments around the nature of specific latent variables according to which the measurement model should be built. Emphasising the

21 The SEM features and modelling will be discussed in chapter 4 (methodology).
22 Formative constructs will be fully explained in Chapter 4.
significance of appropriate model estimation to build a measurement theory, the authors applied PLS path modelling to deal with any possible model mis-identification and presented the difference between results obtained from formative versus reflective measurement models.

On the basis of natural RBV, Latan et al. (2018) have examined the relationship between environmental performance and financial performance of firms operating in Indonesia. The data is obtained through surveys collected from companies that follow ISO 14001 during the period of 2016 to 2019. The study is conducted by means of PLS-SEM method but has failed to measure the mediating factors on the EP-FP relationship. In addition, the authors have only included the internal factors affecting the EP-FP relationship (i.e. Eco-learning and environmental strategy) and hence, recommend evaluating the impact of external factors on this relationship.

Makanyeza et al. (2018) investigated the effect of different factors of corporate social responsibility (CSR) on financial performance (measured by profit, ROA, ROI, market share performance and competitiveness) of firms operating in various economic sectors in Zimbabwe via the SEM technique to analyse the survey data. The positive impact of employee relations, community relations, investors’ relations and customer relations on firms’ financial performance confirms the significance of the stakeholder theory grounding the impact of corporate social responsibility dimensions on firms’ financial performance. However, this study found no relationship between the environmentally friendly activities of firms on their financial performance which necessitates the intervention of the government to protect the natural environment of the country.

The study of Ramanathan and Gunasekaran (2014) attempted to reveal the effect of collaborative planning, decision making and execution in supply chains on their performance which is measured by sales growth and market share. The structural equation modelling was
applied along with the confirmatory factor analysis to analyse the survey data obtained from the customers of a leading textile company in India. On the ground of resource-based view and resource-dependant theories, the study indicated a significant relationship between the collaborative planning and long-term successful performance of supply chains while it found no significant impact of decision making and execution on the performance within a long-run.

Karacaoglu, Bayrakdaroğlu et al. (2013) applied structural equation modelling to present the relationship between the corporate performance (productivity, market performance, technology and management) of industrial manufacturing firms and their financial performance (ROA, ROE, NPM, EBIT and depreciation, EBIT/.assets, net sales/assets). The authors collected survey data from 140 manufacturing firms in Turkey during 5 years and found strong interaction between firms’ performance (internal performance) and financial performance.

By means of PLS-SEM technique, Roldán, Leal-Rodríguez et al. (2012) investigated the causal-predictive relationship between different levels of quality cultures (detection, anticipation and creative cultures) on the total quality management performance (TQM). The survey data was collected from the CEOs/top executives of 113 firms in Spain and the study indicated negative impact of the detection culture (DC) and positive impact of anticipation (AC) and creative cultures (CC) on the total quality management performance.

Sila (2018) has applied the SEM technique in order to evaluate the impact of the total quality management (TQM) practices (“leadership, strategic planning, customer focus, information and analysis, human resources management, process management and supplier management”) on corporate social performance (CSP measured by environmental activities, pollution and noise levels, social involvement and effectiveness) and financial and market performance (FMP measured by market share, profit, ROA, competitiveness, innovation) of
manufacturing and service firms in Turkey and North Cyprus (Sila 2018, p.1108-1109). The analysis of the survey data on the basis of stakeholder theory, legitimacy theory and integrative social contracts theory and with consideration of country and sector effects, indicated a strong positive relationship among these constructs.

Marie et al. (2014) assessed the impact of financial and non-financial performance on the service quality of Islamic banks in the United Arab Emirates by means of structural equation modelling. The main data are collected via questionnaire to evaluate “the relationship between Islamic banks customers’ satisfaction and their effects on banks performance mediated by the bank’s internal operations in UAE” (Marie et al. 2014, p.204). The financial performance consisted of ROA which depended on the capital structure, management efficiency, profitability and size. The results confirm the impact of banks’ internal operations on their financial performance.

Stating the effectiveness of sustainable competitive advantage as a mediator in the relationship between corporate environmental and financial performance, Saeidi et al. (2015) referred to Rowley and Berman (2000), Galbreath and Shum (2012), Urbach and Ahlemann (2010) and Iacobucci, Saldanha et al. (2007) and confirm the superiority of the structural equation modelling (SEM) comparing to traditional regression approach within CSR research. SEM technique evaluates the causal relationship among various dependant and independent variables. This method is capable of reducing bias by considering measurement errors through repeated data measurements integrated in SEM models (Iacobucci et al. 2007). Empirically, SEM methodology was found to be more powerful to discover a mediation result than regression analysis and thus, the most appropriate approach on both theoretical and empirical statistical grounds\(^{23}\) (Saeidi et al. 2015, p.345-346). According to this study involvement of organisations in environmentally friendly activities results in higher customer satisfaction and

\(^{23}\) The advantages of SEM over traditional regression methods will be discussed in chapter 4.
therefore, better reputation and competitive advantage which mediates relationship between the firms’ environmental performance and financial performance.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Data</th>
<th>Analysis</th>
<th>Results</th>
</tr>
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</table>
| Makanyeza et al. (2018) | Zimbabwe | 155 companies- various economic sectors | • CSR-FP  
• EP-FP | • Positive  
• Negative |
| Sila (2018) | Turkey & North Cyprus | 156 firms in Turkey; 132 firms in North Cyprus. Various economic sectors of both countries | TQM-CSP-FMP | Positive |
| Karacaoglu et al. (2013) | Turkey | 140 manufacturing companies | IO-FP relationship | Positive |
| Ramanathan and Gunasekaran (2014) | India | 1 leading textile company | Relationship:  
• Planning-FP  
• Decision making-FP  
• Execution-FP | • Positive  
• Negative  
• Negative |
| Roldán et al. (2012) | Spain | 113 companies | Relationships:  
• DC-TQM  
• AC-TQM  
• CC-TQM | • Negative  
• Positive  
• Positive |
| Giovanni and Vinzi (2012) | Italy | 1400 companies; survey | EP-FP relationship | Positive |
| Latan et al. (2018) | Indonesia | 250 firms; surveys | Relationships:  
• EP-FP relationship  
• Eco-learning impact on EP-FP relationship | • Positive  
• Positive |
<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Data</th>
<th>Analysis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marie et al.</td>
<td>The United Arab Emirates</td>
<td>230 external customers and 174 internal customers; survey</td>
<td>The impact of financial and non-financial performance on the service quality of Islamic banks</td>
<td>Positive</td>
</tr>
</tbody>
</table>

### 3.7 Research Gaps

The review of the literature above on the studies that have examined the relationship between environmental performance and financial performance of organizations revealed a number of research gaps that needs to be addressed in future studies. These are explained below.

a) Prior studies (e.g. Harvathova 2012, Lin et al. 2009, Nollet et al. 2016 and Delmas et al. 2015) conducted to assess EP-FP relationship have predominantly examined the relationship in the short run. However, given that impact of environmental performance on financial performance is more likely to be experienced in the long-run, there is a need to examine this relationship in a longer time span such as 5-year lagged period.

b) Prior studies have been confined to examine the impact of the environmental performance on financial performance; they have not distinguished between accounting based financial performance such as ROA and ROE and market based performance measures such as Tobin Q. Considering that the accounting-based measures are short-term criteria of financial performance and market-based measures are the long-run performance criteria reflecting the investors attitude towards firms, the impact of the environmental performance on market performance is required to be analysed separately from the financial performance (e.g. Lin et al. (2009), Lee at al. (2015), Horváthová 2012, Saeidi et al. (2015), Misani and Pogutz (2015), Gonenc and Scholters (2017), Lioui and Sharma (2012), Gatsi et al. (2016) and Konar and Cohen (2001)).
c) Prior studies have also failed to examine the potential impact of financial performance on market performance. If company’s financial performance is impacted by its environmental performance, it is likely to have an impact on the market response to company performance resulting in a movement in share price and firm value of the company. This relationship has not been measured in prior studies.

d) Environmental regulations and standards play an important role in the environmental considerations by firms. Nevertheless, the impact of environmental regulations and standards on firms’ environmental performance and their financial performance has not been distinctly addressed by the prior studies.

e) The efficiency has been identified as an important factor in the relationship between environmental performance and financial performance of firms (Galdeano-Gomez 2008). However, a few of the prior studies have assessed the effect of efficiency only as a control variable (Giovanni and Vinzi 2012; Marie et al. 2014) without taking into consideration the efficiency’s main components. Therefore, it is important to evaluate clearly the effect of decomposed efficiency of firms on the relationship between their environmental performance and financial performance.

f) Level of firms’ efficiency affects both short-term financial performance and long-term financial performance and might have indirect impact on firms’ environmental performance. However, to evaluate the important factors in the EP-FP analysis majority of the prior studies have employed regression method which is unable to reveal the mediating relationships. Therefore, there is a need to apply a modified methodology in order to capture the mediating relationships such as those connecting efficiency to the environmental performance.

Considering these gaps in the previous literature, the present study will focus on the different dimensions of the impact of Australian electricity generating firms’ environmental
performance on their financial and market performance. The relationships among these
dimensions and variables will be discussed through Chapter 4 of the present study. Our
analysis will provide answers to the following research questions:

1. What is the relationship between the efficiency, internal operation and the
   environmental performance of Australian electricity generation firms?
2. What is the relationship between the efficiency and financial performance of
   Australian electricity generation firms?
3. What is the relationship between the environmental performance and financial
   performance of Australian electricity generation firms?
4. What impact do environmental standards have on the relationship between the
   environmental performance and financial performance of Australian electricity
   generation firms?
5. What is the relationship between the financial performance and market performance
   of Australian electricity generation firms?
6. Does the relationship between environmental performance of firms and their
   financial performance vary in different geographical regions?

3.8 Summary

As it can be observed in the preceding sections, to analyse the link between environmental
performance and financial performance studies have been conducted on different
combinations of firms and industries but not on the electricity producing firms or in the
Australian context. Furthermore, the literature on the EP-FP relationship suffers from the
inaccuracy of the measurement models and variables and lack of agreed upon methodologies.
According to the literature on the theoretical background, the inconsistency in the
methodology and results could be a result of the lack of an efficient theoretical framework to
reason the relationship between environmental performance and financial performance of
firms. In an attempt to overcome this deficiency of the literature, we have proposed a theoretical background on the basis of the most reliable literature to ground our EP-FP model estimation and analysis.

Inspired by the previous literature, the present study will employ additional variables which are expected to be more effective in this relationship and their effect would be investigated with 5-year lagged period. Those studies which measured this impact with lagged periods (maximum 2 years), found it negative in the first year but starting to be positive in the second year. Thus, to ensure the exactitude of these findings, we will extend this exploration to a larger lagged period. The following chapter will explore the methodology in detail to estimate the model and to assign variables to accomplish our EP-FP analysis.
Chapter 4  
Methodology and Research Design

4.1 Introduction

The purpose of the present study is to evaluate the relationship between environmental performance (EP) and financial performance (FP) of the Australian electricity producing firms through an advanced statistical analysis. On the basis of the findings of the literature review and to fill the research gaps presented in the previous chapter, this chapter develop a measurement model through research questions and the hypothesis set to answer the research questions of the study.

This chapter is organised as follows: Section 4.2 will present the research framework of the study followed by the development of hypothesis in Section 4.3. This is followed by explanation of the SEM methodology used to examine the relationship between the key variable in the research model discussed through section 4.4 including the evaluation process of the PLS-SEM model. Section 4.5 describes the data collection process while section 4.6 describes the data and variables and model estimation. The data Envelopment Analysis, which is a method used to measure a key variable of the research model, is presented and described in Section 4.7. The hypothesis testing of the present study will be demonstrated in section 4.8 and the chapter will be summarised in section 4.9.

4.2 Research Framework

As discussed in the review of literature in the previous chapter, there has been no consensus in the academic literature on the EP-FP relationship and the variables that led to mixed results (McWilliams and Siegel 2001; Kim 2015; Salem 2012). Furthermore, the varying measurements used to measure the environmental performance have also contributed to these mixed results. In order to address the research gaps in relation to the prior studies that examined EP-FP relationship addressing the theoretical and methodological weakness of prior
studies, the present study proposed the following evaluation model (see Figure 4.1). The justification of model and the establishment of the hypothesis are presented in the Section 4.3.

Figure 4.1: Research Model

4.3 Hypothesis Development

The figure 4.1 presented above present how efficiency, internal operations, environmental performance, market performance and financial performance are related. Specific hypotheses will be discussed.

4.3.1 Efficiency and environmental performance

Business efficiency can minimize waste and increase cost-savings which will lead to improved environmental performance resulting in higher competitive advantage (Rao and Holt 2005). In addition, more efficient firms have a lower emission intensity\(^{24}\) since they are able to increase their output volume at the same input level. In fact, firms’ efficiency affect

\(^{24}\text{Emission level per unit of output (Cui et al.2015)}\)
directly their environmental performance (Cui, Lapan et al. 2016). Therefore, the relationship between environmental performance and financial performance of firms will also be affected by their efficiency level.

On the other hand, internal operation of firms (reflected by technology, risk, size and retention ratio in our study) is directly affected by the efficiency level of firms. Efficiency improvement will result in higher productivity of the firms’ resources and processes which will lead to less emissions intensity of firms and hence, the whole industrial sector (Acquaye, Ibn-Mohammed et al. 2018).

Galdeano-Gómez (2008) has also evaluated the impact of efficiency on the relationship between environmental performance and financial and market performance. Efficiency has been reflected in the capital intensity indicator in this analysis affecting firms’ profitability and market share and hence, influencing their environmental performance. The related literature argued the impact of various factors on the environmental performance of firms in addition to efficiency and environmental standards such as market value, firms’ size, risk and level of technology.

As presented in the review of literature in Chapter 3, the corporations’ resources are vital in their competitiveness based on the Resource-based View (RBV) theory considering uneven distribution of resources (Salem, Hasnan et al. 2012). The following question is raised on this basis:

**RQ1: What is the relationship between the efficiency, internal operation and the environmental performance of Australian electricity generation firms?**

This question will be answered through the testing of following 4 null hypotheses and alternative hypotheses:

**H01. There is no relationship between Efficiency and Environmental Performance of Australian electricity generation firms.**
H1. Firm Efficiency will be positively associated with environmental performance of Australian electricity generation firms

H02. There is no relationship between Efficiency and Internal Operations of Australian electricity generation firms.

H2. Firm Efficiency will be positively associated with internal operations of Australian electricity generation firms

H03. There is no relationship between Internal Performance and Environmental Performance of Australian electricity generation firms.

H3. Internal performance will be positively associated with environmental performance of Australian electricity generation firms

H04. Internal Operations does not play a mediatory role between the Efficiency and Environmental Performance of Australian electricity generation firms.

H4. Internal operations play a mediating role between the firm efficiency and environmental performance of Australian electricity generation firms

4.3.2 Firm efficiency and financial performance

The firms’ profitability, financial performance and stakeholders’ attitude is significantly affected by “efficient utilization of human and material resources” (Semenova, Hassel et al. 2010, p.267). Therefore, higher efficiency will cause improved long-term benefits by positively impact on the market performance of the firms (Lioui and Sharma 2012).

Efficiency level of firms has been evaluated in the EP-FP relationship analysed by the previous literature in addition to its significant effect on the firms’ performance (Giovanni and Vinzi 2012; Marie et al. 2014). To investigate the EP-FP relationship, Marie et al. (2014) have measured efficiency by means of three ratios (non-performing loans ratio, asset turnover
and operating revenue per employee) reflected by internal operation construct affecting the financial performance. In addition, based on the Resource-based view (RBV) theory, the resource utilisation by firms will increase their efficient competitiveness along with addressing environmental concerns (Salem et al. 2012) which raises the research question as below:

**RQ2: What is the relationship between the efficiency and financial performance of Australian electricity generation firms?**

This question will be answered through the testing of following null and alternative hypotheses:

**H05. There is no relationship between Efficiency and Financial Performance of Australian electricity generation firms**

**H5. Firm Efficiency will be positively associated with financial performance of Australian electricity generation firms**

### 4.3.3 Environmental performance, financial performance and market performance

Firms’ valuation and hence, their financial and market performance are affected by both financial and non-financial information. In addition, environmental performance of a firm is an indicator of its adequate usage of environmental resources which influences cost-efficiency, profitability and regulatory attainment of the firm. Therefore, examining the impact of environmental performance of firms on their financial performance and market value could prompt firms to operate more environmental-friendly (Kumar and Shetty 2018).

Majority of the literature reviewed in Chapter 3 have evaluated the impact of environmental performance of firms on their market performance (measured as Tobin’s Q and share growth) and financial performance (measured as profitability) (e.g. Semenova et al.
The results of relevant literature present that “increased firm’s emissions deplete company profitability in the 2-years lag period but improve in the 1-year lag period” (Horváthová 2012, p.96). The results support the Porter’s idea (1991) about the effect of the environmental performance on financial performance in the long run. In particular, the study concludes that “it takes more than one accounting period before firms can benefit from decreasing pollution” (Horváthová 2012, p. 96). In other words, the early costs of becoming environmentally friendly will reduce the profitability of firms in the short-run but improve it within a long-run. Therefore, we will test the following hypotheses to answer the first research question:

**RQ3: What is the relationship between the environmental performance and financial performance of Australian electricity generation firms?**

This question will be answered through the testing of following three null hypotheses and their alternative ones:

**H06. There is no relationship between Environmental Performance and Financial Performance of Australian electricity generation firms.**

*H6. Environmental performance will be positively associated with financial performance of Australian electricity generation firms*

**H07. There is no relationship between Environmental Performance and Market Performance of Australian electricity generation firms.**

*H7 Environmental performance will be positively associated with Market performance of Australian electricity generation firms*
H0s. There is no future (long-run) financial advantages for Australian electricity generation firms as a result of Environmental Performance and Financial Performance.

Hs. Environmental performance will be positively associated with financial performance of Australian electricity generation firms in the short-run but will be negatively associated with financial performance in the long-run.

4.3.4 Environmental standards and environmental performance

Similar to the quality standards which will reduce quality cost and defect and increase productivity and hence, competitiveness, the implementation of environmental standards will also result in higher competitive advantages of firms. In fact, environmental standards enable firms to discover and delete deficiencies of resource consumptions and improve their productivity (Grolleau, Mzoughi et al. 2013).

To survive in today’s global market and to retain competitiveness, corporations are required to become environmentally sustainable to become legitimised to avoid prospective regulatory actions. Legitimacy is identified as a firms’ “vital resource” in today’s world and non-responsible (socially and environmentally) management practices will cause organisational failure within a long-run (Dragomir 2013).

However, according to the related literature, Aggarwal (2013) concluded that large volume of environmental reporting will not necessarily suggest great environmental performance. Consequently, to exclude manipulative practices, valid and sincere reporting is essential which is achievable by severely enforceable regulations (Aggarwal 2013). Also, Hatakeda, Kokubu et al. (2012) revealed a significant effect of adapting environmental policies and standards on firms’ emission reduction. The studies conducted by Magness (2006), Ghomi and Leung (2013) and Juhmani (2014) also hold this view. Considering these arguments, the following hypotheses will be tested in order to answer the third research question:
**RQ4: What impact do environmental standards have on the relationship between the environmental performance and financial performance of Australian electricity generation firms?**

This question will be answered through the testing of following null and alternative hypotheses:

**H09.** There is no relationship between Environmental Standards and Environmental Performance of Australian electricity generation firms.

**H9.** Environmental standards will be positively associated with environmental performance of Australian electricity generation firms.

### 4.3.5 Financial performance and market performance

Along with environmental and non-financial information, the market value, stock prices and shares returns are also affected by the accounting/financial measures (e.g. firms’ profitability). In fact, market performance of the firms is explained by both their financial performance and environmental performance (Callan and Thomas 2009).

As discussed in Chapter 3, a few prior studies have examined the relationship between the financial performance and market performance of a firm. Generally, one would expect the market to respond to change in a firm’s financial performance positively or negatively depending on the direction of the performance. Basing stakeholder theory, Semenova et al. (2010) studied the reflection of firms’ financial performance on their market performance. It attempted to examine the impact of the accounting-based performance measures on the market value of the firms and considered the firms’ environmental performance as a “long-term performance-related factor” which increases the organizational value (Semenova et al. 2010, p.272).
Also, the stakeholder theory emphasizes on the involvement of the stakeholders’ concerns in business strategies in order to retain stakeholders and hence, to improve the firms’ performance (Salem et al. 2012). On the other hand, the managerial disclosure of firms is a strong factor to enhance their public image and to achieve the stakeholders’ trust which is highlighted by the legitimacy theory (Aggarwal 2013 and Magness 2006). Therefore, the question is:

**RQ5: What is the relationship between the financial performance and market performance of Australian electricity generation firms?**

This question will be answered through the testing of following null and alternative hypotheses:

**H0**. There is no relationship between Financial Performance and Market Performance of Australian electricity generation firms.

**H1.** Financial performance will be positively associated with market performance of Australian electricity generation firms.

### 4.3.6 Financial performance and market performance in regions

The local economic state/diversity, resources/technological opportunities and constraints plus the geographical characteristics are the regional variables influencing the firms’ environmental performance, financial performance, market performance and their interaction (Hodgkinson 2008). In addition, the firms’ productivity could be positively affected by the “agglomeration economies” as a regional internal factor (Andersson and Loof 2011, p.603).

To control for the regional factors and characteristics on the relationship between environmental performance of organizations with their financial and market performance, Misani and Pogutz (2015) have included country dummies in their analysis. Also, Gonenc and Scholtens (2017) investigated the EP-FP relationship in a sample of firms from 50
countries and both these studies resulted in significantly different outcomes in different regions of operation. Considering the discussion by the literature and variety of regional factors and policies in the Australian states and territories, the research question that the present study attempts to answer is

**RQ6: Does the relationship between environmental performance of firms and their financial performance vary in different geographical regions?**

In order to answer this question, we will run the model for different states and territories (Queensland, New South Wales, Victoria, South Australia, Tasmania, Northern Territory and Western Australia) and will test the following hypotheses:

**H011:** There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Queensland and those in other states.

**H11:** The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in Queensland and those in other states.

**H012:** There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in New South Wales and those in other states.

**H12:** The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in New South Wales and those in other states.

**H013:** There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Victoria and those in other states.

**H13:** The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in Victoria and those in other states.
$H_{13}$: The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in Victoria and those in other states.

$H_{014}$: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in South Australia and those in other states.

$H_{14}$: The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in South Australia and those in other states.

$H_{015}$: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Tasmania and those in other states.

$H_{15}$: The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in Tasmania and those in other states.

$H_{016}$: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Northern Territory and those in other states.

$H_{16}$: The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in Northern Territory and those in other states.
H017: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Western Australia and those in other states.

H17: The relationship between environmental performance and financial performance of the Australian electricity generators will be significantly different between electricity generators in Western Australia and those in other states.

In order to test the above hypotheses, the present study uses a SEM modelling which is considered the most appropriate method\(^\text{25}\) to examine the underline research through review of the various methods used in prior studies conducted in the previous chapter. The Data Envelopment Analysis (DEA) approach will be applied to measure the efficiency construct of the Australian electricity firms in the sample as discussed through section 4.4.

4.4 Efficiency Measurement: Data Envelopment Analysis (DEA)

According to Heras-Saizarbitoria et al. (2011), higher environmental proactivity which is a result of adoption of ISO 14001 will improve firms’ efficiency. This will led to firms’ higher market value (Heras-Saizarbitoria, Molina-Azorin et al. 2011). Therefore, the present study measures the efficiency of the Australian electricity generators (EF construct) in the sample and its effect on firms’ internal, environmental and financial performance (IO, EP and FP constructs). This analysis will test hypotheses 3 and 4 of the present study and answer the third research question.

In the financial measurement model proposed by Marie, Ibrahim et al. (2014), internal operation of banks (their sample) depends on their management efficiency (measured by non-performing loan ratios, asset turnover and operating revenue per employee). Instead of ratio analysis, we measure efficiency of firms in our sample by means of Data Envelopment

\(^{25}\)As will be described through sections 4.5 and 4.8
Analysis (DEA) to increase the accuracy of our efficiency measurement due to the advantages of DEA approach which will be discussed through this section.

To measure the efficiency and to evaluate the performance of organizations, there are two approaches which are:

- parametric approaches including the Stochastic Frontier Analysis (SFA), Dynamic Financial Analysis (DFA), and Thick Frontier Approach (TFA)
- non-parametric methods including DEA and Free Disposal Hull (FDH).

While the parametric approaches estimate a functional form to link inputs and outputs and distinct inefficiency from random error, there are some inadequacies inherent in them:

- the model type (linear, non-linear, logarithmic, etc.) should be estimated and according to Berger and Humphrey (1997) this may result in an unfitting model;
- it is impossible to deal with a group of inputs and outputs through parametric methods (Thanassoulis 2001).

Considering the above-mentioned shortcomings of the parametric approaches to assess the efficiency of financial institutions, we have applied the DEA method as a non-parametric approach to measure the efficiency of the Australian electricity generators.

4.4.1 Why DEA?

DEA is a technique designed to achieve frontiers rather than central tendencies. The best practice decision-making unit (DMU) is identifiable by the means of DEA in the sample of homogenous units. Then, every single DMU will be compared to that to determine the efficient and inefficient DMUs with the restriction that all DMUs locate on, above or below the efficient frontier (Sathye 2001). Those which lie on the efficient frontier are the best practice ones achieving score 1 and the rest, enveloped by the efficient frontier or located underneath, are relatively inefficient scoring 0 to 1. It does not estimate a functional form to connect inputs and outputs; instead, tries to construct a production possibility set from the
DMUs’ input-output correspondences which are wrapped by a piece-wise linear frontier. Thus, it is easier to estimate the efficient frontier by the means of DEA resulting into a stronger efficient frontier (Seiford and Thrall 1990).

Based on this method, instead of fitting a regression level in the centre of the data, a piecewise linear surface will be lied on top of the observations. This distinctive feature of DEA qualifies this method to proficiently disclose the relationships which are hidden under other approaches (Seiford and Thrall 1990). In this regard, Sathye (2001) states that “The ability to identify possible peers or role models as well as simple efficiency scores gives it an edge over other methods” (Sathye 2001, p665).

Characteristics such as isotonicity, nonconcavity, economics of scale, piecewise linearity, Cobb-Douglas forms, discretionary and nondiscretionary inputs, categorical variables, and ordinal relationships are treatable using DEA. Furthermore, this approach enables constructive development of an empirical production function with its fractional derivatives (Seiford and Thrall, 1990).

Another advantage of DEA is its ability to provide useful information regarding performance management of the DMUs such as productivity evaluation over time, measurement of optimal scale size and decomposition of efficiency into different levels of management involved in units functioning. Taking into account these advantages plus the capability to measure the efficient frontier and to determine the role models for inefficient DMUs, Sathye (2001) recognises DEA as a preferred method of efficiency measurement rather than parametric ways to be applied for the small sample sizes. Furthermore, different measurement units can be utilized for inputs and outputs by applying DEA; for example, asset size as an input can be defined in dollar and another input could be number of staffs without a need to priori exchange between them (Coelli et al. 2005).
Considering above-mentioned benefits, we have applied DEA technique to measure the efficiency variable with maximum accuracy of the analysis.

4.4.2 Input-Output Orientation

Technical inefficiency is a result of proportionally decreasing the amount of input used while maintaining the output levels or increasing the level of output production while maintaining the input levels. Under constant return to scale (CRS) approach, same efficiency score will be obtained by both measurements, but variable return to scale (VRS) approach will lead into different scores (Coelli et al. 2005).

Although, the choice of orientation is mostly arbitrary and imposes very little effect on the efficiency scores, the key factor in the selection of the orientation is based on the managers’ control level on the inputs or output quantities (Wheelock and Wilson 1999). To investigate firms (DMUs), that have stable resource capacities and are required to produce maximum possible level of output, DEA models need to be output-oriented. On the other hand, when the DMUs are firms with specific obligations (such as the Australian electricity generators in our analysis), the inputs level will be the main decision variables. Therefore, the input-oriented models are the most appropriate to the present study because of the higher control of the managers over inputs to the operation.

To elaborate different aspects of the DEA methodology applicable to our study, the textbook written by Coelli et al. (2005) and working paper by Coelli (1996) are used to complete section 4.6 of the present chapter.

The output and input-oriented models are very similar considering the following example of an output-oriented VRS model:
\[
\left[ D'_o(x_{i,t}, y_{i,t}) \right]^{-1} \max_{\phi, \lambda} \phi,
\]
\[
st \quad -\phi y_{i,t+1} + Y_{i+1} \lambda \geq 0,
\]
\[
x_{i,t+1} - X_{i+1} \lambda \geq 0,
\]
\[
N1^t \lambda = 1
\]
\[
\lambda \geq 0,
\]

(4.19)

Where:
D: DMU
N: number of inputs
I: number of firms
X_t: input matrix
Y_t: output matrix
y_t: vectors of outputs
x_t: vectors of inputs
\( \phi \): technical efficiency
\( \lambda \): vector of constants

\( \phi - 1 \) specifies the proportional increase in outputs while the input level is held constant, and
\( 1 \leq \phi \leq \infty \). So, \( 1/\phi \) outlines the TE score, which is between 0 and 1 (Coelli 1996, p.27; Coelli et al. 2005).

Coelli et al. (2005) argue that an input-oriented model “sought to identify technical inefficiency as a proportional reduction in input usage, with output levels held constant” (Coelli et al. 2005, p180). Considering the fact that firms tend to reduce costs, the majority of the related literature have applied the input-oriented approach to assess the efficiency of DMUs. The present study follows the same approach because of the higher control of the managers over inputs to the operation to find out how efficient is the Australian electricity generators as our DMUs.

### 4.4.3 Constant Return to Scale (CRS) vs. Variable Return to Scale (VRS) DEA

To discuss about the input-oriented CRS model, notations are assumed as follows:

- \( N \): number of inputs
- \( M \): number of outputs
- \( I \): number of firms (DMUs)
The data are signified by the $N \times 1$ input matrix, $X$, and the $M \times 1$ output matrix, $Q$, for all $I$ firms. For the $i$-th DMU, $N$ inputs are presented on the column vectors $x_i$ and $M$ outputs on $q_i$. The calculation of ratio of all outputs over all inputs for every single DMU will result in the maximum efficiency measure of each, like $u'^t q_i / v'^t x_i$, where $u$ is a $M \times 1$ vector of output weights and $v$ is a $N \times 1$ vector of input weights. The solution of the following mathematical programming problem will lead to the best input/output weights:

$$\max_{u,v} (u'^t q_i / v'^t x_i)$$
$$st \quad u'^t q_i / v'^t x_i \leq 1, \quad i = 1, 2, \ldots, I$$
$$u, v \geq 0$$

(4.20)

Where:
- $u$: $M \times 1$ vector of output weights
- $v$: $N \times 1$ vector of input weights
- $q_i$: vectors of outputs
- $x_i$: vectors of inputs

There are several solutions to this ratio formulation and this is its inherent problem. The efficiency measure of the $i$-th firm which is subject to the constraint that all efficiency scores should be less than or equal to 1, will be maximised through the values of $u$ and $v$.

To avoid that problem, the constraint $v'^t x_i = 1$ could be imposed as follows:

$$\max_{\mu, \nu} (\mu'^t q_j),$$
$$st \quad v'^t x_j = 1,$$
$$\mu'^t q_j - v'^t x_j \leq 0, \quad j = 1, 2, \ldots, J,$$
$$\mu, \nu \geq 0,$$

(4.21)

Where:
- $\mu$: $M \times 1$ vector of output weights
- $\nu$: $N \times 1$ vector of input weights
- $q_j$: vectors of outputs
- $x_j$: vectors of inputs
In the formulation number (4.20), notations \( u \) and \( v \) are altered with \( \mu \) and \( \nu \) due to the application of multiplier form of DEA which is another type of linear programming (LP) problem.

An equivalent envelopment form of this LP problem is the preferred type of LP problem to solve because there are fewer constraints associated with it i.e. \( N + M < I + 1 \). The application of the duality in linear programming will help to derive this form of the LP problem:

\[
\begin{align*}
\min_{\theta, \lambda} & \quad \theta, \\
\text{st} & \quad -q_i + Q\lambda \geq 0 \\
& \quad \theta x_i - X\lambda \geq 0 \\
& \quad \lambda \geq 0
\end{align*}
\]  

(4.22)

Where:
- \( X \): input matrix
- \( Q \): output matrix
- \( \lambda \): \( I \times 1 \) vector of constants
- \( \theta \): a scalar and the technical efficiency score of the \( i \)-th firm presented by the value of \( \theta \)
- \( q_i \): vectors of outputs
- \( x_i \): vectors of inputs

The \( I \) times solution of the LP problem once for each DMU in the sample result into the estimation of the value of \( \theta \) for every firm. This problem induces \( \theta \leq 1 \) when \( \theta = 1 \), the firm is technically efficient since the production point relies on the efficient frontier (Farrell 1957).

The changes in variations between VRS and CRS could be discovered by scale efficiency which is a result of decomposition of the efficiency change component under CRS model as well as pure technical efficiency change which is measured under VRS approach.

The application of CRS will result in the misperception between the technical efficiency measures with scale efficiencies when firms do not operate at their optimal scale due to the government regulations, imperfect competition, economic constraints and the like.
This misleading result is because the TE scores achieved from the CRS DEA is created by the two components which are the outcomes of scale inefficiency and pure technical inefficiency.

By modestly adding the convexity constraint $\mathbf{I}' \lambda = 1$ to the envelopment form of DEA, the VRS model will be created as below to overcome this problem:

$$\begin{align*}
\min_{\theta, \lambda} & \theta, \\
\text{st} & - q_i + Q \lambda \geq \theta \\
& \theta x_i - X \lambda \geq \theta \\
& \mathbf{I}' \lambda = 1 \\
& \lambda \geq 0,
\end{align*}$$

(4.23)

Where:
- $X$: input matrix
- $Q$: output matrix
- $\lambda$: $1 \times 1$ vector of constants
- $\theta$: a scalar and the technical efficiency score of the $i$-th firm presented by the value of $\theta$
- $q_i$: vectors of outputs
- $x_i$: vectors of inputs

In the 3-dimensional case, the input-oriented VRS DEA model creates a convex structure of intersecting planes and in the case with more than three dimensions, it forms surfaces with convex hull that “envelop the data points more tensed than the CRS conical hull” (Coelli et al. 2005, p172). This will result in technical efficiency scores higher than or equal to the efficiency scores acquired through the CRS model.

In addition to the above-mentioned features of both approaches to DEA, the VRS approach to DEA is appropriate to analyse the efficiency level of firms with different sizes, because their size may effectively impact their capability to their output generation (Halkos and Tzeremes 2009); (Cullmann and Hirschhausen 2008). Therefore, the present study employs the input-oriented VRS DEA approach to measure the efficiency of the Australian electricity generators in the sample which are of different sizes.
4.4.4 Scale Efficiency

A one-input, one-output VRS production technology is illustrated in the following graph:

**Figure 4.2: The Effect of Scale on Productivity**

![Diagram showing scale efficiency with points A, B, and C on the VRS Frontier and CRS Frontier]

Source: Coelli et al. 2005, p59

Between the VRS production frontier, q, and the x-axis, inclusive of these bounds, a production set is presented by the Area S. “The firms operating at the points A, B and C are all technically efficient, because the productivity of each of these firms is equal to the ratio of their observed output and input quantity (y/x) and this expression indicates that even though these three firms are all technically efficient, they are not equally productive. This apparent inconsistency is due to the effects of scale” (Coelli et al. 2005, p58).

Firm A operates in the mounting returns to scale part of the production frontier and could be more productive by improving its scale of operation towards point B. Point C works in the falling returns to scale portion of the production frontier and could be more productive by decreasing its scale of operation towards point B.
However, the firm functioning at point B is not capable of becoming more productive by modifying its operation scale. The assumption is that the firm at point B operates at the most productive scale size (MPSS) or steadily at the technically optimal productive scale (TOPS). A ray from the origin is visible to be tangential to the production frontier at this point which is termed as the CRS technology. $TOPS = \max \{ y / x | (x, y) \in S \}$ describes this TOPS mathematically which is equivalent to determine the possible production point that maximizes productivity.

The value does not identify whether the firm is operating in an increasing or decreasing area of returns to scale which is a problem with the above assessment of scale efficiency. This issue could be overcome by specifying further DEA problem with the imposition of non-increasing returns to scale (NIRS). This is reachable by modifying the DEA model in LP 4 by replacing the $II'\lambda = 1$ constraint with $II'\lambda \leq 1$, to achieve the following model:

\[
\begin{align*}
\min_{\theta, \lambda} & \theta, \\
\text{st} & -q_i + Q\lambda \geq \theta \\
& \theta x_i - X\lambda \geq \theta \\
& II'\lambda \leq 1 \\
& \lambda \geq 0, \\
\end{align*}
\]

(4.24)

Where:
X: input matrix
Q: output matrix
$\lambda$: $I \times 1$ vector of constants
$\theta$: a scalar and the technical efficiency score of the $i$-th firm presented by the value of $\theta$
$q_i$: vectors of outputs
$x_i$: vectors of inputs
The NIRS DEA frontier is demonstrated in the following figure:

**Figure 4.3: Scale Efficiency Measurement in DEA**

The nature of the scale inefficiencies, due to increasing or decreasing returns to scale, for a specific firm is definable by observing if the NIRS TE score is equal to the VRS TE score.

Such as the case at point $P$ in Figure 4.3, there are increasing returns to scale for a DMU when they are not equal. At point $G$ of this figure, they are equal and therefore, there is decreasing returns to scale. An example of this approach is presented in the study of Fare, Grosskopf and Logan (1983) on the electricity industry.

It should be considered that the restriction, $II'\lambda \leq 1$ certifies that the $i$-th firm is not “benchmarked” against noticeably larger firms but could be matched with smaller firms.

Figure 4.3 describes measurements of scale inefficiency by the means of one-input, one-output case and specifies the CRS and VRS DEA frontiers. The distance $PP_c$ under CRS is presented in the input-oriented technical inefficiency of the point $P$; under VRS, the
technical inefficiency is PPv. The difference between these technical efficiency measures, PcPv, is the result of the scale efficiency.

\[ \text{TE}_{\text{CRS}} = \frac{A_{P}}{A_{P}} \]  \hspace{1cm} (4.25)
\[ \text{TE}_{\text{VRS}} = \frac{A_{P}}{A_{P}} \]  \hspace{1cm} (4.26)
\[ \text{SE} = \frac{A_{P}}{A_{P}} \]  \hspace{1cm} (4.27)

All of these evaluations are bounded by zero and one. We also note that

\[ \text{TE}_{\text{CRS}} = \text{TE}_{\text{VRS}} \times \text{SE} \]  \hspace{1cm} (4.28)

because

\[ \frac{A_{P}}{A_{P}} = \left(\frac{A_{P}}{A_{P}}\right) \times \left(\frac{A_{P}}{A_{P}}\right). \]  \hspace{1cm} (4.29)

As a result, pure technical efficiency and scale efficiency are the two components of the CRS technical efficiency measure. The scale efficiency measure is the ratio of the average product of the firm operating at point Pv to the average product of the firm operating at the technical optimal scale, point R.

According to Coelli et al. (2005), “scale efficiency measures can be obtained for each firm by conducting both a CRS and a VRS DEA, and then decomposing the TE scores obtained from the CRS DEA into two components, one due to residual scale inefficiency and one due to pure technical inefficiency (i.e. VRS TE). If there is a difference in the CRS and VRS TE scores for a particular firm, then this indicates that the firm has scale inefficiency” (Coelli et al. 2005, p172).

**4.4.5 Specification of Input and Output**

In order to measure the economic efficiency of the Australian electricity producers, we have employed input-oriented approach to DEA based on two inputs and one output in line with the study of Halkos and Tzeremes (2009). Specified inputs are capital and operating expenses similar to the studies of Çelen (2013), Pereira de Souza, Souza et al. (2014) and Hon, Boon et al. (2014). Net profit is applied as the only output of our DEA model inspired by Hirschhausen, Cullmann et al. (2006) and Sanhueza, Rudnick et al. (2004) who used energy
sold and number of customers as outputs.26 Because of the advantages of DEA method compared with parametric techniques (discussed through section 4.6 of the present chapter) and specified inputs and output on the basis of previous studies, we expect to maximise the accuracy of our efficiency scores (used as efficiency indicator in our PLS-SEM model) and therefore, to increase the precision of our EP-FP relationship analysis.

The required data, covering the 2006-2017 period, is obtained from the financial statements of these firms. Number of DMUs may differ in different years due to various reasons such as structural changes (e.g. Mergers). The data analysis is conducted by means of DEAP V.2 software which is the most suitable one to our DEA modelling following the study of Coelli et al. (2005).

The section 4.5 describe the SEM and the steps undertaken by the present study to ensure that the results produced by the model are accurate and reliable.

4.5 Structural Equation Modelling (SEM) for the analysis of the EP-FP Relationship

As described in the previous chapter, the studies that examined the EP-FP relationship have predominately used a form of regression analysis in analysing data. However, the first-generation regression models such as linear regression, LOGIT, ANOVA, and MANOVA used in prior studies were subjected to a major methodological shortcoming as they were only capable of analysing one layer of linkages between independent and dependent variables at a time. Therefore, in order to obtain a valid model, it is necessary to run such analysis many times with different combination. To address the shortcomings of the methods used in previous studies, this study adopts a structural equation modelling (SEM) method which is a second-generation data analysis method capable of answering a set of interrelated research questions in a single, systematic, and comprehensive analysis by modelling the relationships

26We specify net profit as the output of our DEA model instead of energy sold and number of customers to increase the accuracy of our efficiency measurement.
among multiple independent and dependent constructs simultaneously. Specially, it allows researchers to examine the interaction of many independent variables and the dependent variable\textsuperscript{27}, whose influence is either direct or sometimes indirect.

Prior studies have discussed different reasons for the increasing importance of SEM method; some of the ones related to the present study are as follows:

- Since this method is a combination of factor and multiple regression analysis, it is feasible to investigate complex relationships among observable and/or unmeasured latent variables (Hartmann, Klink et al. 2015, p.111).

- Performance is a kind of latent variable since it cannot be measured directly (Lemstra, Voogt et al. 2015, p.256). SEM is learned to be the only statistical technique to analyze “variables that are dependent in one relation and independent in another relation” (Lemstra et al. 2015, p.256).

- Its major feature is the ability to identify the latent variable models estimating relationship among latent constructs and their visible indicators known as the measurement model as well as the structural model.

- There are measures of global fit under SEM method providing a summary evaluation of compound models with large number of linear equations; while alternative methods such as multiple regression models could only provide “separate mini-tests of model components that are conducted on an equation-by-equation basis” (Tomarken and Waller 2005, p.34).

- The latent growth modelling approach to SEM is capable of specifying time-varying covariates (e.g., Curran and Hussong (2003), Muthén & Curran (1997)) (Tomarken and Waller 2005, p.34).

\textsuperscript{27}Because of the capabilities of the SEM method which is based on factor and multiple regression analysis (Hartmann et al. 2015).
As mentioned above, the generally applied statistical methods referred to as the first-generation techniques (e.g. multiple regression, exploratory factor analysis and multidimensional scaling) are applied to prove a priori founded theories or ascertain models and relationships between data (Fornell, 1982, 1987). “Specifically, they are confirmatory when testing the hypotheses of existing theories and concepts and exploratory when they search for latent patterns in the data in case there is no or only little prior knowledge on how the variables are related” (Hair et al. 2014, p.3). Although the social science researchers have been commonly applying the first-generation methods, the second-generation techniques known as structural equation modelling (SEM) have become more popular over the past two decades to overcome the flaws of the first-generation techniques (Hair, Hult et al. 2014).

The distinct feature of SEM is the capability to evaluate unobserved/hidden variables via indicator variables as well as measuring the error in observed variables. This method consists of two types which are Covariance-based SEM (CB-SEM) and Partial Least Square SEM (PLS-SEM or PLS path modelling). Basically, CB-SEM is applied to confirm or reject theories by ascertaining the ability of a proposed theoretical model to measure the covariance matrix for a sample data set. On the other hand, PLS-SEM is essentially applied to develop theories in exploratory research by the description of variance in the dependent variables throughout the model evaluation (Kumar 2015).

Therefore, to estimate the model and to measure variables, the present study will apply the PLS-SEM approach because of its characteristics which will be explained in subsections 4.5.1 to 4.5.4 below.

28A set of logic relationships between various variables and related hypotheses developed to be empirically examined through scientific method to predict and explain results. In fact, hypotheses are individual assumptions while theory consists of numerous hypotheses rationally related together (Hair et al. 2014, p.4).
4.5.1 PLS-SEM

In addition to the above-mentioned capabilities of the SEM method, it is a prominent approach on both technical and theoretical grounds in assessment of the causal relationship among multiple variables (dependant and independent) with less bias and with higher precision comparing to the conventional methods (Saeidi, Sofian et al. 2015). Furthermore, it is the most powerful approach to reveal mediating relationships among variables (Saeidi et al. 2015) which makes it the most suitable to test the hypotheses of the present study.

4.5.1.1 Why PLS-SEM?

The main methods to estimate structural equation models are CB-SEM and PLS-SEM of which the application of PLS-SEM has increased in recent years specifically for the studies which seek to identify a relationship and not to confirm it (Çakir 2017). The main reasons for the priority of PLS-SEM include its capability to overcome issues with small sample sizes and less restrictions about variable distribution and error terms. Thus, it can estimate complex models which cannot be accurately dealt with by other methods (Henseler et al. 2009). Furthermore, to explain endogenous constructs, PLS-SEM is the preferred analysis method which also can analyse formative and reflective constructs (Zhang 2009). This method is powerful for “prediction-oriented research” and is specifically helpful to assess and confirm exploratory models through the early stages of theoretical development (Henseler et al. 2009, p.311). PLS-SEM “maximises the explained variance of all dependant variables to support prediction-oriented goals” while CB-SEM aims at explaining the covariation among variables (Henseler et al. 2009, p.297). PLS-SEM models can predict values of latent variable scores which are proxies of the constructs whereas CB-SEM models generate the observed covariance matrix. In other words, latent variable scores are exact linear groups of the observed measures. This enables PLS-SEM method to provide an accurate description of
factor scores by avoiding the indeterminacy problems\textsuperscript{29}. In fact, PLS-SEM estimates the components by means of minimising the residual variances of latent and observed dependant variables.

Another common multivariate data analysis method is the PLS regression “that explores the linear relationships between multiple independent variables and a single or multiple dependent variable(s)” (Hair et al. 2014, p.15). This technique creates composite factors from both the multiple independent variables and the dependant variable(s) via principal component analysis. Whereas, PLS-SEM technique “relies on pre-specified networks of relationships between constructs as well as between constructs and their measures” (Hair et al. 2014, p.15). The assessment of partial path model structures is the basis for examining the estimation results of PLS-SEM via tests such as bootstrapping (explained in chapter 5) (Lin and Syrgabayeva 2016; Zhang 2009).

Considering the statistical differences between the CB-SEM and PLS-SEM, we can conclude that the research context identifies which approach to be selected. In fact, neither of these methods could be claimed to be superior since they differ from statistical viewpoint which makes them not suitable for every situation. “In general, the strengths of PLS-SEM are CB-SEM's weaknesses, and vice versa” (Hair et al. 2014, p.18). Each technique should be applied on the basis of its capabilities appropriate to the field of research objectives, characteristics of data and model. However, when there are issues about sample sizes, big standard errors, model complication, and distributional hypotheses or when the premises of other statistical methodologies are violated, PLS-SEM would be a rational and applicable alternative to the methodology (Henseler et al. 2009). In addition, the statistical power of PLS-SEM is much greater comparing to CB-SEM which means higher possibility to extract the

\textsuperscript{29}Indeterminacy of component score estimation results in loss of accuracy of prediction (Henseler et al. 2009, p.296).
significance of a specific relationship when it is also significant within the population. This capability results in highly efficient factor estimation (Hair et al. 2014). The present study will investigate the relationship between environmental performance and financial performance of the Australian electricity generating firms which create a small sample. Also, the EP-FP relationship will be evaluated from different aspects considering the effect of various variables as will be discussed through section 4.4 of the present chapter. Therefore, compared with other statistical methods applied within the literature (reviewed in Chapter 3) PLS-SEM is the most appropriate in the present study to predict the constructs with the highest possible accuracy and to develop our measurement model.

4.5.1.2 PLS Path Models

While applying SEM, the hypotheses and relationships between variables are visually displayed by means of diagrams referred to as path models (Rigdon, Ringle et al. 2011). The diagram is constructed of constructs (circles/ovals) and indicators (rectangles). Constructs are variables that are not directly evaluated and indicators (known as items or manifest variables) are directly measured proxy variables enclosing the raw data. The arrows are single-headed, representing predictive directional relationships between constructs plus between constructs and their allocated indicators (theoretically supported to be interpreted as causal relationships) (Hair et al. 2014).

Two elements constructing a PLS path model include a structural model (inner model) and measurement models (outer models) of the constructs. The constructs and the relationships/paths between them are presented by the structural model. The relationships between the construct and the indicator variables are displayed through the measurement models of the constructs. Measurement models are of two types for both the exogenous latent variables and the endogenous latent variables. The measurement model for the exogenous latent variables includes the constructs that explain other constructs in the model. The
measurement model for the endogenous latent variables contains the constructs to be explained through the model (Henseler et al. 2009). To conventionally describe the PLS, Henseler et al. (2009) applied the following equations to present the relationship between standardised latent and manifest variables. The relationship between latent variables is described in the inner model which aims at specification of predictor. The inner model is constituted of residuals not correlated with each other nor with the endogenous and explanatory latent variables and establishes a causal chain structure presented by the following equation:

$$\delta = A\delta + \epsilon \quad (4.30)$$

Where:
- $\delta$: the vector of latent variables
- $\epsilon$: residuals of the inner model

When path models are estimated, error terms, that are associated with the endogenous constructs and reflectively estimated variables by single-headed arrows, signify the unexplained variance. On the contrary, there is no error term connected to the formatively measured indicators (when the relationship is from the indicator towards the construct). The structural model also includes error terms while the exogenous latent variables (explaining only other latent variables in the structural model) do not (Henseler et al. 2009).

“Path models are developed based on theory” (Hair et al. 2014, p.12). To develop a path model, two types of theories are required that are measurement theory (how each construct is calculated) and structural theory (how the constructs are interrelated in the structural model) (Henseler et al. 2009). These two modes of PLS path modelling will be further discussed through subsections 4.4.2 and 4.4.3.
4.5.1.3 Measurement theory

This theory identifies how the constructs (i.e. latent or unobservable variables) are measured commonly through two different approaches which are reflective measurement and formative measurement. Under formative measurement model, the causal/predictive relationship is directed from the indicator variables to the constructs which is presented by Henseler et al. (2009) through the following equation:

\[ \delta = \Psi Z_x + \alpha_x \]  \hspace{1cm} (4.31)

Where:
\( \delta \): the latent variable/ construct
\( \Psi \): coefficient matrix of the relationship between latent variables and manifest variables
\( Z \): the manifest variable
\( \alpha \): the residual

On the other hand, the reflective measurement model assumes that the construct causes the assessment of the indicator variables demonstrating the direction of the causal relationship from the construct to the indicator variables which is described via the following equation derived by Henseler et al. (2009):

\[ Z_x = K \delta + \alpha_x \]  \hspace{1cm} (4.32)

Where:
\( Z \): the manifest variable
\( K \): loading coefficient
\( \delta \): the latent variable/ construct
\( \alpha \): the residual

Considering the description of the variables through section 4.3, the constructs applied in our measurement model are displayed by their indicators based on the reflective measurement concept. Therefore, the reflective measurement model is more appropriate to the present study compared with the formative one as will be demonstrated through section 4.6. To explain the
interrelation of the latent variables within a structural model, the structural theory will be discussed in the next sub-section.

**4.5.2 Structural Theory**

The constructs (latent variables) and the path relationships between them are demonstrated by the structural theory. “The location and sequence of the constructs are based on theory or the researcher’s experience and accumulated knowledge” (Hair et al. 2014, p.13). In developed path models, the sequence is from left to right; independent variables are located on the left side of the path model and dependant variables on the right side. In fact, “variables on the left are shown as sequentially preceding and predicting the variables on the right” (Hair et al. 2014, p.13). It is noteworthy to mention that variables could either be independent or dependant. The latent variables are called exogenous latent variables when they are independent variables and have only single-headed arrows. The endogenous latent variables are only used as dependant variables or as both independent and dependant variables having single-headed arrows directed in and out of them or only into them. In addition, there is no error terms associated with the exogenous latent variables since they are independent variables “explaining the dependent variables in the path model” (Hair et al. 2014, p.14).

In order to create the measurement model, definite test statistics are required to be conducted to assure the viability of the variables and their relationships which will be elaborated through subsections 4.4.2 to 4.4.4.

**4.5.3 Reflective Measurement Model**

The evaluation process of reflective measurement models includes the following steps:

- Internal consistency reliability
- Convergent validity
- Discriminant validity
The succeeding sections will elaborate these criteria and discuss the obtained results of our analysis of reflective measurement model (Low, Ong et al. 2017).

### 4.5.3.1 Internal Consistency Reliability

To evaluate internal consistency, Cronbach’s alpha is known as a traditional criterion estimating the reliability of the observed indicator variables based on their inter-correlation. This standard assumes that all indicators are equally reliable and have equal outer loadings on the construct. The internal consistency reliability might be underestimated due to the sensitivity of Cronbach’s alpha to the number of items in the scale and as a result, it is considered as a conservative measure of internal consistency reliability. Therefore, to deal with different outer loadings of the indicator variables, the composite reliability is also applied as an additional measure of internal consistency reliability. Nevertheless, the results of both approaches are interpreted in the same way. The composite reliability “varies between 0 and 1 (higher values representing higher reliability) and is calculated through the following formulae as presented in the study of Hair et al. (2014, p.101):

\[
\rho_c = \frac{\left(\sum l_i^2\right)^{\frac{1}{2}}}{\left(\sum l_i^2\right)^{\frac{1}{2}} + \sum \text{var}(e_i)\}
\]

Where:
- \(\rho_c\) = composite reliability
- \(l_i\) = standardised outer loading of the indicator variable i of a specific construct
- \(e_i\) = the measurement error of indicator variable i
- \(1 - l_i^2\) = the measurement error
- \(\text{var}(e_i)\) = variance of the measurement error” (Hair, Hult et al. 2014, p.101)

### 4.5.3.2 Convergent Validity

To test the correlation, convergent validity is applied which means “the extent to which a measure correlates positively with alternative measures of the same construct” (Hair et al.
Indicators of a reflective construct are treated as various approaches to assess the same construct throughout the domain sampling model. Hence, “the items that are indicators (measures) of a specific construct should converge or share a high proportion of variance” (Hair et al. 2014, p.102). To initiate convergent validity, both the outer loadings of the indicators and the average variance extracted (AVE) should be considered.

“High outer loadings on a construct indicate that the associated indicators have much in common, which are captured by the construct” and also known as indicator reliability (Hair et al. 2014, p.102). At least, outer loadings of all indicators should be statistically significant. However, there is a common rule of thumb that the outer loadings should be 0.708 or above because it is probable that a significant outer loading may be still fairly weak. “The rationale behind this rule can be understood in the context of the square of a standardised indicator’s outer loading, referred to as the communality of an item. The square of standardised indicator’s outer loading represents how much of the variation in an item is explained by the construct and is described as the variance extracted from the item” (Hair et al. 2014, p.102-103). Based on the rule of thumb, a latent variable should describe usually at least 50% of each indicator’s variance. It indicates that “the variance shared between the construct and its indicator is larger than the measurement error variance” (Hair et al. 2014, p.103). Consequently, an indicator’s outer loading should be higher than 0.708 since that number squared is 0.50 (i.e. 0.708²)³⁰.

When the outer loading of indicators is below 0.70, there should be careful examination on the effects of item removal on the composite reliability and the construct’s content validity, instead of eliminating an indicator.

³⁰Mostly, 0.70 is acceptable since it is close enough to 0.708.
In general, indicators with outer loadings between 0.40 and 0.70 could be deleted from the scale only when the removal of the indicator results in an increase in the composite reliability or the AVE is higher than the proposed threshold value (Hair et al. 2014).

To decide about the removal of an indicator, the extent to which its deletion affects content validity should be considered as well. “Indicators with weaker outer loadings are sometimes retained on the basis of their contribution to content validity. Indicators with very low outer loadings (below 0.40) should, however, always be eliminated from the scale” (Hair et al. 2011 as cited in Hair et al. 2014, p.103).

The AVE is a common measure to find convergent validity on the construct level and is described as the sum of the squared loadings divided by the number of indicators (which is known as the grand mean value of the squared loadings of the indicators associated with the construct) and hence, the AVE is the equivalent to the communality of a construct. Similar to the individual indicators, an AVE value of 0.50 or above specifies that, on average, the construct describes more than half of the variance of its indicators. On the contrary, an AVE value of less than 0.50 indicates that, on average, more error remains in the items than the variance revealed by the construct. The AVE of each reflectively measured construct should be assessed (Low et al. 2017).

4.5.3.3 Discriminant Validity

Initiating discriminant validity displays the uniqueness of a construct and reveals phenomena not denoted by other constructs in the model. In fact, discriminant validity is the accurate distinctive level of a construct from other constructs by empirical standards and being measured by the means of two proposed methods as follows.

1. Examination of the cross loadings of the indicators: Outer loading of an indicator on the associated construct should exceed the cross loadings (all of the indicator’s outer loadings on other constructs). A discriminant validity problem exists when cross
loadings are greater than the indicators’ outer loadings. However, this approach is realised to be a quite flexible measure of discriminant validity (Hair et al. 2011).

2. The Fornell-Larcker criterion: This measure compares the square root of the AVE values with the latent variable correlations and is known as a more conservative method. Based on this approach, the square root of each construct’s AVE should be higher than its highest correlation with any other construct. This measure, which can also be defined as the AVE, should exceed the squared correlation with any other construct. The rationale behind this approach is founded on the idea that a construct shares more variance with its related indicators than with any other construct (Henseler et al. 2009).

4.5.4 Formative Measurement Model

Reflective measurement model evaluation criteria are usually incorrectly applied to assess the quality of formative measures in PLS-SEM. However, the statistical evaluation criteria for reflective measurement scales cannot be directly assigned to formative measurement models where indicators are expected to signify the construct’s independent causes and consequently, do not necessarily correlate greatly (Low et al. 2017). In addition, the internal consistency reliability is considered inappropriate because formative indicators are assumed to be error free. Furthermore, when formative indicators and their weights are involved, it is meaningless to evaluate convergent and discriminant validity by means of criteria similar to those associated with reflective measurement models (Henseler et al. 2009).

Therefore, content validity should be established before empirical estimation of formatively measured constructs. To do so, we need to ensure that the formative indicators capture all or foremost features of the construct. To create formative constructs, content validity issues are stated by the content specification. Hence, the content’s domain of the indicators to be measured is clearly specified. A comprehensive set of indicators that entirely
exhausts the formative construct’s domain should be included and omission of any facet of the relevant formative indicators will result in exclusion of essential parts of the construct itself (Henseler et al. 2009). The procedure to examine the empirical PLS-SEM results of formative measurement models includes steps as described through following sub-sections.

4.5.4.1 Evaluation of Collinearity

While reflective indicators are fundamentally interchangeable, there are no high correlations between indicators in formative measurement model. “In fact, high correlations between two formative indicators also referred to as collinearity, can prove problematic from a methodological and interpretational standpoint” (Hair et al. 2014, p.123). And it is called multicollinearity when more than two indicators are involved. High degrees of collinearity occur very commonly while perfect collinearity rarely happens. “High levels of collinearity between formative indicators are a crucial issue because they have an impact on the estimation of weights and their statistical significance” (Hair et al. 2014, p.123) and practically affect the results in two ways:

1. Collinearity increases the standard errors and hence, decreases the ability to determine that the estimated weights are significantly different from zero. In smaller sample sizes with usually larger standard errors, this situation is specifically problematic.

2. High collinearity can result in the incorrectly estimated weights and their reversed signs.

Where two or more formative indicators are perfectly correlated (i.e. they are in the same block of indicators containing precisely similar information), the most critical form of collinearity appears. It happens when one indicator is a linear combination (multiple) of another indicator, the same indicator is entered two times, or if redundant indicators are used as sole factors to measure two or more constructs. Therefore, one of these two coefficients
cannot be estimated by PLS-SEM. The redundant indicators are required to be omitted (Hair et al. 2014).

The variance inflation factor (VIF) is applied to measure the collinearity and is defined as \( \text{VIF}_x = 1 / \text{TOL}_x \) (the reciprocal of the tolerance) (Hair et al. 2014). This term is derived from the square root of the VIF which is an extent to which the standard error is increased because of the existence of collinearity. The collinearity becomes problematic when the VIF value rises above 5 and higher. This level specifies that 80 percent of an indicator’s variance is clarified by the remaining formative indicators related to the same construct. Therefore, the corresponding indicator(s) with VIF value of 5 or above might be required to be removed with the requisite that the remaining indicators would adequately capture the construct’s content from a theoretical perception. The other option to deal with collinearity issue is to create higher-order constructs or to merge the collinear indicators into one new composite indicator (i.e., an index, their average values or weighted average values) (Low et al. 2017).

4.5.4.2 Relevance and Significance of Formative Indicators

Outer weight of a formative indicator is another important measure in assessing its contribution and relevance. “The outer weight is the result of a multiple regression (Hair et al., 2010) with the latent variable scores as the dependent variable and the formative indicators as the independent variables” (Hair et al. 2014, p.126-127). The construct is created by its underlying formative indicators as a linear combination of the indicator scores and outer weights in the formative measurement model; therefore, the result from running such a multiple regression analysis is the \( R^2 \) value of 1 which indicates complete explanation of the construct by the indicators with no error variance. The outer weights’ values determine each indicator’s relative contribution to the construct or its relative significance because they can be compared with each other (Hair et al. 2014).
To find out if the formative indicators really contribute in creation of the construct, we apply bootstrapping technique to test if the outer weights in formative measurement models are significantly different from zero.

Subsamples are randomly withdrawn from the original data set to be applied in bootstrapping and then in model estimation. To create a large number of random subsamples, generally around 5000, the process is repeated. The indicator weights (parameter estimates estimated from subsamples) are applied to derive standard error for the estimates through which, calculated t values will measure the significance of every indicator weight. “It is important to note that the values of the formative indicator weights are influenced by other relationships in the model. Hence, the exogenous formative construct(s) can have different contents and meanings depending on the endogenous constructs used as outcomes” (Hair et al. 2014, p.127). Consequently, caution is required to compare formative constructs across numerous PLS path models with different structures, and as a result different endogenous latent variables.

4.5.4.3 Implications of the Number of Indicators Used on the Outer Weights

It is expected that one or more indicators will have low or nonsignificant outer weights when a construct is measured by a large number of formative indicators. Formative measurement has an essential limit to the number of indicators that can maintain a statistically significant weight while for reflective measurement models the number of indicators has slight bearing on the measurement results (Hair et al. 2014). “Specifically, when indicators are assumed to be uncorrelated, the maximum possible outer weight is $1/\sqrt{n}$, where n is the number of indicators” (Hair et al. 2014, p.128).

Rather than interpreting nonsignificant indicator weights as a result of poor measurement model quality, a formative indicator’s absolute contribution to its construct (the
information provided by an indicator without considering any other indicator) should be considered as well. The formative indicator’s outer loading is always provided together with the indicator weights and estimates the absolute contribution to the construct. Unlike the outer weights, the outer loadings are resulted from single regressions of every indicator on its corresponding construct. “When an indicator's outer weight is nonsignificant but its outer loading is high (i.e., above 0.50), the indicator should be interpreted as absolutely important but not as relatively important. In this case, the indicator would generally be retained. But when an indicator has a nonsignificant weight and the outer loading is below 0.50, the researcher should decide whether to retain or delete the indicator by examining its theoretical relevance and potential content overlap with other indicators of the same construct. If the theory-driven conceptualization of the construct strongly supports retaining the indicator (e.g., by means of expert assessment), it should be kept in the formative measurement model” (Hair et al. 2014, p.129). On the other hand, the nonsignificant indicator is required to be removed if it is not empirically relevant or strongly supported by the conceptualisation (Hair et al. 2014).

From an empirical point of view, deletion of formative indicators (that do not meet threshold levels regarding their contribution) does not influence the parameter estimates when re-estimating the model. However, formative indicators should never be rejected on account of statistical results. Removal of an indicator from the formative measurement model indicates omission of the construct’s content. Therefore, relevance of the indicator should be checked from a content validity perspective before deleting it (Hair et al. 2014).

4.5.5 Evaluation of the PLS Path Structural Model

Once the construct measures are confirmed to be reliable and valid, the structural model results should be evaluated as the next step which predicts the model capabilities and the relationship between the constructs.
In the structural models, the estimation of path coefficients is based on OLS regressions of each endogenous latent variable on its corresponding previous constructs. Therefore, the first step is to examine the structural model for collinearity. Similar to a regular multiple regression, if the estimation contains significant levels of collinearity throughout the predictor constructs, the path coefficients could be biased. PLS-SEM should fit the model to the sample data to achieve the best parameter estimates by maximizing the described variance of the endogenous latent variable(s) while examining the structural model. “This aspect of PLS-SEM is different from CB-SEM, which estimates parameters so that the differences between the sample covariances and those predicted by the theoretical/conceptual model are minimized. As a result, with CB-SEM, the covariance matrix implied by the theoretical/conceptual model is as close as possible to the sample covariance matrix. Goodness-of fit measures associated with CB-SEM (which are based on the difference between the two covariance matrices), such as the chi square ($\chi^2$) statistic or the various fit indices, are not applicable in a PLS-SEM context.” (Hair et al. 2014, p.136, p.168-169). The structural model in PLS-SEM is evaluated based on heuristic measures (defined by the model’s predictive competencies) instead of goodness of fit approach. Testing the overall goodness of the model fit in a CB-SEM is not permitted by these measures. Reasonably, the model is evaluated concerning how well it forecasts the endogenous variables/constructs and is assumed to be specified properly.

In conclusion, the main criteria to evaluate the structural model include the following steps according to Hair et al. (2014, p.169):

1. Collinearity issues
2. The significance of the path coefficients
3. The level of the $R^2$ values
4. The $f^2$ effect size
5. The predictive relevance and the Q² effect size

We will apply these steps through sections to evaluate our proposed structural model with the data to analyse the results presented in Chapter 5.

4.5.5.1 Bootstrapping Technique: Significance and Relevance of Path Coefficients

Data are not normally distributed according to PLS-SEM assumption and consequently, parametric significance tests (common in regression analyses) are not applicable to test the significance of coefficients such as outer weights, outer loadings, and path coefficients. Therefore, non-parametric bootstrap method (Davison & Hinkley 1997; Efron&Tibshirani 1986 as cited in Hair et al. 2014) is to be relied on to test coefficients for their significance.

To perform bootstrapping, a large number of bootstrap samples (subsamples) are pulled out from the main sample with replacement. “Replacement means that each time an observation is drawn at random from the sampling population, it is returned to the sampling population before the next observation is drawn (i.e., the population from which the observations are drawn always contains all the same elements). Therefore, an observation for a certain subsample can be selected more than once or may not be selected at all for subsample” (Hair et al. 2014, p.130 and 132). The number of bootstrap samples should be at least as high as the number of valid observations in the data set and commonly 5000 subsamples are recommended (Henseler et al. 2009).

It is noteworthy to clearly specify the size of each subsample which must generally be the same as the main sample (e.g. the original sample has 150 valid observations so as each of the 5000 subsamples). Otherwise, the significance tests would generate biased results.

The PLS path models are estimated by means of bootstrap samples (i.e. 5000 bootstrap samples estimate 5000 PLS path models). The estimates of the coefficients create a bootstrap distribution which is considered as an estimation of the sampling distribution based on which,
the standard error and the standard deviation of the estimated coefficients are possible to be
determined. The estimated bootstrap standard error is denoted by \(se^*\) to indicate that it is
resulted through the bootstrap procedure (Henseler et al. 2009).

“The bootstrap distribution can be viewed as a reasonable approximation of an
estimated coefficient's distribution in the population, and its standard deviation can be used
as proxy for the parameter's standard error in the population” (Hair et al. 2014, p.134).

To test if \(w_1\) is significantly different from zero “(i.e., \(H_0: w_1 = 0\) and \(H_1: w_1 \neq 0\)”, t test is
calculated by means of the standard error resulted from the bootstrap distribution applying the
following formulae:

\[
t = \frac{w_1}{se^*_{w_1}}
\]  

(4.34)

Where:
\(w_1\): the weight resulted from the original model estimation using the original data
set
\(se^*_{w_1}\): the bootstrap standard error of \(w_1\) (Hair et al. 2014, p.134)

Clearly, “the test statistic follows a t distribution with degrees of freedom (df)\(^{31}\) equal to the
number of observations minus 1” (Hair et al. 2014, p.134). The general rule is to estimate the
t distribution by the normal (Gaussian) distribution for more than 30 observations. However,
the number of observations is usually higher than this threshold and thus, the normal
(Gaussian) quantiles can determine critical t values for significance testing. “Therefore, when
the size of the resulting empirical t value is above 1.96, we can assume that the path coefficient
is significantly different from zero at a significance level of 5% (\(\alpha = 0.05\); two-tailed test).
The critical t values for significance levels of 1 % (\(\alpha = 0.01\); two-tailed test) and 10% (\(\alpha =
0.10\); two-tailed test) probability of error are 2.57 and 1.65, respectively” (Hair et al. 2014,
p.134).

\(^{31}\)Degrees of freedom is “the number of values in the final calculation of the test statistic that are free to vary”
(Hair et al. 2014, p.134).
4.5.5.2 Bootstrap Confidence Intervals:

The bootstrap confidence interval provides additional information about the stability of a coefficient estimate. Therefore, it is worthy to report it along with reporting the significance of a parameter (Henseler et al. 2009).

“The confidence interval is the range into which the true population parameter will fall assuming a certain level of confidence (e.g., 95%)” (Hair et al. 2014, p.136). In bootstrapping procedure, the obtained standard errors are the basis of the construction of the confidence interval. The following formula provides the corresponding confidence interval for a two-tailed test (1-α):

\[ w_1 \pm z_{1-\alpha/2} \times SE_{w_1}^* \]  

(4.35)

where:
- \( w_1 \): outer weight
- \( SE_{w_1}^* \): bootstrap standard error of the outer weight
- \( z_{1-\alpha/2} \): derived from the standard normal (z) distribution table (Hair et al. 2014)

If the corresponding (1-α) bootstrap confidence interval does not consist of 0, a null hypothesis, \( H_0: w_1 = 0 \) in the population, is rejected at a given level of α; therefore, a significant effect is assumed. The stability situation of the estimate is indicated by the range of the confidence interval plus the significance testing aspect; the wider the confidence interval of a coefficient, the lower its stability (Hair et al. 2014).

The significance testing approach is improved by the bias-corrected bootstrap confidence interval as proposed by Gudergan, Ringle et al. (2008) and enhanced by Henseler et al. (2009) and Sarstedt, Henseler, and Ringle (2011) (Hair et al. 2014, p.134). According to Henseler et al. (2009), the corresponding approximate 1-α (two-tailed) confidence interval is computed through the following formulae:

\[ t - b_B \pm \sqrt{b_B} \times z_{1-\alpha/2} \]  

(4.36)

Where:
This equation creates a foundation to overcome the probable issue of asymptotic normality of the test statistic. Therefore, the bias corrected confidence interval approach is an appropriate technique to test the significance of estimated coefficients of PLS path model (Gudergan, Ringle et al. 2008).

The significance of a coefficient ultimately depends on its standard error which is resulted through bootstrapping procedure. Calculation of the empirical $t$ value is allowed by the bootstrap standard error by means of the following equation:

$$ t_{\text{emp}} = \frac{w}{\text{se}(w)} $$

(4.37) (Henseler et al. 2009, p.306)

The $t_{\text{emp}}$ distribution can be practically estimated for sample sizes larger than 30 and the empirical $t$ values will be compared to the quantiles from the normal distribution as critical values. “When the empirical $t$ value is larger than the critical value, we say that the coefficient is significant at a certain error probability (i.e., significance level). Commonly used critical values for two-tailed tests are 1.65 (significance level = 10%), 1.96 (significance level = 5%), and 2.57 (significance level = 1%). In marketing, researchers usually assume a significance level of 5%. This does not always apply, however, since consumer research studies sometimes assume a significance level of 1 %, especially when experiments are involved” (Hair et al. 2014, p.171). On the other hand, a significance level of 10% is assumed in experimental studies. Essentially, the choice of significance level is according to the objective and field of the study. In addition, the bootstrapping confidence interval for a pre-specified probability of error can be identified along with $t$ and $p$ values by means of the following formulae:

$$ p_i \pm z_{1-\alpha/2} \cdot se^*_{p_i} $$

(4.38) (Hair et al. 2014, p.173)

The relevance of significant relationships is required to be examined after assessment of the significance of relationships. Although some studies do not perform this assessment and
simply rely on the significance only, the size of the path coefficients in the structural model might affect their significance. Therefore, the relative importance of relationships is essential for the interpretation of results and conclusion. “The structural model path coefficients can be interpreted relative to one another. If one path coefficient is larger than another, its effect on the endogenous latent variable is greater. More specifically, the individual path coefficients of the path model can be interpreted just as the standardized beta coefficients in an OLS regression. These coefficients represent the estimated change in the endogenous construct for a unit change in the exogenous construct” (Hair et al. 2014, p.173-174). If the path coefficient is significantly different from zero in the population that is statistically significant, its value specifies the extent to which the exogenous construct is linked to the endogenous construct. To determine significant path coefficients in the structural model plus significant and relevant effects is the objective of PLS-SEM (Hair et al. 2014).

4.5.5.3 Coefficient of Determination

The coefficient of determination is a measure of the model’s predictive precision computed as the squared correlation between a specific endogenous construct’s real and predicted values. The most commonly applied measure to assess the structural model, the coefficient represents the exogenous latent variables’ combined effects on the endogenous latent variable. The squared correlation of real and anticipated values, the coefficient also denotes the extent of variance in the endogenous constructs clarified by all of the exogenous constructs associated with it. “The $R^2$ value ranges from 0 to 1 with higher levels indicating higher levels of predictive accuracy” (Hair et al. 2014, p.175). Problems arise when the $R^2$ values are used to compare models with the same endogenous construct but are identified differently. For instance, the $R^2$ increases if nonsignificant constructs are added to a structural model which are moderately correlated with the endogenous latent variable; the impact would be most remarkable when the sample size is close to the number of exogenous latent variables.
forecasting the endogenous latent variable under consideration. Therefore, model selection based on the $R^2$ value is not recommended.

The reason is when the $R^2$ value is the only basis to comprehend the model’s predictive accuracy, there is an intrinsic bias in choosing models with many exogenous constructs, comprising of those which are only slightly connected with the endogenous constructs. “The more paths pointing toward a target construct, the higher its $R^2$ value” (Hair et al. 2014, p.176). In addition, desirable models, which are called parsimonious, are those with high $R^2$ values and fewer exogenous constructs that explain the data well.

Similar to multiple regressions, the adjusted $R^2$ value ($R^2_{adj}$) is an applicable measure to avoid bias in complicated models. This measure is modified based on the number of exogenous constructs relative to the sample size and is defined as follows:

$$R^2_{adj} = 1 - (1 - R^2) \cdot \frac{n - 1}{n - k - 1}$$  \hspace{1cm} (4.39)

where:
$n$: the sample size
$k$: the number of exogenous latent variables used to predict the endogenous latent variable under consideration (Hair et al. 2014, p.176)

The $R^2$ value is reduced by the $R^2_{adj}$ through the number of explaining constructs and the sample size and therefore, steadily compensates for the addition of nonsignificant exogenous constructs simply to increase the explained variance $R^2$. The $R^2_{adj}$ is used to compare PLS-SEM results concerning models with different numbers of exogenous latent variables and/or data sets with different sample sizes.

4.5.5.4 The Effect Size of $f^2$

The other stage in assessing the structural model is to measure the change in the value of $R^2$ of the endogenous constructs after the omission of a certain exogenous construct from the
model. This will evaluate the impact of the deleted construct on the endogenous constructs and is called the $f^2$ effect size and measured via following formulae:

$$f^2 = \frac{R^2_{\text{included}} - R^2_{\text{excluded}}}{1 - R^2_{\text{included}}}$$  \hspace{1cm} (4.40)

$R^2_{\text{included}}$ and $R^2_{\text{excluded}}$ represent $R^2$ Values of the endogenous latent variable after the inclusion or exclusion of the specified exogenous latent variable (Hair et al. 2014, p.177). The result is obtained by two runs of the PLS Algorithm; first time with the exogenous construct included and second time with the exogenous construct excluded. The criterion for this assessment is that $f^2$ of 0.02 is a small effect size, 0.15 is a medium and 0.35 is a large effect sizes (Hair et al. 2014, p.178).

4.5.5.5 Predictive Relevance

The Stone-Geisser’s $Q^2$ value (Geisser 1974 and Stone 1974) should be evaluated in addition to the extent of the $R^2$ values (a measure of predictive accuracy) and is an indicator of the model’s predictive relevance. “More specifically, when PLS-SEM exhibits predictive relevance, it accurately predicts the data points of indicators in reflective measurement models of endogenous constructs and endogenous single-item constructs (the procedure does not apply for formative endogenous constructs). In the structural model, $Q^2$ values larger than zero for a certain reflective endogenous latent variable indicate the path model’s predictive relevance for this particular construct.” (Hair et al. 2014, p.178).

The blindfolding method for a certain omission distance is applied to determine the $Q^2$ value. Blindfolding is a sample reuse procedure that omits every $d$th data point in the endogenous construct’s indicators and calculate the parameters with the remaining data points (Henseler et al. 2009 and Tenenhaus et al. 2005). The omitted data points are regarded as missing values and they are treated by using mean value replacement while running the PLS-SEM algorithm. Then, the resulted estimates will be applied to predict the omitted data points.
“The difference between the true (i.e., omitted) data points and the predicted ones is then used as input for the $Q^2$ measure” (Hair et al. 2014, p.178). Blindfolding is a continual procedure and being repeated till each data point has been omitted and the model re-estimated. It is only applicable to endogenous constructs with a reflective measurement model specification plus endogenous single-item constructs. By the application of the blindfolding technique to the PLS-SEM, the data points in the measurement model of the reflective endogenous construct are assessed through a two-step approach. First step is to predict the scores of latent variables by the information from the structural model. Then, the predicted scores of the reflective endogenous latent variable will be applied in the second step to predict systematically omitted data points of the measurement model indicators. The omission distance, which is required in running the blindfolding procedure, influence the systematic pattern of data point omission and prediction. For example, an omission distance of 3 indicates that every third data point of the indicators is deleted in a single blindfolding round. The blindfolding method should consist of three rounds because it has to remove and predict every data point of the indicators used in the measurement model of a reflective endogenous latent variable. “Hence, the number of blindfolding rounds always equals the omission distance” (Hair et al. 2014, p.180).

Every data point of the indicators of a selected reflective endogenous latent variable has been deleted and then predicted by the end of the last blindfolding round. Therefore, the original values are comparable with the predicted values by means of the blindfolding procedure. “If the prediction is close to the original value (i.e., there is a small prediction error), the path model has a high predictive accuracy. The prediction errors (calculated as the difference between the true values [i.e., the omitted values] and the predicted values), along with a trivial prediction error (defined as the mean of the remaining data), are then used to estimate the $Q^2$ value” (Hair et al. 2014, p.183). $Q^2$ values more than 0 indicate that the model has anticipating relevance for a definite endogenous construct and values of 0 and less indicate
that there is no predictive relevance. There are two approaches to calculate the $Q^2$ value. “The cross-validated redundancy approach builds on the path model estimates of both the structural model (scores of the antecedent constructs) and the measurement model (target endogenous construct) of data prediction. Therefore, prediction by means of cross-validated redundancy fits the PLS-SEM approach perfectly” (Hair et al. 2014, p.183). The other technique is the cross-validated communality approach that applies only the construct scores measured for the target endogenous construct (without containing the structural model information) to predict the deleted data points. We have used the cross-validated redundancy approach of $Q^2$ measurement to predict omitted data points because it includes the fundamental factor of the path model (the structural model).

4.5.5.6 Heterogeneity

The heterogeneity of observations can falsify the PLS-SEM results and therefore, can be a threat to the validity of results and is another significant feature of evolution of the structural model. There could be a situation through research when different factors occur for different sub-populations like groups of consumers, organisations and etc. In the presence of heterogeneity in a sample, two or more subgroups reveal different fundamental relationships with the constructs. Such probability is usually forecasted by empirical researchers and they should always consider possible sources of heterogeneity (e.g. parameters for a model vary between males and females or for different ethnic heritage in cross-cultural research). This is known as observed heterogeneity since the researcher is aware of possible differences in the sub-groups under examination. To create data sets based on a priori information (for example age or gender equivalent to observed heterogeneity) and examine separate models for each group is a possible way to deal with this situation (Henseler et al. 2009).

However, the heterogeneity which exist in a sample cannot be acknowledged as a priori. The situations where the researcher might not be aware of the presence of the
heterogeneity and its sources or the researcher might not be sure if it is causing estimation biases, are referred to as the unobserved heterogeneity. As a result of the unobserved heterogeneity, the PLS path model could not be accurately estimated. Therefore, complementary techniques should be applied for response-based segmentation which is called “latent class techniques” (Hair et al. 2014, p.255) to identify and threat unobserved heterogeneity. The recently proposed latent class techniques include finite mixture modelling, typological regression or genetic algorithms to PLS-SEM described in studies such as Sarstedt (2008), Hahn, Johnson, Herrmann, & Huber (2002), Sarstedt, Becker, et al. (2011), Ringle, Wende et al. (2010), Sarstedt and Ringle (2009) (Hair et al. 2014, p.255-257). Among these latent class approaches, finite mixture modelling (FIMIX-PLS) is the most important and applicable one along with genetic algorithm segmentation in PLS-SEM (PLS-GAS; Ringle et al. 2012) and prediction-oriented segmentation in PLS-SEM (PLS-POS; Becker, Rai, et al. 2012). Since the FIMIX-PLS is the most recommended approach (Hair et al. 2014, p. 257), we have used it to reveal the probable unobserved heterogeneity in our data and the results will be presented through Chapter 5 of the present study.

According to the concept of mixture regression, the path coefficients are estimated altogether with the determination of data’s heterogeneity by computing the probability of the observations’ segment membership (then they fit into a pre-set number of groups) via FIMIX-PLS (Hair et al. 2014).

The estimation of model parameters and affiliations of observations could be segmented all together under the FIMIX-PLS technique (Mclachlan and Krishnan 1997). The heterogeneity of scores of the latent variables provides the basis for segmentation under SEM approach. The procedure proposed through the study of Jedidi et al. (1997) which is a combination of finite mixture models and the expectation-maximisation (EM) algorithm, is an extension to covariance structure analysis (CSA) but not applicable in PLS path modelling.
Therefore, the finite mixture partial least square (FIMIX-PLS) technique is proposed by Hanh et al. (2002). Under this approach, a finite mixture method is joined to an EM algorithm especially concerning the ordinary least squares (OLS) based predictions of PLS which is regarded as the most inclusive and commonly applied technique to treat heterogeneity in PLS path modelling resulting in more efficient strategies (Ringle, Wende et al. 2010, p.196).

FIMIX-PLS is applied for the purpose of additional analysis to facilitate the interpretability of distinct clusters and it is known as “the most challenging analytical step” (Ringle et al. 2010, p. 201).

“The FIMIX-PLS approach combines the strengths of the PLS-SEM method with the advantages of finite-mixture modelling when carrying out segmentation tasks in structural equation modelling” (Sarstedt and Ringle 2009, p.3). The underlying assumption of this approach is that the data source is numerous segments or sub-populations (Mclachlan and Krishnan 1997). The overall population is a combination of segment-specific density functions and every segment is modelled individually. Homogeneity is defined at a distributional level not as a common set of scores. Therefore, dealing with heterogeneity in data set would be facilitated by simultaneously clustering of observations and estimation of parameters via FIMIX-PLS. Consequently, distinguished biases occurring through the separate estimation of models will be prevented while all measurement parameters will be retained fix (Oh and Raftery 2003). The latent variable scores of the estimated PLS path model will be used on the aggregate data level to simultaneously calculate the parameters of segment-specific model in the inner model. “Thereby, FIMIX-PLS ascertains the heterogeneity of the data structure within a PLS-PM framework” (Sarstedt and Ringle 2009, p.3). The first step through this method is the estimation of a path model by means of PLS-SEM algorithm and observed data on the basis of values of visible variables in the outer measurement models (Hahn et al. 2002). In the next step, the FIMIX-PLS algorithm will apply
the resulted scores of latent variables. Thereby, the only objective of the FIMIX-PLS is to capture unobserved heterogeneity in the estimated parameters of the inner model concerning the relationship between latent variables. “FIMIX-PLS computes the probabilities of membership for each observation to fit into the predetermined S numbers of segments. Each endogenous latent variable $\eta_i$ is defined by the weighted average of segment-specific distributional functions $f_{i,s}()$” (Sarstedt and Ringle 2009, p.4) as follows:

$$
\eta_i = \sum_{s=1}^{S} \pi_s \left[ \frac{|B_s|}{(2\pi)^{J/2}} \right] \exp\left\{-\frac{1}{2} (B_s \eta_i + \Gamma_s \xi_j) \Psi_s^{-1} (B_s \eta_i + \Gamma_s \xi_j) \right\}
$$  \hspace{1cm} (4.41)

Where

- $\xi_i$: an exogenous variable vector in the inner model regarding observation $i$
- $B_s$: the path coefficient matrix of the endogenous variables and $\Gamma_s$ of the endogenous latent variables
- $\Psi_s$: describes the matrix of every segment’s regression variances of the inner model on the diagonal, zero otherwise
- $\pi_s$: mixing proportion determining the relative size of segment $s$ ($s=1,\ldots,S$) with $\pi_s > 0 \sum_{s=1}^{S} \pi_s = 1$
- $\eta_i$: endogenous latent variable
- $J$: the number of endogenous latent (dependant) variables in the inner model

(Sarstedt and Ringle 2009, p.4)

According to Ringdon et al. (2010), the likelihood of the observed data can be stated as follows:

$$
L = \prod_{i=1}^{I} \left( \sum_{k=1}^{K} \rho_k f(\eta_i | \xi_i, B_k, \Gamma_k, \Psi_k) \right)
$$  \hspace{1cm} (4.42) (Ringdon et al. 2010, p.274)

Afterwards, the log-likelihood of this model will be:

$$
\ln L = \sum_{i=1}^{I} \ln \left( \sum_{k=1}^{K} \rho_k f(\eta_i | \xi_i, B_k, \Gamma_k, \Psi_k) \right)
$$  \hspace{1cm} (4.43) (Ringdon et al. 2010, p.274)

In order to maximise the likelihood and confirm the convergence in the model, an EM (expectation maximisation) formulation of the FIMIX-PLS algorithm will be applied. This approach is based on the mixture regression concept and differentiate the dependent
(endogenous latent) and explanatory (exogenous latent) variables in the inner model. The
mixture regression concept enables the model to estimate “separate linear regression functions
and several segments’ corresponding object memberships” (Sarstedt and Ringle 2009, p.4).
Therefore, the probabilities of each observation relevant to a specific segment $s$ will be
provided by the FIMIX-PLS (Sarstedt and Ringle 2009).

Next equation presents an EM approach maximising the log-likelihood for the whole data
issue:

$$
\ln L_c = \sum_{i=1}^{I} \sum_{k=1}^{K} z_{ik} \ln (f(\eta_i | \xi_i, B_k, \Gamma_k, \Psi_k)) + \sum_{i=1}^{I} \sum_{k=1}^{K} z_{ik} \ln (\rho_k)
$$

(4.44)

Where

- $\rho_k$: segment size
- $\xi_i, B_k, \Gamma_k$ and $\Psi_k$: parameters of the conditional probability function (Ringdon
et al. 2010, p.274)

In the above equation, if subject $i$ fits in segment $k$, then $z_{ik}$ equals 1 (and 0 otherwise). In
comparison with the original FIMIX method, this part of the FIMIX-PLS algorithm is the
most advanced one to fit this approach to PLS-SEM (Jedidi et al., 1997a as cited in Ringdon
et al. 2010). Originally, the average of the adjusted expected values, $P_{ik}$ resulting from the
following equation, will determine $\rho_k$, new mixing proportions.

$$
P_{ik} = \frac{\rho_k f_{ik}(\eta_i | \xi_i, B_k, \Gamma_k, \Psi_k)}{\sum_{k=1}^{K} \rho_k f_{ik}(\eta_i | \xi_i, B_k, \Gamma_k, \Psi_k)} \forall i, k
$$

(4.45) (Ringdon et al. 2010, p.275)

Subsequently, OLS regressions will be applied to compute $B_k, \Gamma_k$, and $\Psi_k$, which are optimal
parameters, for every relationship between latent variables. “The EM algorithm stops
whenever $\ln L_c$ no longer improves, and an a priori specified convergence criterion is reached”
(Ringdon et al. 2010, p.276).

The number of segments is commonly unknown when FIMIX-PLS is being applied
and there is not a frank statistical process to identify a proper number of segments. The reasons
could be firstly, the mixture models do not allow the computation of the log-likelihood ratio statistics concerning precise decision making since they are not asymptotically $\chi^2$ distributed. Second, the EM algorithm converges for any specified number of K categories. Consistent with the setting of the PLS (Rigdon et al. 2010, p.283)\textsuperscript{32}, the present study will also start the identification by two segments and sequentially increase the number of segments in every run to six segments (the results will be described in Chapter 5) in order to decide how many segments are adequate.

We can never make sure if FIMIX-PLS stops at a small number of optimum solutions and hence, the algorithm should be re-run several times for every number of segments for various starting partitions (Ringle, Sarstedt et al. 2009, p.32). Successively, the maximum log-likelihood outcome will be obtained from the analysis of every alternative segments number. “Moreover, the FIMIX-PLS model may result in the computation of non-interpretable segments for endogenous latent variables with respect to the class-specific estimates $B_k$ and $\Gamma_k$ of the inner path model relationships and with respect to the regression variances $\Psi_k$ when the number of segments is increased” (Ringle et al. 2009, p.32). As a result, segment size is a valuable indicator to stop the analysis of extra numbers of latent categories to avoid inexplicable FIMIX-PLS outcomes (Ringle, Sarstedt et al. 2009).

In practice, estimates of different segment solutions are comparable via “heuristic measures such as Akaike’s information criterion (AIC), consistent AIC (CAIC), or Bayesian information criterion (BIC)” (Ringle et al. 2009, p.32). Because these information criteria take likelihood (goodness-of-fit) of a model simultaneously, they are based on a controlled form of the likelihood. “Information criteria generally favour models with a large log-likelihood and few parameters and are scaled so that a lower value represents a better fit” (Ringle et al. 2009, p.32).

\textsuperscript{32}The PLS-SEM setting is to initially compute the results starting from two segments (Rigdon et al. 2010, p.283).
An entropy statistic (designates the degree of separation between segments) is the basis of classification criteria and is used to investigate if the analysis creates well-divided groups (Ringle et al. 2009). “Within this context, the normed entropy statistic [EN; 58] is a critical criterion for analysing segment-specific FIMIXPLS results” (Ringle et al. 2009, p.33). This measure specifies the degree of arrangement of all observations and their evaluated segment membership probabilities (i.e. $P_{ik}$). This process is taken place on the basis of case-by-case which consequently discloses the most suitable number of latent segments for an accurate segmentation. The EN is measured as follows:

$$EN_K = 1 - \left[ \frac{\sum_i \sum_k -P_{ik} \ln(P_{ik})}{T \ln(K)} \right]$$  \hspace{1cm} (4.46) \hspace{1cm} (Ringle et al. 2009, p.32)

The classification process is corresponding to the increase in $EN_K$ which ranges between 0 and 1. “The more the observations exhibit high membership probabilities (e.g., higher than 0.7), the better they uniquely belong to a specific class and can thus be properly classified in accordance with high EN values” (Ringle et al. 2009, p.33). Specifically, the entropy criterion is mostly relevant to examine if a FIMIX-PLS solution is interpretable or not. EN values of 0.5 or higher evidently produce estimates of $P_{ik}$ that consent unambiguous segmentation (Ringle et al. 2009).

Along with EN value of 0.5 or higher, the minimal value of the empirical CAIC and AIC$_3$ measures are the basis of selecting the adequate model (the number of segments) (Sarstedt and Ringle 2009). In addition, the selected model should be supported by the segment sizes of beyond 0.5 (Rigdon, Ringle et al. 2011). In order to assure the validity of our model and analysis, we have used the FIMIX-PLS approach and the obtained results will be presented in Chapter 5.
4.6 Sample and Data Collection

The companies operating in the Australian Electricity generating sector will be considered to assess the impact of their environmental activities on their financial performance from 2006 to 2017. As mentioned earlier through Chapter 1 (Section 1.9), due to some mergers or acquisitions among the electricity generation companies, there have been changes in the reporting bodies of financial and environmental data throughout the sample period. Therefore, we could not obtain all required data for all 20 Australian electricity generating firms and ended up with a sample of 12 companies. This section below provides a brief background of the sample firms.

The Australian Gas Light Company (AGL)

AGL was established in 1837 starting as an Australian Gas light and provided the first gas street lamps in Sydney. This company launched new pipe technology which resulted in carbon emission reduction by 13 million tonnes plus the solar generators in South Australia. In 2006, AGL joined the Australian Stock Exchange and is the only Australian energy retailer listed as a member of the leading global ranking of sustainability (the Dow Jones Sustainability World Index). As the provider of innovative sustainable energy sourcing, the company opened the largest hydroelectric asset and largest wind farm in the Southern Hemisphere. AGL merged with Alinta Limited and acquired Loy Yang A Power station and its adjacent coal mine. In 2015, AGL released a new Greenhouse Gas Policy to achieve gradual decarbonisation of its generation by 2050. In addition, an innovative new financing initiative designed by AGL in 2016 support the development of renewable energy generation as well as establishment of the world’s largest virtual power plant to help customers saving on energy bills (AGL 2018).

Alcoa

Alcoa invented the aluminum industry in 1888 and improved to create “independent and industry-leading” 500 companies comprising of “Bauxite, Aluminum, Casting and energy...
Business units”. Alcoa Energy is aiming to achieve lower operational costs. In order to follow up their sustainability goals, almost 61 percent of Alcoa’s power production capacity is obtained from renewable and hydroelectric operations. Their present goal is to reduce 10 percent of their “energy intensity by 2020 and 15 percent by 2030” (Alcoa 2018).

**CS Energy**

CS Energy is a foremost electricity provider in the National Electricity Market (NEM) established by Queensland government in 1997. According to its asset portfolio, there are coal-fired and hydroelectric power stations owned by this company including the Callide A, Callide B and half of the Callide C power stations plus Kogan Creek and Wivenhoe power stations. The primary environmental laws governing the company’s operations are Queensland’s Environmental Protection Act 1994 and Sustainable Planning Act 2009. In fact, all the power stations owned by CS Energy operate within an Environmental Management System (EMS) which is certified by the international environmental standard ISO 14001: 2004. By means of this EMS, the company is provided with a framework to plan and implement environment protection assessments by monitoring daily operations (Cs Energy 2018).

**Energy Developments Pty Limited (EDL)**

EDL is an international energy company providing low GHG emissions energy plus remote energy solutions and renewables. In fact, its two major fields of business are remote energy and clean energy and operating in liquefied and compressed natural gas energy solutions, landfill gas and wind power generation plus waste coal mine gas power generation as main operating areas. Energy Developments provide services to “large public companies, government bodies, large energy retailers and owners of landfill sites”. The company maintains high environmental standards by operating through small and efficient power generation plants designed to minimize emissions (Energy Development Pty Limited 2018).
**Ergon energy**

The Queensland Government established Ergon energy in 1999 owning 160000 kilometres of powerlines, 100000 power poles plus allied infrastructure (substations and power transformers), 33 stand-alone power stations for the isolated communities across the state and Barcaldine gas-fired power station. The company seeks to reduce greenhouse gas emissions and harmful pollutants from diesel burning and therefore the solar farm at Doomadgee and a solar concentrated power station at Windorah are operating together with the diesel power system. The Doomadgee’s solar power station achieved the Clean Energy Council (CEC) Innovation Award in 2014 because of the innovative development of advanced control systems. In addition, one of the few low-temperature geothermal power stations in the world is owned by Ergon Energy (in Birdsville). However, this power station only supplies power to Birdsville’s isolated mini grid and not linked with the national electricity network. Compared to other renewable sources the importance of this power station is the consistent power production. Furthermore, Ergon Energy established a wind generation plant in Thursday Island in the Torres Strait which is not connected to the national power network but reduces considerable amount of greenhouse gas emissions annually (Ergon Energy 2018).

**Horizon Power**

Owned by state Government, Horizon Power is commercially-focused power utility supplying electricity, sustainable energy solutions and improving renewable energy sites in Western Australia. The company attempts to support several not-for-profit organizations and projects to strengthen the community values and safety. In addition, the company supplies power as well as job offers to more than 40 aboriginal communities. Horizon Power supplies solar power to customers. However, it is costly for the company which restricts their renewable service providing (Horizon Power 2018).
*Hydro-Electric Corporation (Hydro Tasmania)*

(Hydro Tasmania is aged about 100 years and the leading and largest Australian renewable energy producer. Combining water, wind and solar power, the company supplies natural energy along with diesel and innovative renewable technologies to the national market. It is also the largest water manager in Australia owning an advanced hybrid power system on King Island plus involvement in various joint ventures. Momentum Energy and Entura are acquired by Hydro-Electric Corporation providing energy consultations and competitive products in national and international markets. The company has achieved Excellency awards in the areas of operation at state and national level such as Climate Leadership Awards in 2015. The company aimed to continue as the predecessor of low carbon intensity business (Hydro Tasmania 2018).

*Origin Energy*

Origin Energy, established in 2000 as a result of a demerger, became the largest energy company in 2011 and acquired Eraring Energy, the largest power station in Australia in 2013. The company tries to supply cleaner energy by means of solar, wind and storage technologies and production of natural gas in Australia and New Zealand. The SEA Gas Pipeline constructed by this company connects Victoria to South Australia and the Australia Pacific LNG Project main gas transmission connects Queensland gas fields with Curtis Island (the LNG facility). By launching their carbon reduction scheme, the company tries to reduce the negative effect on environment and is one of the foremost green energy retailers in Australia (Origin Energy 2018).

*Power and Water Corporation*

Power and Water Corporation is one of the largest employers and suppliers of electricity and water services to the Northern Territory. Although, the company’s operation is commercial and For-Profit, it supports more than 70 remote communities via the Indigenous Essential
Services Pty Ltd which is its not-for-profit subsidiary. The company has 4 solar power stations in remote communities and the Solar SETuP project providing solar energy to 30 remote communities in the Northern Territory in addition to wind power generation turbines, landfill sites of gas and hydropower turbines and plans to develop renewable technologies (PowerWater 2018).

**APA Group**

APA Group is the merger of Australian Pipeline Trust and APT Investment Trust owning distribution networks, gas-fired power stations, wind farms and gas storage facilities and was listed in the Australian stock exchange in 2000 and acquired CMS Energy Corporation, Carpentaria Gas Pipeline, Murraylink electricity interconnector, GasNet Australia and several other power plants (or some portion of them) established across Australian states and territories. The APA Group has investments in various renewable energy projects and wind farms such as agreements with Origin Energy and Synergy supported by government grants (APA 2018).

**Snowy Hydro Limited**

The establishment of the Snowy Mountains Hydro-electric Scheme (Snowy Hydro) presents a great innovation and ingenuity and is a developing dynamic energy provider known as the Snowy Hydro Limited. This integrated energy company is the prominent provider of peak renewable energy to the NEM along with gas and diesel fired energy generators and it also provides price risk management products for wholesale and individual sales. The company operates in the NSW and Victoria states and is partially owned by the Commonwealth Government and is the 4th largest energy retailer in the NEM which is expanding and developing (Snowy Hydro 2018).
**Transfield Worley Power Services Pty Limited (TWPS)**

TWPS is acknowledged as the largest independent asset and service provider to the power generation market in Australia and New Zealand. In order to satisfy their commitment to Zero Harm to the environment and ensure their reputation for integrity, the company aligns their environmental management system to ISO14001 international standards. The company experiences extensive technology of renewable and conventional power generation with coal, gas, diesel, wind, solar and biomass.

As observed through the above summary about the Australian electricity generators being investigated in the present study, our sample includes firms with various sizes, expansions and backgrounds contributing to the Australian National Electricity Market (NEM) (TW Power Services 2018). To conduct the analysis, both financial data and environmental data are required for every company.

Raw financial data are collected from the company’s financial statements to manually\(^3\) calculate the required financial ratios and variables (including data required to measure efficiency via data envelopment analysis) as will be discussed through section 4.7. Also, some financial ratios (return on assets, return on equity and dividend payout ratio) were accessible through Bloomberg terminal for AGL, Ergon, Origin and EDL companies for the years of 2006 to 2010.

To obtain the environmental variable which is the EP (environmental performance) Indicator, the annual emission amount of Carbon Monoxide, Oxides of Nitrogen and Sulfure Dioxide\(^4\) are collected from the National Pollutant Inventory (NPI) which is an Australian governmental website through which companies release their environmental pollution/emission reports every year. The data is browsed from the Electricity Generation group of the

\(^{3}\) All environmental and financial variables and ratios are calculated by means of excel spreadsheet.

\(^{4}\) These pollutants are the only ones available for all the sample companies for the whole period of 2006-17 which is discussed through section 1.9 of the first chapter of the present thesis.
Electricity Supply subdivision of the Electricity, Gas, Water and Waste Services industry for the present research. Every company in the sample is consisted of several electricity generation plants each of which separately releases the pollutant emission report. Therefore, we have summed up the annual emission amount of every pollutant by all the operating plants of every company in the sample\textsuperscript{35} in order to measure the annual emission amount of every pollutant by every company\textsuperscript{36}. The resulting variable will be applied in the compilation of the EP indicator as will be described through section 4.7 along with the description of all the data and definition of variables and their relationships with each other.

4.7 Description of Data and Variables

The model presented in Figure 1 comprised of the following variables.

- $EP_{i,t-1}, \ldots, EP_{i,t-5}$: Environmental performance of a company lagged by 1-5 years
- Size: Firm’s size
- Tech: Firm’s level of technology
- Risk: Capital Structure measured as Debt to Equity ratio
- RR: Retention ratio = 1-Dividended payout ratio
- FP: Measure of financial performance construct impacting ROA, ROE, GPM, NPM
- MP: PE as a measure of market value
- ES: Dummy variable of firms following environmental standards
- EP: Measure of environmental performance construct affected by $EP_{i,t-1}, \ldots, EP_{i,t-5}$
- IO: Measure of internal operation construct affected by RR, Size, Risk and Tech
- Moderating Effect of IO: A construct moderating (strengthening) the impact of the IO construct on the EP construct via efficiency (EF construct)
- EF: The technical, scale and allocative efficiency scores obtained by the means of DEA analysis

This measurement model is a reflective PLS-SEM model in which FP, MP, EP and IO construct are endogenous and EF and ES are exogenous constructs. The EF-IO, EF-EP, EF-FP and IO-EP relationships will be measured by means of this model according to the Resource-based view (RBV) as discussed in Chapter 3. The EP-MP, EP-FP and FP-MP

\textsuperscript{35} By means of excel spreadsheet.
\textsuperscript{36} In this way, we measure the variable $P_{ijt}$ to compile the index 4.47 as will be elaborated through section 4.7.
relationships will be assessed on the basis of the stakeholder theory. Finally, ES-EP relationship will be evaluated on the ground of the legitimacy theory. Also, the prior studies suggested considering important moderating role of the organisational factors on the relationship between environmental performance and financial performance of firms (Lin, Yang et al. 2009). Therefore, we will examine the moderating effect of IO construct on EP construct through efficiency level of firms. The relationships among the variables are described via Figure 4.4 as below:

As can be observed, the distinct feature of our proposed model compared to the literature includes broader dimensions of environmental performance and financial performance of

---

37 The stakeholder theory highlights the importance of consideration of the stakeholders’ concerns (firms’ environmental performance, level of efficiency and profitability) in business strategies in order to retain stakeholders which will improve the firms’ financial/market performance (Salem et al. 2012).

38 The legitimacy theory emphasizes on the environmental and social disclosure of firms as a strong factor to enhance their public image and obtain the stakeholders’ trust (Agarwal 2013 and Magness 2006).
firms with higher lagged period in order to assess the EP-FP relationship within a longer time span. The model is further analysed with inclusion of the RD (Regional Dummy) construct to examine the impact of regional factors on the firms’ environmental performance and therefore, on the EP-FP relationship. For this purpose, the following model, presented by Figure 4.5, will be measured for every single Australian state and territory separately (7 times) as below:

**Figure 4.5: PLS-SEM Model with RD Construct**

As observed throughout the literature on EP-FP relationship reviewed in the previous chapter, environmental performance could be evaluated qualitatively or via quantitative measures. The applied qualitative variables include practice of environmental management system (Chen et al. 2015, Lucas and Noordewier 2016, Rodrigues-Fernandez 2016) and environmental ratings (Salama 2005, Elsayed and Paton 2005, Lioui and Sharma 2012, Saeidi et al. 2015, Gonenc and Scholters 2017). On the other hand, amount of GHG emissions by firms (Delmas et al.
2015, Lee et al. 2015, Kim 2015, Ernhart and Lizal 2002, Giovanni and Vinzi 2012) and EP indicators modified/proposed through studies (Horváthová 2012), Hatakeda et al. 2012, Misani and Pogutz 2015, Nollet et al. 2016) are the quantitative measures of environmental performance used through the literature. This variety of EP indicators and measures is a result of limitation such as data availability or standard reporting (Saeidi et al. 2015).

Different indices have been constructed through the prior studies to measure environmental performance of organizations. For instance, Stern et al. (1996) used the natural log of tons of sulphur dioxide divided by the population to solve the Panayotou’s SO2 regression (Stern, Common et al. 1996, p.1157). To evaluate the effects of ownership structure on environmental performance, Earnhart and Lizal (2006) estimated environmental performance using absolute emissions and emissions divided by the production level referred to as relative emissions (Earnhart and Lizal 2006, p. 120). Clarkson, Li et al. (2011) constructed an empirical proxy for a firm’s environmental performance named Pollution Propensity (PP) which is equal to the amount of toxics released in pounds scaled by the cost of goods sold. The environmental performance is measured as the inverse of the PP (Clarkson et al. 2011, p.129). In order to relate the market value of firms to the measures of their environmental performance, Konar and Cohen (2001) investigated two environmental performance measures which are “the aggregate pounds of toxic chemicals emitted per dollar revenue of the firm and the number of environmental lawsuits pending against the firm in 1989” (Konar and Cohen 2001, p.286).

In conclusion, these two measurement models will be analysed separately. The model presented in Figure 4.4 will be first assessed and then, the modified model presented in Figure 4.5 with the addition of exogenous regional dummy (RD) construct will examine the impact of the regional factors on the environmental performance of the Australian electricity producing firms.
In order to evaluate the impact of environmental performance of firms on their financial performance both environmental and financial data are required to create relevant variables. The required environmental data is obtained from the National Pollutant Inventory (NPI) data source which is available until 2017 only and therefore, we are not able to extend our analysis to 2018. Also, the emission amounts of all pollutants were not available for all firms and only three main pollutants (Carbon Monoxide, Oxides of Nitrogen and Sulfure Dioxide) are included our EP index.

The financial data are accessible through the financial statements of the sample companies as well as Bloomberg database. However, financial data for some firms were not available for all years plus some mergers and acquisitions and hence, we ended up with 12 firms with all data available. Therefore, our sample contains 12 companies and investigation period is 2006-2017. The relevant variables to be included in our analysis are created by means of collected data and are defined as follows.

**Financial Performance (FP):** the effect of this endogenous latent variable is manifested by the gross profit margin (GPM), net profit margin (NPM), return on assets (ROA) and return on equity (ROE) indicators. In other words, the causality is from FP construct to these indicators according to the definition of the reflective measurement theory (Hair et al. 2014) which will be discussed in section 4.5 of the present chapter.

Accounting-based measures (ROA, ROE, NPM and NGM) are applicable to evaluate the financial performance within a short-term (such as factors effective to reduce operating costs) and market-based measures (MP) are suitable to assess financial performance during a long-term (i.e. investors’ long-term judgements of the prospective profitability of firms’ present managing practices). Therefore, these measures are complementary, and it is not sufficient to use only one of these measures to analyse the EP-FP relationship within a short and long timespan (Delmas, Nairn-Birch et al. 2015). To evaluate the relationship between
environmental performance and financial performance of firms, ROA, ROE and Tobin’s q are the FP variables mostly applied through the literature (e.g. (Lioui and Sharma 2012), Delmas et al. 2015, Lee et al. 2015, Misani and Pogutz 2015, Rodrigues-Fernandez 2016, Gonenc and Scholters 2017) plus profitability variables such as profit margin and return on sales (ROS) (e.g. Saeidi et al. 2015, Hatakeda et al. 2012, Misani and Pogutz 2015, Giovanni and Vinzi 2012). On the basis of the related literature we measure firms’ financial performance by means of NPM (ratio of net profit to revenue), GPM (revenue minus cost of goods sold divided by revenue), ROA (ratio of net income to the total assets), ROE (ratio of net income to the total equity) as the reflective indicators of the FP construct. However, we will assess the impact of market-based indicators separately reflected by MP construct as explained below.

**Market Performance (MP) Construct:** Investment decisions will affect the shareholders’ value based on the level of capital spending (Ke 2017). Although a broad literature on market-based measures and investment rate applied Free Cash Flow and Tobin’s Q theory as sufficient market value measurements, these criteria and their relationship are controversial due to the variety of approaches used to predict and interpret the results (Ke 2017). On the other hand, corporate finance theory believes in the importance of share price information to predict the future business situation and hence, the investment rate. The ground of this theory is the information contained in share prices which are aggregated from various market participants without any interaction with the firm (Chen, Goldstein et al. 2007). This will result “stock prices to contain some information that managers do not have” (Chen et al. 2007, p.620).

Considering above discussion, we will measure the effect of market performance of firms represented by PE ratio (Stock price/Earnings per share (EPS) (Ke 2107)) as “a meaningful measurement of the investment opportunities” (Ke 2017, p.5).
**Environmental Performance (EP) Construct:** the endogenous latent variable modelled based on the reflective measurement model presented by the EP indicators. Horváthová (2012) recommended to normalize firms’ environmental performance measurement based on the dangerousness level of emitted pollutants and proposed an EP indicator which is the ratio of absolute emitted amount of a pollutant to its reporting threshold\(^39\). However, we increase the accuracy of the EP measurement by using the risk score of the toxic chemicals with the highest threat to human health provided by the Scorecard website to build the EP indicator. Scorecard is a free-public information service launched by Environmental Defense in 1998 and now owned by Green Media Toolshed (GMT). Purposes of this non-profit organization have been to identify and highlight the most polluting companies based on their environmental records. Since no one would like to be acknowledged as the “top polluter” in the society, the Scorecard would create strong incentives for less pollution.

According to Scorecard, “risk scores are calculated for reported TRI releases to air or water by multiplying each chemical’s release quantity (in pounds) by the appropriate chemical-specific TEP” (http://scorecard.goodguide.com/env-releases/def/tep_gen.html). TEPs (Toxic Equivalency Potentials) are defined as the relative risk to the human health allied with a release of one pound of a chemical which is compared to the risk posed by release of a reference chemical. The reference chemical is applied in the construction of “a common denominator for chemicals that may cause cancer or noncancer chronic health effects” (Scorecard 2017).

The following equation is proposed to be applied as the EP indicator in our PLS-SEM model:

\[^{39}\text{Environmental data applied in the study by Horváthová (2012) is obtained from European Pollutant Release and Transfer Register (EPRTR). There is a reporting threshold set by the EPRTR Regulation based on which “pollutants are reported if their emitted amount exceeds a reporting threshold” (Horváthová 2012, p.94).}\]
\[ EP_{i,t} = \sum P_{ijt}S_j / Q_{it} \]  

(4.47)

Where:
- \( EP_{i,t} \): Environmental performance of a company
- \( P_{ij,t} \): Emission amount for pollutant \( j \)
- \( S_j \): Risk score
- \( Q_{it} \): KWh electricity production

As discussed earlier, the development of this formula is inspired by the criterion introduced through the study of Horváthová (2012) which is justified in order to increase the accuracy of the environmental performance measurement. Therefore, the environmental performance of the Australian electricity generators is measured by the sum of normalised emission of pollutants (Carbon Monoxide, Oxide of Nitrogen and Sulphure Dioxide) based on their level of dangerousness and volume of electricity generation (KWh) by every firm in the sample.

On the other hand, the emission reduction depends on the initial amount of emission of every pollutant (Horváthová 2012). Thus, normalizing the amount of emission is recommended to overcome this issue. For this purpose, instead of using the total emitted amount for every pollutant, Horváthová (2012) proposed an index\(^{40}\) which provides a basis for our EP measurement model.

**Internal Operation (IO) Construct**: We apply this variable as the endogenous latent variable modelled based on the reflective measurement model consisted of technology level (Tech), risk (Risk), retention ration (RR) and size (Size) indicators. This modelling is based on the study of Marie, Ibrahim et al. (2014) where IO plays a mediating role in the relationship between size and financial performance. The present study will assess the impact of IO on FP indirectly. In addition, studies such as Busch, Stinchfield et al. (2011), Misani and Pogutz (2015) and Nollet, Filis et al. (2016) found risk and research and development (R&D) as effective variables in the financial performance of firms. Debt to equity ratio is the measure of risk which is in line with the risk measurement in the study of Misani and Pogutz.

---

\(^{40}\) the emitted amount of a pollutant divided by its reporting threshold (Horváthová 2012)
Firms’ investments in innovation and technology development is valued by consumers\textsuperscript{41} and hence, improves firms’ financial performance. Technological advancements can confront environmental issues which will result in firms’ enhanced competitive advantage and market performance (Lin et al. 2009; Misani and Pogutz 2015). Therefore, we include a measure of technological level (Tech indicator) in the measurement model affecting internal operation (IO construct) and hence, EP and FP constructs. In line with the study of Gonenc and Scholtens (2017), our Tech indicator is measured as the ratio of property and plant divided by total assets (except that Gonenc and Scholters (2017) divided total expenses spent on R&D by total assets).

**Efficiency (EF) Construct:** To maximize the accuracy of our analysis, we have measured firms’ efficiency by means of Data Envelopment Analysis (DEA) which will be discussed in section 4.9. The Efficiency is an exogenous construct designed on the basis of reflective measurement model presented by technical efficiency (Technical EF), scale efficiency (Scale EF) and allocative efficiency (Allocative EF) indicators. The impact of this construct on EP, FP and IO is measured through the present analysis. Furthermore, the EF construct will be applied as a moderator variable in order to strengthen the relationship between IO and EP constructs (Hair et al. 2014). This moderated relationship is presented by the construct named as the Moderating Effect of IO.

**Environmental Standards Dummy (ES):** Although Heras-Saizarbitoria et al. (2011) claimed a potential impact of the ISO14001 certification on the EP-FP relationship,

\textsuperscript{41} Such investments will improve quality of products and make consumers feel that they support the environmental movements by buying these products (Lin et al. 2009).
they believed in the influence of more variables on this relationship than they included. To assess this hypothesis, we will test the effect of ISO14000 series on EP construct and hence, FP construct by means of ES construct. To build this exogenous construct, score 1 will be given to a firm if it follows ISO14000 series and score 0 otherwise which is in line with the study of Heras-Saizarbitoria et al. (2011).

**Regional Dummy (RD):** The effect of firms’ region of operation on the environmental performance (EP construct) and hence, on FP construct will be assessed by means of this exogenous construct in line with studies of Misani and Pogutz (2015) and Gonenc and Scholters (2017) who control for country dummies in their EP-FP assessment. To build our regional variable (RD), we will run the model for every individual state and territory separately by giving score 1 to the specific region and 0 to the rest. The impact of RD on EP is illustrated via Figure 4.3 presented in this section.

The section 4.7 below will explain the Data Envelopment Analysis (DEA) used to measure the Efficiency (EF), the remaining main variable in our model.

### 4.8 Hypothesis Testing

To test the hypotheses developed through this section and to perform our analysis of the relationship between environmental performance and financial performance of the Australian electricity producing firms, the model estimated measurements based on the PLS-SEM analysis.

The 1st research question will be answered by testing hypotheses number 1 to 4 via measuring the impact of EF construct on IO and EP constructs. To answer this question, we will also test the impact of IO construct and its mediation on the EP construct. The relationship between firms’ efficiency level and their financial performance will be tested via hypothesis number 5 answering the 2nd research question. Our hypotheses number 6 to 8 will be tested
by assessing the impact of EP construct (consisted of EP indicators for 5 years) on MP and FP constructs which will also answer the 3\textsuperscript{rd} research question.

The impact of ES construct on EP construct will be measured to test the 9\textsuperscript{th} hypothesis and reply the 4\textsuperscript{th} research question. Testing the hypothesis number 10 will reveal the impact of FP construct on the MP construct and answer the research question number 5. The present study will assess the impact of regional factors on the environmental performance of firms to answer the last research question via testing hypotheses 11 to 17.

In order to test our hypotheses and reply the research questions, the present study will examine two PLS-SEM models as described in the Section 4.7 (figures 4.4 and 4.5). Figure 4.6 will illustrate the process of testing the hypotheses as described in the present subsection:

Figure 4.6: Hypotheses Testing
4.9 Summary

The aim of the present study is to investigate the relationship between environmental performance and financial performance of the electricity generators in Australia. To overcome the deficiency of the prior studies which is the lack of inclusive theory, method and therefore, inconsistent results of EP-FP analysis, we have proposed a distinct model based on a complemented theoretical framework and methodology.

While regression analysis is the major technique applied by the prior studies to measure the EP-FP relationship, the features of PLS-SEM enable this method for theoretical development, small sample analysis, predictive research and examining the linear relationship among multiple independent variables. Therefore, PLS-SEM is the most appropriate method to maximise the precision of our analysis.

The PLS-SEM model, proposed through section 4.6, will evaluate the impact of firms’ internal operation on their environmental performance and financial performance plus analysing the impact of the former on the latter. Our methodology will further contribute to the literature by introduction of an indicator (EP indicator) to measure the environmental performance of firms which will increase the accuracy of the analysis. The EP indicator will be obtained by normalising the emission amount of the pollutants based on the dangerousness score and production volume.

The efficiency construct includes firms’ technical, scale and allocative efficiency scores which will be measured via DEA analysis independently (section 4.7). Section 4.5 briefly introduced the electricity generation companies included in our sample. The results obtained from our analysis will be explored in the next chapter to test the hypotheses and to answer the research questions.
Chapter 5
Empirical Analysis and Results

5.1 Introduction

The major objective of the present study is to examine the EP-FP relationship in the context of Australian electricity industry using a structural equation model to identify the factors that are critically important for performance improvements in the sector. Accordingly, based on the extensive literature review conducted in Chapter 3 on the studies that have examined EP-FP relationship, the present study identified a number of research gaps to be filled. Based on literature review presented in Chapter 3, six research questions were formulated in Chapter 4 to be answered in this chapter through testing of 17 hypotheses established in chapter 4 which also presented the methodology that the present study adopts to answer the research questions. As stated in Chapter 4, the six research questions that this study aims to answer are:

RQ1: What is the relationship between the efficiency, internal operation and the environmental performance of Australian electricity generation firms?

RQ2: What is the relationship between the efficiency and financial performance of Australian electricity generation firms?

RQ3: What is the relationship between the environmental performance and financial performance of Australian electricity generation firms?

RQ4: What impact do environmental standards have on the relationship between the environmental performance and financial performance of Australian electricity generation firms?

RQ5: What is the relationship between the financial performance and market performance of Australian electricity generation firms?

RQ6: Does the relationship between environmental performance of firms and their financial performance vary in different geographical regions?
As explained in Chapter 4, the study will first apply a Data Envelopment Analysis (DEA) to measure the efficiency of the Australian electricity producing firms in the sample. The obtained efficiency scores then along with the other latent variables identified in the previous chapter will be applied into a PLS-SEM model to examine the relationship between financial performance and environmental performance of Australian electricity producing firms.

This chapter is organised as follows: first, the level of efficiency of sample firms used in the model as reflective constructs are measured in Section 5.2. This is followed by the evaluation of the measurement model in Section 5.3. Bootstrapping results and testing of the structural model are presented in Section 5.4. Section 5.5 will explain the impact of regional factors on the relationship between environmental performance and financial performance of the Australian electricity producing firms in the sample. The significance of the relationships between the constructs will be evaluated based on the bootstrap analysis results to test the hypotheses presented in Section 5.6. Finally, main findings of the analysis are discussed in Section 5.7 followed by a presentation of a chapter summary in Section 5.8.

### 5.2 Analysis of level of efficiency in sample firms.

As described in the previous chapter, the technical efficiency of sample firms is measured by the VRS DEA method. The Table 5.1 presents the level of annual efficiency calculated under production approach for all firms included in the sample during the sample period of 2006-2017. Firms with efficiency score of 1 have the full efficiency level and the firms with efficiency score less than 1 are less efficient in comparison with other firms. The firms are sorted in descending order based on their average efficiency score (the last column) placing most efficient firms on top, presenting Horizon Power as the most efficient firm and Alcoa as the least. The results of this analysis are presented in Table 5.1 below.
### Table 5.1: Efficiency Trend of Australian Electricity Generators, 2006-2017

<table>
<thead>
<tr>
<th>Firms/Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizon Power</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.975</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.989</td>
<td>0.997</td>
</tr>
<tr>
<td>EDL</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.985</td>
<td>0.964</td>
</tr>
<tr>
<td>Snowy hydro</td>
<td>1.000</td>
<td>0.686</td>
<td>0.848</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.950</td>
<td>0.967</td>
</tr>
<tr>
<td>Origin</td>
<td>1.000</td>
<td>0.334</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.088</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.925</td>
<td>0.600</td>
</tr>
<tr>
<td>APA Group</td>
<td>0.961</td>
<td>1.000</td>
<td>0.590</td>
<td>0.550</td>
<td>0.554</td>
<td>0.459</td>
<td>0.789</td>
<td>0.840</td>
<td>1.000</td>
<td>0.949</td>
<td>0.900</td>
<td>0.940</td>
<td>0.794</td>
</tr>
<tr>
<td>Cs Energy</td>
<td>0.419</td>
<td>0.847</td>
<td>0.845</td>
<td>0.662</td>
<td>0.234</td>
<td>0.787</td>
<td>0.691</td>
<td>0.855</td>
<td>1.000</td>
<td>1.000</td>
<td>0.945</td>
<td>0.988</td>
<td>0.773</td>
</tr>
<tr>
<td>AGL</td>
<td>1.000</td>
<td>0.497</td>
<td>0.451</td>
<td>0.857</td>
<td>0.749</td>
<td>1.000</td>
<td>0.162</td>
<td>0.445</td>
<td>1.000</td>
<td>0.684</td>
<td>0.869</td>
<td>0.912</td>
<td>0.719</td>
</tr>
<tr>
<td>Ergon</td>
<td>0.578</td>
<td>1.000</td>
<td>0.574</td>
<td>0.314</td>
<td>0.399</td>
<td>0.446</td>
<td>1.000</td>
<td>1.000</td>
<td>0.695</td>
<td>0.767</td>
<td>0.897</td>
<td>0.987</td>
<td>0.721</td>
</tr>
<tr>
<td>Power Water</td>
<td>0.335</td>
<td>0.302</td>
<td>1.000</td>
<td>1.000</td>
<td>0.318</td>
<td>0.467</td>
<td>0.517</td>
<td>0.522</td>
<td>1.000</td>
<td>0.906</td>
<td>0.876</td>
<td>0.900</td>
<td>0.679</td>
</tr>
<tr>
<td>Hydro elec</td>
<td>0.366</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.809</td>
<td>0.467</td>
<td>0.321</td>
<td>0.173</td>
<td>0.308</td>
<td>0.404</td>
<td>0.317</td>
<td>0.359</td>
<td>0.544</td>
</tr>
<tr>
<td>TWPS</td>
<td>0.210</td>
<td>0.210</td>
<td>0.285</td>
<td>0.483</td>
<td>1.000</td>
<td>1.000</td>
<td>0.970</td>
<td>0.411</td>
<td>0.338</td>
<td>0.745</td>
<td>0.445</td>
<td>0.512</td>
<td>0.551</td>
</tr>
<tr>
<td>Alcoa</td>
<td>1.000</td>
<td>1.000</td>
<td>0.009</td>
<td>0.011</td>
<td>0.096</td>
<td>1.000</td>
<td>0.100</td>
<td>0.021</td>
<td>0.042</td>
<td>0.164</td>
<td>0.167</td>
<td>0.200</td>
<td>0.318</td>
</tr>
<tr>
<td>Average</td>
<td>0.759</td>
<td>0.760</td>
<td>0.739</td>
<td>0.760</td>
<td>0.686</td>
<td>0.747</td>
<td>0.735</td>
<td>0.711</td>
<td>0.799</td>
<td>0.811</td>
<td>0.746</td>
<td>0.779</td>
<td>0.737</td>
</tr>
</tbody>
</table>
As per the data in the above table, Horizon Power, EDL and Snowy Hydro are found to be most efficient throughout the investigation period with technical efficiency scores of 1 or close to 1. The technical efficiency of Origin experienced a sharp drop in 2007 which is the result of launching carbon reduction scheme during this year which imposes additional operating costs on the company. There is another sharp drop in 2011 due to the reduction of “Green Power” customers who preferred to use the discounted energy products according to the company’s Sustainability Report (2011, p.9) plus acquiring the Eraring Energy in this year. The APA Group, Cs Energy, AGL, Ergon, Power Water, Hydro elec and TWPS display unsteady trends. These trends are possibly a result of mergers42 which affect (positively or negatively) the efficiency level of companies (Çelen 2013) as well as structural change43 and capacity reduction which reduce the scale efficiency (Barros 2008) during the investigation period or years very close to it. Alcoa experienced drastic up and down movement from 2006 to 2015 and is the least efficient firm in the sample which is due to structural and operational expansions during this time span (Halkos and Tzeremes 2009). In addition to these reasons, firms’ economic efficiency might have been affected by the Global Financial Crisis (2007-2009) which occurred during the middle of our investigation time period. The yearly technical efficiency of firms presented in the above table is applied as the measurement of efficiency construct in our PLS-SEM model.

The trend of changes in the efficiency of the Australian electricity generating firms based on the data presented through Table 5.1 will be illustrated through Figure 5.1 as below:

42 APA Group acquired Allgas gas distribution business, GasNet Australia, Directlink electricity interconnector, and some storage facilities and pipelines throughout the study period; AGL merged with Alinta Limited and acquired Loy Yang A Power station and its adjacent coal mine within the investigation period; Hydro elec acquired the China Light and Power in 2011; Ergon Energy merged with Energex in 2016.

43 Cs Energy’s asset portfolio was changed in 2011 by transferring of Wivenhoe Power Station, undeveloped coal assets, and the Gladstone Interconnection and Power Pooling Agreement (IPPA); the electricity generation part and the electricity retail part of Power Water were divided into two government-owned corporations (Territory Generation and Jacana Energy) in 2014; expansions of TWPS in New Zealand and Southeast Asia.
5.3 Structural model results

The analysis of our PLS path model using Smart-PLS 3 software has produced the results presented in Figure 5.1 below. It presents the results of PLS algorithm calculations for all dependant and independent variables and the relationships among these variables together with the measurements of all indicators of the variables. The values of outer loadings of indicators are shown for the reflective constructs of IO, EP, FP and EF. Figure 5.1: PLS Algorithm Calculation Results obtained by Smart-PLS Analysis of PLS Path Model.
Following the procedure discussed in Chapter 4, the measurement model of the present study is assessed in the following section. In doing so, we will (1) assess the internal consistency by means of composite reliability, (2) assess the convergent validity measured by average variance extracted (AVE) and outer loadings of indicators, (3) assess discriminant validity via cross-loadings and Fornell-Larcker criterion, and (4) assess reliability of individual indicator based on outer loadings. The composite reliability and content validity of the indicators are presented by the statistical significance of outer loadings. Indicators with outer loading of less than 0.70 are weakly reliable and their removal should be considered based on the estimated impact on the content validity. However, indicators with outer loading of less than 0.40 should

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44 All these measurements are described through Chapter 4 of the present thesis.
be certainly removed (Hair et al. 2014). As will be observed through Table 5.2 as well as Figure 5.2, the outer loading of Size indicator presents small and not reliable outer loading (0.388 which is much lower than the accepted level of 0.40). The small outer loading of Size indicator is the reflection of the insignificant contribution of this indicator to the IO construct (i.e. minor influence on the internal operation of firms). Therefore, we need to remove it from the scale (as discussed through Chapter 4) and to re-run the model.

Outer loadings for indicators of the reflective constructs presented below in Table 5.2 reveal the reliability of indicators. These results confirm the significant long-run effect of environmental activities on firms’ performance rather than the short-run according to the outer loadings values (as discussed above, the maximum significance is presented by the outer loadings of EP(t-2), EP(t-3) and EP (t-4) indicators representing the firms’ environmental performance by 2, 3 and 4 year-lagged period).
Table 5.2: Outer Loadings of Reflective Constructs` Indicators

<table>
<thead>
<tr>
<th>Reflective Indicators</th>
<th>EF</th>
<th>EP</th>
<th>FP</th>
<th>IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale EF</td>
<td>0.717</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical EF</td>
<td>0.618</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allocative EF</td>
<td>0.449</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP(t-1)</td>
<td></td>
<td>0.533</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP(t-2)</td>
<td></td>
<td>0.753</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP(t-3)</td>
<td></td>
<td>0.903</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP(t-4)</td>
<td></td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP(t-5)</td>
<td></td>
<td>0.482</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPM</td>
<td></td>
<td>0.786</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPM</td>
<td></td>
<td>0.783</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROA</td>
<td></td>
<td>0.743</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROE</td>
<td></td>
<td>0.642</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td></td>
<td></td>
<td>0.532</td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td></td>
<td></td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td>0.388</td>
<td></td>
</tr>
<tr>
<td>Tech</td>
<td></td>
<td></td>
<td>0.81</td>
<td></td>
</tr>
</tbody>
</table>

The new model resulted a satisfactory level of outer loadings as presented in Figure 5.3 and Table 5.3 as follows:
Through the second run of the model as presented above, the outer loading of Allocative Efficiency indicator is reduced to 0.404 which is relatively low according to the relevant rule of thumb. The small outer loading of this indicator reflects its very low level of contribution to the EF construct. However, we do not remove the Allocative Efficiency indicator until after the bootstrap analysis to evaluate its statistical significance (as discussed through Sub-section 4.5.3 of the Chapter 4 in the present thesis).

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45 To remove the indicators with outer loadings of below 0.4 and make further analysis of the significance of indicators with outer loadings of between 0.4 and 0.7.
Table 5.3: Outer Loadings of Reflective Constructs’ Indicators

<table>
<thead>
<tr>
<th>Reflective Indicators</th>
<th>EF</th>
<th>EP</th>
<th>FP</th>
<th>IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale Efficiency (Scale EF)</td>
<td>0.736</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Efficiency (Technical EF)</td>
<td>0.624</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allocative Efficiency (Allocative EF)</td>
<td>0.404</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Performance-1 years lagged (EP(t-1))</td>
<td></td>
<td>0.529</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Performance-2 years lagged (EP(t-2))</td>
<td></td>
<td>0.749</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Performance-3 years lagged (EP(t-3))</td>
<td></td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Performance-4 years lagged (EP(t-4))</td>
<td></td>
<td>0.713</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Performance-5 years lagged (EP(t-5))</td>
<td></td>
<td>0.488</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Profit Margin (GPM)</td>
<td></td>
<td>0.792</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Profit Margin (NPM)</td>
<td></td>
<td>0.779</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return on Assets (ROA)</td>
<td></td>
<td>0.736</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return on Equity (ROE)</td>
<td></td>
<td>0.633</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td></td>
<td></td>
<td></td>
<td>0.814</td>
</tr>
<tr>
<td>Technology Level (Tech)</td>
<td></td>
<td></td>
<td></td>
<td>0.829</td>
</tr>
<tr>
<td>Retention Ratio (RR)</td>
<td></td>
<td></td>
<td></td>
<td>0.57</td>
</tr>
</tbody>
</table>

The internal consistency of constructs is evaluated based on the value of Cronbach’s \( \alpha \) as well as the composite reliability. The satisfactory level of Cronbach’s \( \alpha \) for the construct is above 0.70 and the constructs’ composite reliability has to be within the range of 0.70 to 0.90 to be accepted as a reliable and valid construct (Hair et al. 2014). The analysis of the internal consistency of our reflective model resulted in Cronbach’s \( \alpha \) and composite reliability of higher than 0.70 which are at the satisfactory level. Table 5.4 and Figure 5.3 below summarise the results of internal consistency and composite reliability:
Table 5.4: Internal Consistency and Composite Reliability of Reflective Constructs

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Cronbach's Alpha</th>
<th>Composite Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (EF)</td>
<td>0.760</td>
<td>0.721</td>
</tr>
<tr>
<td>Environmental Performance (EP)</td>
<td>0.716</td>
<td>0.814</td>
</tr>
<tr>
<td>Environmental Standards (ES)</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Financial Performance (FP)</td>
<td>0.789</td>
<td>0.826</td>
</tr>
<tr>
<td>Internal Operation (IO)</td>
<td>0.708</td>
<td>0.787</td>
</tr>
<tr>
<td>Market Performance (MP)</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Moderating Effect of IO</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Figure 5.4: Internal Consistency and Composite Reliability

According to our observed results of construct validity analysis, the AVE values are higher than the required minimum level of 0.50. Therefore, it can be concluded that the convergent validity levels of reflective constructs are satisfactory since they all present the AVE of above 0.50. The internal convergent validity situation of the constructs of our reflective model is presented in Table 5.5 and Figure 5.4 below:
Table 5.5: Convergent Validity of Reflective Constructs

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Average Variance Extracted (AVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (EF)</td>
<td>0.566</td>
</tr>
<tr>
<td>Environmental Performance (EP)</td>
<td>0.580</td>
</tr>
<tr>
<td>Environmental Standards (ES)</td>
<td>1.000</td>
</tr>
<tr>
<td>Financial Performance (FP)</td>
<td>0.544</td>
</tr>
<tr>
<td>Internal Operation (IO)</td>
<td>0.558</td>
</tr>
<tr>
<td>Market Performance (MP)</td>
<td>1.000</td>
</tr>
<tr>
<td>Moderating Effect of IO</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Figure 5.5: AVE Values (Convergent Validity)

To evaluate the discriminant validity based on the cross loadings, Table 5.6 presents the values of cross loadings to be compared with the outer loadings of the indicators.
### Table 5.6: Cross Loadings

<table>
<thead>
<tr>
<th>Reflective Indicators</th>
<th>Cross Loading</th>
<th>Outer Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EF</td>
<td>EP</td>
</tr>
<tr>
<td>Allocative Efficiency (Allocative EF)</td>
<td>0.404</td>
<td>-0.116</td>
</tr>
<tr>
<td>Environmental Performance-1 years lagged (EP(t-1))</td>
<td>0.008</td>
<td>0.529</td>
</tr>
<tr>
<td>Environmental Performance-2 years lagged (EP(t-2))</td>
<td>-0.124</td>
<td>0.749</td>
</tr>
<tr>
<td>Environmental Performance-3 years lagged (EP(t-3))</td>
<td>-0.186</td>
<td>0.9</td>
</tr>
<tr>
<td>Environmental Performance-4 years lagged (EP(t-4))</td>
<td>-0.189</td>
<td>0.713</td>
</tr>
<tr>
<td>Environmental Performance-5 years lagged (EP(t-5))</td>
<td>-0.195</td>
<td>0.488</td>
</tr>
<tr>
<td>Environmental Standards (ES)</td>
<td>-0.183</td>
<td>0.142</td>
</tr>
<tr>
<td>Gross Profit Margin (GPM)</td>
<td>0.328</td>
<td>0.296</td>
</tr>
<tr>
<td>Reflective Indicators</td>
<td>EF</td>
<td>EP</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Net Profit Margin (NPM)</td>
<td>0.082</td>
<td>0.181</td>
</tr>
<tr>
<td>Price/ Earnings Ratio (PE)</td>
<td>-0.026</td>
<td>0.405</td>
</tr>
<tr>
<td>Return on Assets (ROA)</td>
<td>0.154</td>
<td>0.112</td>
</tr>
<tr>
<td>Return on Equity (ROE)</td>
<td>0.137</td>
<td>0.023</td>
</tr>
<tr>
<td>Retention Ratio (RR)</td>
<td>0.215</td>
<td>-0.073</td>
</tr>
<tr>
<td>Risk</td>
<td>0.305</td>
<td>-0.113</td>
</tr>
<tr>
<td>Scale Efficiency (Scale EF)</td>
<td>0.736</td>
<td>-0.161</td>
</tr>
<tr>
<td>Technology (Tech)</td>
<td>0.461</td>
<td>-0.14</td>
</tr>
<tr>
<td>Technical Efficiency (Technical EF)</td>
<td>0.624</td>
<td>-0.124</td>
</tr>
</tbody>
</table>

| Cross Loading                        |      |      |      |      |      |      | Outer Loading             |      |      |      |      |      |
|---------------------------------------|------|------|------|------|------|------|---------------------------|------|------|------|------|------|------|
| EF                                     |      |      |      |      |      |      | EF                        |      |      |      |      |      |
| EP                                     |      |      |      |      |      |      | EP                        |      |      |      |      |      |
| ES                                     |      |      |      |      |      |      | ES                        |      |      |      |      |      |
| FP                                     |      |      |      |      |      |      | FP                        |      |      |      |      |      |
| IO                                     |      |      |      |      |      |      | IO                        |      |      |      |      |      |
| MP                                     |      |      |      |      |      |      | MP                        |      |      |      |      |      |
| Net Profit Margin (NPM)               |      |      |      |      |      |      | 0.779                     |      |      |      |      |      |
| Price/ Earnings Ratio (PE)            |      |      |      |      |      |      | 1                         |      |      |      |      |      |
| Return on Assets (ROA)                |      |      |      |      |      |      | 0.736                     |      |      |      |      |      |
| Return on Equity (ROE)                |      |      |      |      |      |      | 0.633                     |      |      |      |      |      |
| Retention Ratio (RR)                  |      |      |      |      |      |      | 0.153                     |      |      |      |      |      |
| Risk                                  |      |      |      |      |      |      | 0.814                     |      |      |      |      |      |
| Scale Efficiency (Scale EF)           |      |      |      |      |      |      | 0.736                     |      |      |      |      |      |
| Technology (Tech)                     |      |      |      |      |      |      | 0.829                     |      |      |      |      |      |
| Technical Efficiency (Technical EF)   |      |      |      |      |      |      | 0.624                     |      |      |      |      |      |
The above table presents both cross loadings and outer loadings of the indicators to test for discriminant validity. When indicators’ cross loadings are greater than their outer loadings, there is a discriminant validity issue representing unfavourable distinctive level of a construct from other constructs (Hair, Hult et al. 2014). Comparing the obtained results of cross loadings with outer loadings above through the Table 5.6, we can conclude that there is no discriminant validity problem since the outer loadings of the indicators are higher than cross loadings. These results confirm the uniqueness of the indicators’ phenomena.

The Fornell-Larcker criterion is the second method to evaluate the reflective constructs for the discriminant validity. For this purpose, the square root of the AVE values are compared with the latent variable correlations and the satisfactory level is the square root of AVE higher than the highest correlation with any other construct for every construct. The obtained results from the Fornell-Larcker criterion are presented in Table 5.7.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>EF</th>
<th>EP</th>
<th>ES</th>
<th>FP</th>
<th>IO</th>
<th>MP</th>
<th>Moderating Effect of IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (EF)</td>
<td>0.604</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Performance (EP)</td>
<td>-0.222</td>
<td>0.693</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Standard (ES)</td>
<td>-0.183</td>
<td>0.142</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial Performance (FP)</td>
<td>0.288</td>
<td>0.267</td>
<td>-0.117</td>
<td>0.738</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Operation (IO)</td>
<td>0.466</td>
<td>-0.152</td>
<td>0.006</td>
<td>0.152</td>
<td>0.747</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Performance (MP)</td>
<td>-0.026</td>
<td>0.405</td>
<td>0.103</td>
<td>0.119</td>
<td>-0.132</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Moderating Effect of IO</td>
<td>-0.159</td>
<td>-0.191</td>
<td>-0.054</td>
<td>-0.269</td>
<td>-0.168</td>
<td>-0.002</td>
<td>1.000</td>
</tr>
</tbody>
</table>

According to the calculated results presented in Table 5.8, we note that the square roots of the AVEs (in italic bold font) for our reflective constructs are higher than the correlations of this construct with other latent variables (on normal font) in our path model. Therefore, the Fornell-Larcker criterion is also fulfilled indicating the satisfactory level of discriminant validity of all constructs. All obtained results to evaluate our reflective
measurement model which has been discussed above are summarised through the Table 5.8 as follows:

Table 5.8: Summary of Results for Reflective Measurement Model

<table>
<thead>
<tr>
<th>Latent Variable</th>
<th>Indicators</th>
<th>Loadings</th>
<th>Cronbach’s Alpha</th>
<th>Composite Reliability</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP</td>
<td>EP (t-1)</td>
<td>0.529</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EP (t-2)</td>
<td>0.749</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EP (t-3)</td>
<td>0.900</td>
<td></td>
<td>0.716</td>
<td>0.814</td>
</tr>
<tr>
<td></td>
<td>EP (t-4)</td>
<td>0.713</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EP (t-5)</td>
<td>0.488</td>
<td></td>
<td></td>
<td>0.580</td>
</tr>
<tr>
<td>FP</td>
<td>GPM</td>
<td>0.792</td>
<td></td>
<td>0.789</td>
<td>0.826</td>
</tr>
<tr>
<td></td>
<td>NPM</td>
<td>0.779</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ROA</td>
<td>0.736</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ROE</td>
<td>0.633</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IO</td>
<td>Risk</td>
<td>0.814</td>
<td></td>
<td>0.708</td>
<td>0.787</td>
</tr>
<tr>
<td></td>
<td>RR</td>
<td>0.570</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tech</td>
<td>0.829</td>
<td></td>
<td></td>
<td>0.558</td>
</tr>
<tr>
<td>EF</td>
<td>Allocative EF</td>
<td>0.404</td>
<td></td>
<td>0.760</td>
<td>0.721</td>
</tr>
<tr>
<td></td>
<td>Scale EF</td>
<td>0.736</td>
<td></td>
<td></td>
<td>0.566</td>
</tr>
<tr>
<td></td>
<td>Technical EF</td>
<td>0.624</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Through the first run of the analysis model, Size indicator shows a small value (as presented through Figure 5.1) and therefore, we omitted this indicator from the EP construct. The outer loadings resulted from the second run of the analysis are of higher statistical significance and hence, reliability (as presented through figure 5.2). Cronbach’s alpha is a traditional and conservative measure to estimate the reliability of the observed variables on the basis of their inter correlation (Henseler et al. 2009). Because of the sensitivity of Cronbach’s alpha to the volume of scale, we applied the composite reliability to deal with different outer loadings of the indicator variables (Nemati, Safooei et al. 2016). Our analysis of internal consistency and reliability represents a satisfactory level (Cronbach’s α and composite reliability level of higher than 0.70) as observed through the above summary Table.
The AVE is employed to assess the convergent validity, “the extent to which a measure correlates positively with alternative measures of the same construct” (Hair et al. 2014, p.102). Our AVE value of higher than the minimum threshold which is 0.50 confirms the optimum level of convergent validity of indicators.

Discriminant validity is measured by means of assessment of the cross loadings of the indicators and the Fornell-Larcker criterion to find out the “extent to which a construct is truly distinct from other constructs, in terms of how much it correlates with other constructs, as well as how much indicators represent only a single construct” (Hair et al. 2014, p.115). The obtained results of our analysis revealed no discriminant validity issue for our constructs because of outer loadings of the indicators higher than cross loadings as well as square root of AVE higher than the correlation of constructs.

### 5.4 Results for the Evaluation of the PLS-SEM Structural Model

As discussed through sections 4.4.2 to 4.4.4 of Chapter 4, the following steps will be taken to assess the structural model.

#### 5.4.1 Collinearity Valuation

To test collinearity, each set of predictor constructs are assessed individually for each sub-part of the structural model. Hence, it is required to clarify if there are significant levels of collinearity between every set of predictor variables. Tolerance levels below 0.20 (VIF above 5.00) in the predictor constructs reflects undesirable and high level of collinearity. In the existence of collinearity problem, the alternatives are to delete constructs, merge predictors into a sole construct or make higher-order constructs to overcome collinearity problems (Low, Ong et al. 2017). Table 5.9 presents the results of collinearity test of the inner model.
Table 5.9: Inner VIF Values

<table>
<thead>
<tr>
<th>Constructs</th>
<th>EP</th>
<th>FP</th>
<th>IO</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (EF)</td>
<td>1.352</td>
<td>1.052</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Environmental Performance (EP)</td>
<td></td>
<td>1.052</td>
<td></td>
<td>1.077</td>
</tr>
<tr>
<td>Environmental Standards (ES)</td>
<td></td>
<td></td>
<td></td>
<td>1.052</td>
</tr>
<tr>
<td>Financial Performance (FP)</td>
<td></td>
<td></td>
<td></td>
<td>1.077</td>
</tr>
<tr>
<td>Internal Operation (IO)</td>
<td>1.305</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderating Effect of IO</td>
<td></td>
<td></td>
<td></td>
<td>1.044</td>
</tr>
</tbody>
</table>

The above table indicates the satisfactory VIF values of the constructs since they are all less than 5 and therefore, no significant level of collinearity.

5.4.2 Bootstrapping Results: Structural Model Path Coefficients

The estimates resulted from running the PLS-SEM algorithm for the path coefficients signify the hypothesized relationships among the constructs. Estimated path coefficients close to +1 imply strong positive relationships (almost always statistically significant) and those closing to -1 represent strong negative relationship since the standardized values for the path coefficients are between -1 to +1. “The closer the estimated coefficients are to 0, the weaker the relationships. Very low values close to 0 are usually nonsignificant (i.e., not significantly different from zero)” (Hair et al. 2014, p.171). Our estimated path coefficients and the R² values of the endogenous constructs (inside the circles) were displayed via Figure 5.2.

To evaluate the significance of the variables in the measurement model, the empirical t values are compared to the critical values. At the 97.5% confidence level46, the critical value (z score) is 1.96 and any empirical t value above this value indicates the statistical significance of the coefficient47. The significance of a coefficient ultimately depends on its standard error and is resulted through bootstrapping procedure. Calculation of the empirical t value is allowed

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46 Determined through the model analysis based on the objective of the study as described in Chapter 4 of the present study.
47 The procedure and formulae are elaborated through Chapter 4 of the present thesis.
by the bootstrap standard error (as discussed in Chapter 4). Table 5.10 presents the results of our path coefficients analysis:

**Table 5.10: Relevance and Significance of Path Confidents**

<table>
<thead>
<tr>
<th>Relationships of Constructs</th>
<th>Original Sample (O)</th>
<th>Sample Mean (M)</th>
<th>Standard Deviation (STDEV)</th>
<th>T Statistics (O/STDEV)</th>
<th>P Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF -&gt; EP</td>
<td>-0.194</td>
<td>-0.178</td>
<td>0.092</td>
<td>2.115</td>
<td>0.017</td>
</tr>
<tr>
<td>EF -&gt; FP</td>
<td>0.365</td>
<td>0.387</td>
<td>0.069</td>
<td>5.294</td>
<td>0.000</td>
</tr>
<tr>
<td>EF -&gt; IO</td>
<td>0.466</td>
<td>0.455</td>
<td>0.086</td>
<td>5.400</td>
<td>0.000</td>
</tr>
<tr>
<td>EP -&gt; FP</td>
<td>0.348</td>
<td>0.329</td>
<td>0.123</td>
<td>2.829</td>
<td>0.002</td>
</tr>
<tr>
<td>EP -&gt; MP</td>
<td>0.401</td>
<td>0.382</td>
<td>0.164</td>
<td>2.442</td>
<td>0.017</td>
</tr>
<tr>
<td>ES -&gt; EP</td>
<td>0.095</td>
<td>0.095</td>
<td>0.071</td>
<td>1.339</td>
<td>0.040</td>
</tr>
<tr>
<td>FP -&gt; MP</td>
<td>0.012</td>
<td>0.014</td>
<td>0.068</td>
<td>0.179</td>
<td>0.082</td>
</tr>
<tr>
<td>IO -&gt; EP</td>
<td>-0.101</td>
<td>-0.115</td>
<td>0.110</td>
<td>0.922</td>
<td>0.000</td>
</tr>
<tr>
<td>Moderating Effect of IO -&gt; EP</td>
<td>-0.232</td>
<td>-0.217</td>
<td>0.104</td>
<td>2.226</td>
<td>0.013</td>
</tr>
</tbody>
</table>

As observed in Table 5.10, the efficiency level of the Australian electricity producing firms imposes a strong impact on their environmental performance presented by the significant statistical relationship between EF and EP constructs supporting 1st hypothesis. The relationship between EF and IO constructs is the strongest one indicating the significant effect of the Australian electricity producing firms’ efficiency level on their internal operation approving our hypothesis number 2. There is a relative significant relationship between the IO and EP constructs, but the significance of this relationship is increased when it is moderated by through the efficiency level of firms. This important effect of the internal operation of the firms in the sample on their environmental performance verifies the hypotheses number 3 and 4 of the study. EF construct imposes a significant statistical impact on the FP construct as well which supports the hypothesis number 5. The statistically significant relationship between EP and FP construct approves our hypothesis number 6 presenting the important impact of the environmental performance of the Australian electricity producing firms on their financial performance. The impact of the EP construct on the MP construct implies the important effect of the environmental performance on the market performance of the Australian electricity
producing firms confirming our 7th hypothesis. Since the indicators of the financial performance are accounting-based and short-term measures and the indicator of the market performance represents the long-term measures of firms’ performance, the hypothesis number 8 is also supported. The relative statistically significant relationship between ES and EP construct confirms the hypothesis number 9 because of the strong influence of the application of environmental standards and frameworks on the environmental performance of the Australian electricity producing firms. There is a statistically weak relationship between the FP and MP constructs but the hypothesis number 10 is approved since the financial performance of the Australian electricity producing firms influences their market performance. The bootstrap complete results are illustrated below within our structural model in figure 5.5:

**Figure 5.6: Bootstrap Analysis Results**
5.4.3 Coefficient of Determination (R² Value)

To assess the model’s predictive precision the R² Value is measured as the squared correlation between a specific endogenous construct’s real and predicted values. The results we obtained from the R² and R² adjusted value analysis are presented in Table 5.11 and Figure 5.6.

Table 5.11: R² Values Test Statistics

<table>
<thead>
<tr>
<th>Constructs</th>
<th>R Square</th>
<th>R Square Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Performance (EP)</td>
<td>0.117</td>
<td>0.091</td>
</tr>
<tr>
<td>Financial Performance (FP)</td>
<td>0.198</td>
<td>0.187</td>
</tr>
<tr>
<td>Internal Operation (IO)</td>
<td>0.218</td>
<td>0.212</td>
</tr>
<tr>
<td>Market Performance (MP)</td>
<td>0.164</td>
<td>0.152</td>
</tr>
</tbody>
</table>

Figure 5.7: R² Values

The dimension of R² value is between 0 and 1 and values closer to 1 represent higher level of predictive precision. According to the above results, EP construct presents R² value lower than other constructs and hence, lower predictive accuracy. The low predictive accuracy of the EP construct negatively affects the answers to research questions 3, 5 and 6. However, an intrinsic bias of this approach causes higher R² value when there are more paths pointing towards a target construct. Also, this measure is the most appropriate to test the predictive accuracy of
models with fewer exogenous variables. Therefore, the R² values are not sufficient for model selection in the present study and we will further test the model to analyse its predictive accuracy according to the effect size of $f^2$ in the next section.

5.4.4 The Effect Size of $f^2$

In order to test the effect of the exogenous constructs on the endogenous ones, we will test the alternative R² values when the exogenous construct is deleted from the model. This criterion is called the $f^2$ effect size and measured through two runs of the PLS Algorithm with and without exogenous constructs. The obtained results of $f^2$ effect size analysis are presented in Table 5.12 and Figure 5.7 as below:

<table>
<thead>
<tr>
<th>Constructs</th>
<th>EP</th>
<th>FP</th>
<th>IO</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (EF)</td>
<td>0.032</td>
<td>0.158</td>
<td>0.278</td>
<td></td>
</tr>
<tr>
<td>Environmental Performance (EP)</td>
<td></td>
<td>0.144</td>
<td></td>
<td>0.179</td>
</tr>
<tr>
<td>Environmental Standards (ES)</td>
<td></td>
<td>0.228</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial Performance (FP)</td>
<td></td>
<td></td>
<td></td>
<td>0.120</td>
</tr>
<tr>
<td>Internal Operation (IO)</td>
<td>0.217</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderating Effect of IO</td>
<td>0.059</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.8: Results of $f^2$ Analysis
According to the rule of thumb (0.02 is a small effect size, 0.15 is a medium and 0.35 is a large effect sizes), EF construct presents a small $f^2$ effect size on EP construct, a large effect on IO construct and a medium effect on FP construct. Therefore, the EF construct explains the EP construct with lower precision than it explains IO and FP constructs. Also, IO has a medium effect on EP while EP imposes medium effect on FP and MP. In other words, IO construct explains EP construct with an acceptable accuracy and EP construct explains FP construct with an acceptable accuracy too. Also, higher accuracy of the impact of the EP construct on the MP construct (comparing to the impact of the EP construct on FP construct) strongly supports our hypothesis number 3 claiming the negative short-run and positive long-run impact of the environmental performance of firms on their financial performance. Through the next section, we will further test the model via Blindfolding approach which is specifically applicable to test the predictive accuracy of the reflective measurement model with higher precision.

5.4.5 Blindfolding and Predictive Relevance Q2
The blindfolding technique is applied to evaluate the predictive relevance of the endogenous constructs of our structural model. It signifies an extent of how well the path model can calculate the initially observed values (Hair et al. 2014). The obtained $Q^2$ values estimated by the blindfolding procedure are presented in table 5.13 as follow.

---

48 FP construct is consisted of accounting-based measures indicating short-term performance of firms and MP construct is measured by the market-based measures indicating long-term performance of firms.
Since the $Q^2$ values of our endogenous constructs are above zero (table 5.13), our model has favourable predictive relevance. In addition to the predictive relevance of the model, there is a risk of unobserved heterogeneity which threatens the validity of the model. In order to identify the heterogeneity and deal with this situation, we have used the finite mixture modelling (FIMIX-PLS) which is the most applicable approach by the PLS-SEM technique and the results will be presented within the next section.

### 5.4.6 Heterogeneity: Finite Mixture Modelling (FIMIX) PLS

The heterogeneity of observations, which is a threat to the validity of results, is another important feature of structural model to be tested. The heterogeneity, which is not always entirely detectible in a sample, known as unobserved heterogeneity, may result in inaccurate estimation of PLS path model. Therefore, we employed the FIMIX-PLS to assess the PLS path modelling results and thereby, ascertain that unobserved heterogeneity in the inner path model would not affect the results of the whole model estimates (Ringle, Wende et al. 2010). Table 5.14 presents the fit indices-model selection as discussed in Chapter 4.

---

<table>
<thead>
<tr>
<th>Constructs</th>
<th>SSO</th>
<th>SSE</th>
<th>$Q^2 (=1-SSE/SSO)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (EF)</td>
<td>438.000</td>
<td>434.000</td>
<td></td>
</tr>
<tr>
<td>Environmental Performance (EP)</td>
<td>570.000</td>
<td>561.000</td>
<td>0.279</td>
</tr>
<tr>
<td>Environmental Standards (ES)</td>
<td>150.000</td>
<td>150.000</td>
<td></td>
</tr>
<tr>
<td>Financial Performance (FP)</td>
<td>566.000</td>
<td>525.869</td>
<td>0.178</td>
</tr>
<tr>
<td>Internal Operation (IO)</td>
<td>572.000</td>
<td>520.293</td>
<td>0.191</td>
</tr>
<tr>
<td>Market Performance (MP)</td>
<td>149.000</td>
<td>135.217</td>
<td>0.099</td>
</tr>
<tr>
<td>Moderating Effect of IO</td>
<td>148.000</td>
<td>148.000</td>
<td></td>
</tr>
</tbody>
</table>

---

Table 5.13: The Cross-Validated Redundancy
Table 5.14: FIMIX Fit Indices-Model Selection

<table>
<thead>
<tr>
<th>Metric</th>
<th>K=2</th>
<th>K=3</th>
<th>K=4</th>
<th>K=5</th>
<th>K=6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AIC</strong> (Akaike's Information Criterion)</td>
<td>270.004</td>
<td>247.014</td>
<td>245.619</td>
<td>241.002</td>
<td>241.910</td>
</tr>
<tr>
<td><strong>AIC3</strong> (Modified AIC with Factor 3)</td>
<td>276.854</td>
<td>257.694</td>
<td>259.610</td>
<td>259.536</td>
<td>264.989</td>
</tr>
<tr>
<td><strong>AIC4</strong> (Modified AIC with Factor 4)</td>
<td>280.616</td>
<td>270.010</td>
<td>278.009</td>
<td>279.530</td>
<td>285.110</td>
</tr>
<tr>
<td><strong>BIC</strong> (Bayesian Information Criteria)</td>
<td>290.050</td>
<td>277.879</td>
<td>289.002</td>
<td>292.964</td>
<td>305.941</td>
</tr>
<tr>
<td><strong>CAIC</strong> (Consistent AIC)</td>
<td>296.866</td>
<td>289.169</td>
<td>303.122</td>
<td>312.940</td>
<td>328.939</td>
</tr>
<tr>
<td><strong>HQ</strong> (Hannan Quinn Criterion)</td>
<td>279.115</td>
<td>261.005</td>
<td>265.022</td>
<td>263.105</td>
<td>267.916</td>
</tr>
<tr>
<td><strong>MDL5</strong> (Minimum Description Length with Factor 5)</td>
<td>423.963</td>
<td>489.001</td>
<td>576.261</td>
<td>657.785</td>
<td>745.056</td>
</tr>
<tr>
<td><strong>LnL</strong> (LogLikelihood)</td>
<td>-125.362</td>
<td>-115.014</td>
<td>-109.104</td>
<td>-102.423</td>
<td>-97.905</td>
</tr>
<tr>
<td><strong>EN</strong> (Entropy Statistic (Normed))</td>
<td>0.730</td>
<td>0.539</td>
<td>0.579</td>
<td>0.610</td>
<td>0.640</td>
</tr>
<tr>
<td><strong>NFI</strong> (Non-Fuzzy Index)</td>
<td>0.789</td>
<td>0.475</td>
<td>0.488</td>
<td>0.485</td>
<td>0.488</td>
</tr>
<tr>
<td><strong>NEC</strong> (Normalized Entropy Criterion)</td>
<td>31.112</td>
<td>55.382</td>
<td>52.006</td>
<td>47.955</td>
<td>45.893</td>
</tr>
</tbody>
</table>

As can be observed through our findings presented in the Table 5.14, these information criteria are met for the three-segment solution confirming the validity of the model.

Under the parametric CSA analysis, the difference between observed and replicated covariance are minimized through model estimation. However, “the PLS-PM algorithm does not optimize any global scalar function and, hence, does not offer comparable global GoF criteria” (Sarstedt and Ringle 2009, p.14) and the $R^2$ values are the main evaluation criteria for the inner model. Table 5.15 presents the FIMIX-PLS results as below:
Table 5.15: FIMIX Results for Three-Segment Solution

<table>
<thead>
<tr>
<th></th>
<th>Segment 1</th>
<th>Segment 2</th>
<th>Segment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relative Segment size</strong></td>
<td>0.103</td>
<td>0.423</td>
<td>0.574</td>
</tr>
<tr>
<td><strong>Path Coefficients</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF → EP</td>
<td>-0.165</td>
<td>0.122</td>
<td>0.515</td>
</tr>
<tr>
<td>EF → FP</td>
<td>0.231</td>
<td>0.740</td>
<td>0.018</td>
</tr>
<tr>
<td>EF → IO</td>
<td>0.245</td>
<td>0.660</td>
<td>0.573</td>
</tr>
<tr>
<td>EP → FP</td>
<td>-0.080</td>
<td>-0.351</td>
<td>0.930</td>
</tr>
<tr>
<td>EP → MP</td>
<td>0.935</td>
<td>-0.545</td>
<td>-0.660</td>
</tr>
<tr>
<td>ES → EP</td>
<td>-0.134</td>
<td>0.348</td>
<td>-0.095</td>
</tr>
<tr>
<td>IO → EP</td>
<td>-0.632</td>
<td>0.571</td>
<td>0.250</td>
</tr>
<tr>
<td><strong>Moderating Effect of IO → EP</strong></td>
<td>0.119</td>
<td>0.681</td>
<td>0.325</td>
</tr>
<tr>
<td><strong>R²</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP</td>
<td>0.639</td>
<td>0.598</td>
<td>0.564</td>
</tr>
<tr>
<td>FP</td>
<td>0.471</td>
<td>0.345</td>
<td>0.829</td>
</tr>
<tr>
<td>IO</td>
<td>0.268</td>
<td>0.501</td>
<td>0.340</td>
</tr>
<tr>
<td>MP</td>
<td>0.901</td>
<td>0.316</td>
<td>0.452</td>
</tr>
</tbody>
</table>

According to the summarised FIMIX-PLS results in the above table, EF construct imposes the strongest impact on EP construct in segment 3 while its relationship with IO construct and FP construct are at the maximum effect in segment 2. The strongest impact of EP construct on FP construct is in segment 3 and on MP construct in segment 1. ES and IO constructs impose the strongest impact on EP constructs in segment 2.

The increased R² values resulted from the group-specific PLS-SEM compared to the original R² values (0.117 for EP construct, 0.198 for FP construct, 0.218 for IO construct and 0.164 for MP construct) are indication of the enhanced inclusive explanatory power of the inner model (Sarstedt and Ringle 2009) plus the AVE value beyond 0.5 (the AVE threshold value as presented in Table 5.5 of this chapter).

5.5 EP-FP Relationship in Different Regions

In order to study the sensitivity of the relationship between environmental activities of firms and their financial performance to the geographical regions, we have separately run the model for every single state and territory in which every firm in the sample operates. As described in Chapter 4 of the present study and presented by Figure 4.2, the regional factors are considered
via modified model as the RD (Regional Dummy) construct. The results obtained from this analysis are presented through Table 5.16 as follows:

**Table 5.16: Environmental Performance in Different Regions**

<table>
<thead>
<tr>
<th>Relationship Region of Operation</th>
<th>NSW</th>
<th>NT</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
<th>VIC</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RD→EP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path Coefficient</td>
<td>0.146</td>
<td>0.210</td>
<td>0.090</td>
<td>0.146</td>
<td>0.142</td>
<td>0.146</td>
<td>-0.120</td>
</tr>
<tr>
<td>Significance</td>
<td>1.831</td>
<td>3.28</td>
<td>1.963</td>
<td>1.989</td>
<td>2.798</td>
<td>1.740</td>
<td>1.991</td>
</tr>
<tr>
<td><strong>EP→FP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path Coefficient</td>
<td>0.349</td>
<td>0.359</td>
<td>0.349</td>
<td>0.350</td>
<td>0.359</td>
<td>0.352</td>
<td>0.361</td>
</tr>
<tr>
<td>Significance</td>
<td>2.783</td>
<td>3.125</td>
<td>2.895</td>
<td>2.981</td>
<td>3.210</td>
<td>3.115</td>
<td>3.364</td>
</tr>
<tr>
<td><strong>EP→MP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path Coefficient</td>
<td>0.421</td>
<td>0.440</td>
<td>0.410</td>
<td>0.403</td>
<td>0.461</td>
<td>0.410</td>
<td>0.409</td>
</tr>
<tr>
<td>Significance</td>
<td>2.393</td>
<td>2.505</td>
<td>2.435</td>
<td>2.410</td>
<td>2.520</td>
<td>2.440</td>
<td>2.430</td>
</tr>
</tbody>
</table>

The results obtained from the EP-FP analysis with consideration of the regional effects\(^{49}\) indicate that there is a relatively significant impact imposed by the regional factors on the firms’ environmental performance. The regional variables affecting the firms’ environmental performance and its relationship with financial performance and market performance can be described based on three important categories of regional factors:

---

\(^{49}\) The impact of RD construct in the EP-FP analysis (included in the 2\(^{nd}\) measurement model; Figure 4.2 in Chapter 4) is evaluated on the whole model. In fact, the model is re-run 7 times for every single state and territory in which the firms in the sample operate with the involvement of the regional variable (construct). We have only presented the relationship between RD construct with EP construct and the impact of EP construct on FP and MP constructs in order to exhibit the impact of regional factors on the firms’ environmental performance and hence, on the relationship between environmental performance of firms and their financial and market performance.
(1) Electricity Generation Mix

One major regional factor is the predominant type of electricity generation in every state and territory. The illustration of the electricity generation-mix across the Australian states and territories are presented below in Figure 5.9:

**Figure 5.9: Electricity Generation-Mix by States and Territories in 2018**

As observed through the Figure 5.8, created by the authors based on the data released by the Australian Energy statistics (2019), larger share of the electricity generation mix in South Australia and Tasmania is comprised of natural gas and renewable energy and hence, the electricity generation mix in Queensland, Northern Territory, New South Wales, Victoria and Western Australia is mostly consisted of the non-renewable resources while containing small percentage of renewable resources (Australian Government 2018). This combination of electricity production might be a result of the domination of the electricity generation by “coal-fired power plants” due to the lower cost of ignite and coal in these states (Nazifi et al. 2016, p. 14).
On the other hand, Figure 5.10 demonstrates the amount of GHG emission by the electricity producing firms operating in every state and territory as below:

**Figure 5.10:** GHG Emission from the Electricity Production by States and Territories

![Graph showing GHG emission from electricity production by states and territories.]

Source: Clean Energy Regulator, Australian Government (2019)

As observed through Figure 5.10, Queensland, Northern Territory, New South Wales, Victoria and Western Australia have the highest emission intensity respectively while South Australia and Tasmania present the smallest emissions respectively. The comparison of Figures 5.8 and 5.9 confirms the results of the RD-EP analysis presented by Table 5.16 highlighting the significance of electricity generation mix as an important factor of regional variables on firms’ environmental performance.

**2) Population Intensity**

Other than the electricity generation mix, the demographic factors such as population density of a region affect the GHG emission level. We have created two figures (Figure 5.11 and 5.11) to illustrate this relationship between population and emission from the electricity
consumption. Figure 5.12 presents the population of every states and territory in the sample as follows:

**Figure 5.11: Population of the Australian States and Territories in 2018**

![Bar chart showing population in thousands for NSW, VIC, QLD, WA, SA, TAS, and NT]

Source: Australian Bureau of Statistics (ABS 2019)

The population size of the Australian states and territory as released by the Australian Bureau of Statistics (ABS 2019) is illustrated based on size order by Figure 5.11. The presentation of the emission level from electricity consumption in every state and territory is provided below in the Figure 5.12:
Higher electricity consumption will lead to higher GHG emission when using fossil fuel in the electricity generation mix (Nnaji, Chukwu et al. 2013). This relationship between the electricity consumption and GHG emission is confirmed in the Australian states and territory through the illustration provided by Figures 5.11 and 5.12. The comparison between GHG emission from electricity consumption in every state and territory (Figure 5.12) and the population of identical states and territory (Figure 5.11) presents the obvious relationship between population size and emission level in every region. In fact, based on these information, larger population indicates higher electricity consumption and hence, higher GHG emission. This implies the necessity of low emission resources and technologies in the process of electricity generation.


50 The GHG emission levels from electricity consumption in Tasmania and Northern Territory are too small for the scale of the diagram.
(3) Type of Electricity Users

Also, type of the users is influential in the emission level by the electricity sector and according to the Annual Report of the Energy Security board (2018) commercial and industrial electricity consumers have a larger consumption share than the residential consumers which indicates a larger share of GHG emissions by the commercial and industrial consumers. The consumer composition of the Australian Electricity Market (NEM) in 2018 is illustrated in the Figure 5.13 as follows:

**Figure 5.13: Electricity Consumers in NEM 2017-18**

Data Source: The Health of the National Electricity Market (2018)

In the long-run, there is a direct relationship between economic activity (commercial and industrial) and electricity consumption as well as the direct relationship between electricity consumption and GHG emission (Palamalai, Ravindra et al. 2015). According to the ABS (2018), the intensity of the economic activity in New South Wales, Victoria and Queensland are higher than the other states. Matching this information released by the ABS (2018) with the results presented by Figure 5.12 (GHG emission from electricity consumption in every state
and territory) highlights the significance of the type of electricity users on the environmental emission level across different regions.

The results obtained from our analysis are discussed above on the basis of three different categories of the regional factors influencing the environmental performance of firms operating in every state and territory. The above discussions highlight the necessity of the environmental policies (which is also supported by the legitimacy theory) to be designed and implemented by the States governments to comply with the regional factors across various states and territories along with the national policies implemented by the Federal government of Australia. We recommend policy makers to develop energy policies focusing on “the end-user metering and pricing” encouraging consumers to decrease their electricity costs and hence, emission reduction along with policies persuading the application of low emission resources in electricity generation process (Nelson and Orton 2016, p.157). Also, policy strategies designed and implemented based on the demand for the type of electricity (either coal- or green-generation mix of electricity) are expected to cause emission reduction (Palamalai et al. 2015).

5.6 Hypothesis Testing

In order to investigate the relationship between environmental performance of Australian electricity producers and their financial performance, our proposed PLS-SEM model tested the hypotheses indicated in the path model in the next page.
Figure 5.14: Hypotheses Testing

The hypothesis indicated in the above path model is tested through the bootstrapping analysis in Smart PLS3. In addition, the tests for the impact of Regional Dummies plus the application of environmental standards are demonstrated through Figure 5.15 as below:
The results of the above analysis are summarised in Table 5.17 as follows:
<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Relationships</th>
<th>Path Coefficient</th>
<th>T values</th>
<th>P values</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: There is no relationship between Efficiency and Environmental Performance of Australian electricity generation firms.</td>
<td>EF → EP</td>
<td>0.194</td>
<td>2.115</td>
<td>0.017</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2: There is no relationship between Efficiency and Internal Operations of Australian electricity generation firms.</td>
<td>EF → IO</td>
<td>0.466</td>
<td>5.400</td>
<td>0.000</td>
<td>Rejected</td>
</tr>
<tr>
<td>H3: There is no relationship between Internal Performance and Environmental Performance of Australian electricity generation firms.</td>
<td>IO → EP</td>
<td>0.101</td>
<td>0.922</td>
<td>0.020</td>
<td>Rejected</td>
</tr>
<tr>
<td>H4: Internal Operations does not play a mediatary role between the Efficiency and Environmental Performance of Australian electricity generation firms.</td>
<td>Moderating effect of IO → EP</td>
<td>0.232</td>
<td>2.226</td>
<td>0.013</td>
<td>Rejected</td>
</tr>
<tr>
<td>H5: There is no relationship between Efficiency and Financial Performance of Australian electricity generation firms.</td>
<td>EF → FP</td>
<td>0.365</td>
<td>5.294</td>
<td>0.000</td>
<td>Rejected</td>
</tr>
<tr>
<td>H6: There is no relationship between Environmental Performance and Financial Performance of Australian electricity generation firms.</td>
<td>EP → FP</td>
<td>0.348</td>
<td>2.829</td>
<td>0.002</td>
<td>Rejected</td>
</tr>
<tr>
<td>H7: There is no relationship between Environmental Performance and Market Performance of Australian electricity generation firms.</td>
<td>EP → MP</td>
<td>0.401</td>
<td>2.442</td>
<td>0.017</td>
<td>Rejected</td>
</tr>
<tr>
<td>H8: There is no future (long-run) financial advantages for Australian electricity generation firms as a result of Environmental Performance and Financial Performance.</td>
<td>EP(t-1) → EP</td>
<td>0.529</td>
<td>1.302</td>
<td>0.046</td>
<td>Rejected</td>
</tr>
<tr>
<td></td>
<td>EP(t-2) → EP</td>
<td>0.749</td>
<td>2.238</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EP(t-3) → EP</td>
<td>0.9</td>
<td>4.191</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EP(t-4) → EP</td>
<td>0.713</td>
<td>2.947</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EP(t-5) → EP</td>
<td>0.488</td>
<td>2.035</td>
<td>0.021</td>
<td></td>
</tr>
<tr>
<td>H9: There is no relationship between Environmental Standards and Environmental Performance of Australian electricity generation firms.</td>
<td>ES → EP</td>
<td>0.095</td>
<td>1.339</td>
<td>0.040</td>
<td>Rejected</td>
</tr>
<tr>
<td>H10: There is no relationship between Financial Performance and Market Performance of Australian electricity generation firms.</td>
<td>FP → MP</td>
<td>0.012</td>
<td>0.179</td>
<td>0.082</td>
<td>Accepted</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>Relationships</td>
<td>Path Coefficient</td>
<td>T values</td>
<td>P values</td>
<td>Result</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>---------------</td>
<td>------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>H11: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Queensland and those in other states.</td>
<td>EP → FP/ QLD</td>
<td>0.349</td>
<td>2.895</td>
<td>0.003</td>
<td>Rejected</td>
</tr>
<tr>
<td>H12: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in New South Wales and those in other states.</td>
<td>EP → FP/ NSW</td>
<td>0.349</td>
<td>2.783</td>
<td>0.003</td>
<td>Rejected</td>
</tr>
<tr>
<td>H13: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Victoria and those in other states.</td>
<td>EP → FP/ VIC</td>
<td>0.352</td>
<td>3.115</td>
<td>0.003</td>
<td>Rejected</td>
</tr>
<tr>
<td>H14: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in South Australia and those in other states.</td>
<td>EP → FP/ SA</td>
<td>0.350</td>
<td>2.981</td>
<td>0.002</td>
<td>Rejected</td>
</tr>
<tr>
<td>H15: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Tasmania and those in other states.</td>
<td>EP → FP/ TAS</td>
<td>0.359</td>
<td>3.210</td>
<td>0.002</td>
<td>Rejected</td>
</tr>
<tr>
<td>H16: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Northern Territory and those in other states.</td>
<td>EP → FP/ NT</td>
<td>0.359</td>
<td>3.125</td>
<td>0.002</td>
<td>Rejected</td>
</tr>
<tr>
<td>H17: There is no difference between the Environmental Performance and Financial Performance of the Australian electricity generators in Western Australia and those in other states.</td>
<td>EP → FP/ WA</td>
<td>0.361</td>
<td>3.364</td>
<td>0.002</td>
<td>Rejected</td>
</tr>
</tbody>
</table>
The findings from the Table 5.17 reveal positive and significant path coefficients between: Efficiency and Environmental Performance ($\beta=0.194$, $p=0.017$); Efficiency and Internal Operations ($\beta=0.466$, $p=0.000$); Internal Operations and Environmental performance ($\beta=0.101$, $p=0.000$); Efficiency $\rightarrow$ Internal Operations $\rightarrow$ Environmental Performance ($\beta=0.232$, $p=0.013$); Efficiency and Financial Performance ($\beta=0.365$, $p=0.000$); Environmental Performance and Financial Performance - long term effect ($\beta=0.529, 0.749, 0.900, 0.713, 0.488; p=0.046, 0.013, 0.000, 0.002, 0.021$). As a result, the null hypothesis established to explain these relationships were rejected and alternative hypothesis on the difference between these variables is accepted. On the contrary, there is a positive but non-significant relationship between the Financial Performance and Market Performance ($\beta=0.012$, $p=0.082$). Therefore, the null hypothesis describing this relationship is accepted. Table 5.17 also reveals positive and significant path coefficients between: Environmental performance and Financial Performance ($\beta=0.348$, $p=0.002$); Environmental performance and Market Performance ($\beta=0.401$, $p=0.007$); Environmental Standards and Environmental Performance ($\beta=0.095$, $p=0.040$); Environmental and financial performance of between various states ($\beta=0.349$, $p=0.002$ and 0.003). As a result, the null hypotheses of these relationships were rejected.

5.6.1 Impact of Efficiency on the Environmental performance, Internal Operation and Financial Performance

As shown in the results in the Table 5.17 above, the efficiency of Australian electricity producers has found to have a significant positive impact on environmental performance ($\beta=0.194$, $p=0.017$) indicating that improvement of firms’ efficiency level will increase their environmental performance (i.e. decrease their environmental pollution)\(^51\). Therefore, we rejected the null hypotheses of no relationship between the EF and EP constructs and

\(^51\) Our EP construct is consisted of EP indicators which are the results obtained from 1-Environmental Pollution Index (index of environmental GHG emissions as a result of operation of the Australian electricity generation firms). Therefore, our EP construct is an implication of non-polluting part of production process and hence, environmental performance (environmentally friendly performance).
accepted an alternative hypothesis of significant positive relationship between the environmental performance of the Australian electricity generation firms and their efficiency level. The relationship between the EF and IO also found to be statistically significant, rejecting the null hypothesis of no relationship and accepting the alternative hypothesis of positive significant relationship between the two constructs ($\beta=0.466$, $p=0.000$). This indicates that while significantly improving EP of the firms, the EF also improves IO of firms allowing it to contribute to the EP indirectly ($\beta=0.101$, $p=0.000$). This result supports the theoretical underpinning of resource-based view (RBV) theory which highlights the importance of the firms’ available resources and the efficient utilisation of resources in their competitiveness (Salem et al. 2012). This result is also in line with the findings of some prior studies (see for example, Galdeano-Gómez (2008), Giovanni and Vinzi (2012) and Marie et al. (2014)). The significant relationship found between IO and EP resulted in a rejection of the 3rd null hypothesis. When we examined whether there is a mediating effect of IO in improving EP of firms via efficiency improvements, we found that IO is in fact playing a mediating role ($\beta=0.232$, $p=0.013$). As a result, we rejected our 4th null hypothesis of no mediating effect between the constructs and accepted the alternative hypothesis of significant positive relationship. These finding are in line with the RBV theory$^{52}$ and the findings of Saeidi et al. (2015).

The above results indicate that efficiency of firms has been a key factor in improving the environmental performance of firms as it not only directly influences the improvement in environmental performance but also indirectly influences improvement in environmental performance through internal operations. Therefore, Australian electricity producers need to pay increased attention to efficiency as a means to improve their environmental performance

$^{52}$ The IO construct (internal operation of firms) is reflected by the firms’ available resources including technology level of firms. The RBV theory supports the significance of firms’ available resources and the efficient usage of resources on the firms’ environmental and financial performance (Salem et al. 2012) and therefore, supports our results.
(i.e. to reduce the amount of pollutants produced by firms). Enhanced efficiency might be achievable via developing the technology of the production considering the firms’ growth rate, size and risk level (in line with the studies of Clarkson et al. (2011); Nakao et al. (2007); Darnall et al. (2008); and Busch et al. (2011)) leading to higher competitive advantage (Rao and Holt 2005).

5.6.2 The Impact of efficiency and Environmental Performance on the Financial and Market Performance

An issue related to the findings in section 5.6.1 above is whether the increased efficiency has helped firms to improve their financial performance directly or indirectly through improvement of internal operations and environmental performance. The results in Table 5.17 show that efficiency has a significant positive effect on the financial performance of the firms ($\beta=0.365$, $p=0.000$). Therefore, the null hypothesis 5 that there is no significant relationship between the EF and FP is rejected while accepting the alternative hypothesis of positive significant relationship between the two constructs.

The results in Table 5.17 also show a significant positive relationship between the EP and FP constructs ($\beta=0.348$, $p=0.002$). As a result, the null hypothesis 6 of no relationship between Environmental Performance and Financial Performance of Australian electricity generation firms is rejected and the alternative hypothesis of significant positive relationship between the two constructs is accepted. Since the EP construct is measured by means of the firms’ GHG emission index reflected by the firms’ GHG emission indices (1-EP Index) within 5-year lagged period, the significant positive impact of the EP on FP indicates that improved environmental performance has resulted an improved financial performance in the sector.

Similarly, when we examined the null hypothesis 7—that here is no relationship between Environmental Performance and Market Performance of Australian electricity generation firms—we found evidence to reject the null hypothesis ($\beta=0.401$, $p=0.017$) and to accept the alternative hypothesis that the relationship between the two constructs is positive.
and significant. This indicates that the market responds positively the improvements that firms makes in improving its environmental performance.

However, the results did not find sufficient evidence to accept the null hypothesis 10 (β=0.012, p=0.082) which predicted that there no relationship between Financial Performance and Market Performance of Australian electricity generation firms. This indicates that the market is not considering financial performance of firms as a key factor when it assesses the value of Australian electricity generation firms.

Overall, these results highlight the fact that firms’ financial performance and market performance will be strengthened and improved by becoming environmentally friendly. Considering the strong relationships between environmental performance of the Australian electricity producing companies and their financial performance as well as market performance, it is important for firms who are willing to enhance their financial advantages to reduce their environmental pollution. The outcomes of this analysis are supported by both RBV and stakeholder theories based on which the firms’ competitiveness and financial performance (reflected by FP construct) lie on the firms’ resources (reflected by IO construct) and efficiency (reflected by EF construct) of resource utilisation (based on the RBV theory) as well as stakeholders’ trust and reliability on the firms (based on the stakeholder theory) which is reflected by the firms’ market performance (MP construct) in our measurement model (Salem et al. 2012). These findings are in line with the findings of a number of studies (see for example, Heras-Saizarbitoria et al. (2011), Semenova et al. (2010), Salama (2005), Gonenc and Scholter, (2017)).

The most significant impact of environmental performance on the FP and MP was evident in the third lagged year, EP (t-3) (β=0.900, p=0.000) and its lowest effect with the least significance is in the first lagged year, EP (t-1) (β=0.529, p=0.046). This result rejects the null hypothesis 8 and accepts the alternative hypothesis, indicating the positive outcomes for
environmentally friendly firms in terms of financial and market performance in the long run.\textsuperscript{53} This result is consistent with results obtained by Horváthová (2012), Lin, Yang et al. (2009), Nollet et al. (2016) and Delmas et al. (2015). This finding suggests that firms need to have a long-term view when committing to resources their environmentally friendly operations as their benefits of such operations are likely to be obtained in the long run rather than in the short run.

5.6.3 The Impact of Environmental Standards on the Environmental Performance

The relationship between environmental standards (ES) and environmental performance is found to be significantly positive ($\beta=0.095$, $p=0.040$) which resulted in the rejection of the null hypothesis 9 and acceptance of alternative hypothesis of positive significant relationship. As suggested by the standard beta coefficient, the impact that ES has on EP is relatively small. This result indicates that when firms follow the specific framework of environmental actions stipulated by the standards, they EP of the firms are likely to be higher. In other words, firms which are strictly following the ES have been more successful in reducing the environmental pollution resulting from their operations than the firms which follow these rules lightly. This findings is in line with the legitimacy theory which highlights the importance of environmental frameworks (ES construct) in attaining firms’ legitimate image by addressing social concerns and values (Sulaiman et al. 2014; Magness 2006)\textsuperscript{54} and also in line with the findings of the analysis conducted by Ghomi and Leung (2013).

\textsuperscript{53} In other words, a firm should not expect immediate financial advantages for its environmentally friendly operations.

\textsuperscript{54} The legitimacy theory believes in the importance of application of environmental standards by firms along with publicly revealing their environmental activities in order to attain legitimate image (Sulaiman et al. 2014; Magness 2006; Ghomi and Leung 2013).
5.6.4 Impact of Regional Factors on the Environmental Performance

The null hypothesis 11 to 17 assumes that there is no difference between the environmental performances of states. However, when these hypotheses were tested it was found that the impact of EP construct on FP construct did differ significantly between each state, rejecting all null hypothesis 11 to 17 and accepting the alternative hypothesis that the EP-FP performance differ from each state to the rest (H11_β=0.349, p=0.003; H12_ β=0.349, p=0.003; H13_ β=0.352, p=0.003; H14_ β=0.350, p=0.003; H15_ β=0.359, p=0.003; H16_ β=0.359, p=0.003; H17_ β=0.361, p=0.003). These results indicate that environmental performance of electricity producing firms significantly vary from state to state due to state own managerial issues, state government policies, etc. These findings are consistent with studies of Gonenc and Scholtens (2017) and Misani and Pogutz (2015) which have examined the impact of regional factors on the environmental performance.

5.7 Main Findings of the Analysis

The Australian federal government is committed to reduce the emission level by 2030 to 26-28 percent, which is less than the 2005 emission levels in Australia. Also, the country is globally obligated to restrict the global warming which is achievable by emission reduction to “net zero” by 2050 through all economic sectors. The biggest polluter accounting for 33% of the total emission, the electricity sector is identified as the major sector for achieving the set target because of its significance and high “technical potentials”. In addition, according to the Australia’s emissions projection report published by the Australian Government in December 2018, the electricity sector is required to reduce its emission by 7 percent until 2020 while the prospect is a huge increase of emission by 2020 because of the increased usage of electricity (Australian Government 2018, p. 17). Considering the incentives for improving environmental performance, Australian electricity producers have taken steps to speed up their processes to improve environmental performance leading to higher financial and market performance.
This study examined the EP-FP relationship in the context of Australian electricity industry with a view to identify the factors that have contributed for electricity producers’ environmental performance and financial and market performance. The study found efficiency of business significantly contributing the environmental performance of the businesses while efficiency also contributes positively to enhance internal operations of the businesses. The study also found that efficiency plays a mediating role in the relationship between internal operation and environmental performance of the businesses. The significance of efficiency on the improved internal operation (constructed of firms’ retention ratio, level of risk and technology), environmental performance and financial performance (constructed of accounting measures) of firms is grounded on the RBV theory which signifies the availability and efficient utilisation of firms’ resources in their competitiveness and financial advantages (Salem et al. 2012). This indicates that electricity companies need to continue to improve their level of efficiency and internal operations in order to improve their financial performance. To enhance the efficiency level, the electricity producing firms are encouraged to replace the conventional aged power plants, an action which will contribute to their environmentally friendly operation. However, firms usually avoid such transition because of its high costs.

To examine the trend of the efficiency level of the Australian electricity producing firms during the study period (2006-2017) the DEA approach is applied. The resultant efficiency scores are employed as indicators of the efficiency construct in the proposed model to find the impact of efficiency level on the firms’ environmental performance and financial performance. This is consistent with the study of Galdeano-Gómez (2008) which has measured the effect of efficiency as a part of firms’ capital structure on the relationship between environmental performance and economic performance of firms. Further, Giovanni and Vinzi (2012) and Marie et al. (2014) have controlled for the effect of efficiency (as a control variable). Deviating from previous studies, the present study employed DEA technique as the method for
measuring a latent construct of a SEM model designed to analyse its impact on the EP-FP relationship. By means of DEA, the firms’ efficiency is decomposed into its components, allocative efficiency, scale efficiency and technical efficiency, reflected by the efficiency construct in our proposed PLS-SEM model. The results obtained from our analysis present a significant impact of the firms’ efficiency level on their environmental performance and the relationship between the environmental performance and financial and market performances.

In order to evaluate the firms’ environmental performance, the present study utilised an index to measure the firms’ GHG emissions through which the emission amount is normalised based on the level of dangerousness of each type of pollutant (as discussed in chapter 4 of the present study). The ratios obtained by means of this index (which is the indicator of firms’ pollution) have been deducted from 1 (indicating the non-polluting ratio of their production process) applied as the firms’ environmental performance indicators reflected by the environmental performance (EP) construct to measure their impact on firms’ financial and market performance.

To conduct this analysis and to distinguish the EP-FP relationship from the EP-MP relationship the present study applied the PLS-SEM as the most appropriate method. Along with various capabilities of this technique compared to regression (which is the commonly used method as identified in the literature review), the PLS-SEM is realised as the only statistical technique capable of analysing variables with different roles in one measurement model with higher accuracy (Lemstra, Voogt et al. 2015). Therefore, we have examined the impact of the environmental performance on the financial performance (short-run accounting indicators) and market performance (long-run market indicators) of the firms in the sample by means of this method.

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55“Variables that are dependent in one relation and independent in another relation” (Lemstra et al. 2015, p.256).
While the high costs of clean electricity generation negatively affect firms’ financial performance, our analysis exhibited that clean production approaches will improve both financial and market performance of firms within a few financial periods after commencement of clean electricity generation technologies. The relationship between firms’ environmental performance and financial performance has been evaluated by the literature with lagged period of maximum 2 years (Horváthová 2012, Lin et al. 2009, Nollet et al. 2016 and Delmas et al. 2015). These studies failed to provide assessment of long-term impact of this relationship. In fact, no prior study has examined the EP-FP relationship of the Australian electricity producing firms within short- and long-run to reveal the financial incentives of the transition from coal-to green-production to persuade the firms to become green. Our analysis indicates the significant impact of the environmental performance on the financial and market performance after a few financial periods (the least significance in the 1st lagged period and the maximum significance in the 3rd lagged period). These findings are in line with the Porter hypothesis analysis which claims that the financial advantages of environmental performance will be assessable in the long run by the consideration of “time-varying effects” (Horváthová 2012, p.96). These results persuade to the Australian electricity producing firms to switch their production approaches to the clean resources and technology with certainty about their future financial advantages. Therefore, firms might not get immediate financial advantages of becoming environmental-friendly but can expect to financially prosper in a near future.

Furthermore, previous studies have examined the impact of environmental performance of firms on their financial performance without distinguishing the financial performance and market performance (for example Lin et al. (2009), Lee at al. (2015), Horváthová (2012), Saeidi et al. (2015), Misani and Pogutz (2015), Gatsi et al. (2016) and Konar and Cohen (2001)). In our study, financial performance is distinguished from market performance by using accounting
performance indicators such as ROA and Row to measure the financial performance and by using Tobin Q to measure the market performance. Evaluation of the effect of the environmental performance on the firms’ financial situation from both financial and market points of view clarifies the consequences and significance of the environmental performance for firms’ perspective. This study contributes to the literature by analysing the EP-FP relationship from both aspects separately. Our analysis resulted in strong impact of firms’ environmental performance on their financial performance (short-run) and market performance (long-run).

Furthermore, the market performance of firms which reflects their long-term performance as well as the shareholders’ attitude towards firms (based on the stakeholder theory), is affected by both environmental performance and profitability of firms within the short run. Moreover, our study is the first to analyse the FP-MP relationship along with analysing EP-MP relationship and comparing both financial and environmental effects on the long-run performance of firms (market performance). However, the obtained results from the analysis presented a very weak effect of FP on MP while EP imposes a strong impact on MP. Therefore, we can conclude that the stakeholders’ attitude is affected by firms’ environmental performance more significantly than by firms’ short-run profitability.

Via the structural equation model presented in this study, this study also examined the impact of applying environmental standards and frameworks by the Australian electricity generating firms on their environmental performance as well as its effect on the relationship between environmental performance of firms and their financial and market performance. This analysis presented that the environmental performance of the Australian electricity producing firms and its relationship with the short- and long-run financial performance is significantly

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56 As discussed in Chapters 3 and 4, Semenova et al. (2010) studied the reflection of firm’s net income on their market performance without considering the EP-FP relationship. In fact, they have measured the impact of firms’ environmental performance and financial performance on their market value.
affected by the environmental standards and frameworks which is also grounded by the legitimacy theory\textsuperscript{57}. These results highlight the importance of following “emission-reduction policy” developed by Australian Government for the Australian electricity sector (Denis 2017, p.2).

The impact of regional factors on the firms’ environmental performance has been examined through a regional dummy variable as in the case of a number of previous (for example, Misani and Pogutz (2015), Gonenc and Scholters (2017)). However, we have examined the effects of regional dummy variable on the EP-FP relationship separately for every single Australian state and territory in which the firms operate by developing 2 measurement models; first analysis did not include the regional factors while the second model was run 7 times (for 7 Australian states and territories in the sample) to capture the impact of regional factors on this relationship in every single state and territory in which the firms in our sample operate\textsuperscript{58}. The regional factors are found to affect (with low statistical significance) the environmental performance of the Australian electricity generating firms and hence, the relationship between environmental performance and the financial and market performance. Our analysis via the second measurement model resulted in significantly different statistical impact of the firms’ environmental performance on their financial performance across different states and territories. The main effective regional factors on the emission level of the Australian electricity generation sector are the electricity generation-mix, demographic factors and the types of electricity consumers. The findings of this analysis highlight the importance of steady and durable\textsuperscript{59} environmental policies by the states as well as the national level in enabling the

\textsuperscript{57} According to the legitimacy theory, firms can obtain the stakeholder trust and reliability by obtaining legitimate image through the application of environmental frameworks and publicly revealing their environmental actions (Magness 2006; Ghomi and Leung 2013; Juhmani 2014).

\textsuperscript{58} To examine the impact of regional factors on the firms’ environmental performance and hence, on the relationships between environmental performance of firms and their financial and market performance, only the relevant results of the relationship between RD construct and EP construct and the impact of EP construct on FP and MP constructs are exhibited in Table 5.16 of the present chapter.

\textsuperscript{59}Policy strategies focusing on the replacement of coal with natural/green resources of energy production along with pricing reform policies as discussed through section 5.5 of the present chapter.
electricity generation sector to reduce the emission level and to meet the environmental target considering the regional conditions.

Next section will summarise the results obtained from our EP-FP analysis via the proposed SEM measurement model.

5.8 Summary

The PLS-SEM has been applied to evaluate the relationship between environmental and financial activities of the Australian electricity producers during the period 2006-2017. Prior to our PLS-SEM analysis, we applied VRS DEA method based on production approach to measure the technical, scale and cost efficiency of firms included in the sample. The obtained efficiency scores are reflected by the efficiency construct of measurement model of the PLS-SEM analysis.

When applying PLS-SEM, the quality of model is examined by measures predicting the capabilities of model. In other words, the structural and measurement models are required to be evaluated in order to build PLS-SEM model “on a set of nonparametric evaluation criteria” (Hair et al. 2014, p.96). The results obtained from the assessment of reflective and structural measurement model were found satisfactory.

The non-parametric bootstrap approach is employed to test the significance of coefficients and blindfolding procedure is applied to assure about the predictive relevance of PLS-SEM reflective measurement model which influences the accuracy of data estimations. Our blindfolding analysis resulted in $Q^2$ values larger than zero representing a satisfactory level of models’ predictive relevance.

In addition to the heterogeneity existing within the sample, which is a threat to the validity of results, there could be unobserved heterogeneity in the data and the probability of occurrence of estimation biases. To treat the unobserved heterogeneity and therefore to prevent the PLS-SEM model from inaccurate estimation of results we applied FIMIX-PLS. According
to our results, there is no unobserved heterogeneity in our inner path model to have negative impact on the results.

Our analysis resulted in the significant impact of efficiency level of firms on internal operation, environmental performance and financial performance of firms. Also, the firms’ environmental performance is influenced by their internal operation and more significantly, by its moderating impact via efficiency. All these results are grounded by the RBV theory highlighting the significance of firms’ available resources and efficient utilisation of the resources on their financial performance.

The firms’ environmental performance is also affected by the environmental standards (to follow environmental standards cause a reduction of the environmental emission) base on the legitimacy theory. Furthermore, the various factors and conditions of every state and territory in which the firms are operating affect the environmental performance of firms and its relationship with financial and market performance.

Our analysis indicated the significant effect of the environmental performance of firms on their financial performance reflected by the accounting measures (short-term financial performance) as well as the significant impact of environmental performance on the market performance (long-term financial performance measured by market indicators). These results are supported by the stakeholder theory highlighting the important role of environmental performance on the stakeholders’ attitude towards the firms.

The impact of the environmental performance of firms on their financial performance was evaluated within 5-year lagged period. The first 2 years of the environmental performance presented very weak impact on the financial performance while the 3rd year exhibited the maximum effect. In conclusion, the obtained results confirmed a negative relationship between the environmental performance and financial performance of firms in the short-run but a positive one in the long-run.
On the basis of our analysis and the results obtained through this chapter, Chapter 6 will discuss some policy implications and provide recommendations applicable to the electricity generation sector of Australia.
Chapter 6
Summary and Conclusion

6.1 Introduction

The Australian electricity sector currently accounts for around one third of Australia’s emissions and is the largest single source of emission in the country (ACIL Allen Consulting, 2015). Given this, unsurprisingly there has been a significant interest in the way electricity manufactures are attempting to improve their environmental performance as it makes a significant impact on the overall emission reduction in the country. The present study develops and presents a structural equation model to show the structural relationship between key variables that contributes to the environmental, financial and market performance of Australian electricity producers and is empirically tests the model to answer the main research questions outlined in the chapter 4.

This chapter presents a summary of the thesis in section 6.2 followed by the summary of the results in section 6.3. Research contributions will be discussed through section 6.4 and the policy implications proposed by the study in section 6.5. Last section will discuss the limitations of the study plus future research perspectives.

6.2 Summary of the research

The present study examines the relationship between environmental performance and financial performance of the Australian electricity producing firms through an analysis of environmental performance of firms over a five-year period. The sample of the study includes 13 firms operating within the Australian National Electricity Market (NEM) during the period 2006 to 2017. The thesis consisted of six chapters. A summary of the contents presented in previous five chapters is provided below.

Chapter 1 provided a brief background to the study and highlighted the statement of the problem addressed in this study. It also presented the motivation to conduct this study along
with the research objectives and research questions. This introductory chapter also provided a brief introduction to the theoretical underpinning of the study, the methodology, as well as expected contribution and limitations.

Chapter 2 provided a background of the Australian electricity sector on which the sample of this study was drawn. Section 2.2 introduced the Australian electricity generation sector which is considered the foremost GHG emitter (coal is the major basis of energy production) in Australia, known as a significant pollution-intensive country in the world. This chapter discussed the aspects and reasons for the requirement of the electricity generation sector to be diversified and developed along with the recommendations to enhance the renewable energy resources for the more efficient and cost-competitive energy production to fulfil the country’s national and international commitments to emission reduction. Section 2.3 presented discussions about the climate change and the role that the energy industry could play in dealing with these issues by transition from coal-fired energy production to renewable and clean production approaches. But there are also financial concerns facing the energy producers and the relevant policies associated with such transition as discussed through this section. To achieve this transition, section 2.4 argues the necessity of the energy efficiency policies and frameworks for the electricity sector and their impact on the electricity generating firms. This section also described the Renewable Energy Target (RET) scheme and the Emissions Reduction Fund, launched in 2009 and 2011 respectively. However, the vague policies resulted in the financial unviability of the renewable energy and investors’ uncertainty while there is only a short time left to achieve the climate change targets. Therefore, the chapter concludes that the policies and frameworks are required to improve in order to encourage the electricity generation firms to replace the coal-fired generation by the renewable energy, responding to community concerns and fulfilling Australia’s international commitments.
Chapter 3 comprehensively reviewed the relevant literature grounding the context of the present study. The relevant studies on the relationship between environmental performance (EP) and financial performance (FP) of firms are reviewed through section 3.2 followed by the discussion of EP-FP studies on the basis of suitable theoretical background in section 3.3. The studies reviewed in these sections analysed the relationship between environmental performance of firms and their financial performance based on various theoretical backgrounds and resulted in positive, negative or neutral impact of environmental performance on financial performance. The above revision of the literature led us to propose the applicable variables in section 3.4 to estimate the evaluation model based on the Resource-based View (RBV), and stakeholder and legitimacy theories. Section 3.5 discussed the studies on the efficiency analysis by means of the Data Envelopment Analysis (DEA) method providing a basis for our efficiency measurement approach (discussed in Chapter 4 of the present study). The reviewed studies presented an important impact of firms’ efficiency level on their productivity and competitiveness. Accordingly, we applied the efficiency of the Australian electricity producing firms as one of the main independent variables which is found to be effective in explaining the EP-FP relationship (on the ground of RBV theory). The prior literature encourages the use of advanced statistical analysis such as structural equation model to analyse the relationship among environmental performance of the Australian electricity generating firms and their financial and market performance. The studies that have used Structural Equation Analysis (SEM) to examine the EP-FP relationship were reviewed in section 3.6.

The thorough literature review conducted in the chapter 3 revealed a number of research gaps in the literature as summarised in section 3.7. These research gaps, which were addressed in the present study, include (1) the conduct of the EP-FP analysis within a time-span longer than the literature; (2) distinction of the short-run (accounting-based indicators) and long-run (market-based indicators) measures of financial performance; (3) evaluation of
the effect of firms’ short-run financial performance (accounting-based indicators) on their long-run performance (market-based indicators); (4) examination of the effect of environmental standards and regional factors on firms’ environmental performance; (5) improved measurement of the firms’ efficiency level and its impact on the EP-FP relationship; and (6) evaluation of the moderating relationship among variables (where appropriate) to reveal the direct and indirect impacts. These gaps in the relevant literature have raised 6 research questions as follows:

1. What is the relationship between the efficiency, internal operation and the environmental performance of Australian electricity generation firms?
2. What is the relationship between the efficiency and financial performance of Australian electricity generation firms?
3. What is the relationship between the environmental performance and financial performance of Australian electricity generation firms?
4. What impact do environmental standards have on the relationship between the environmental performance and financial performance of Australian electricity generation firms?
5. What is the relationship between the financial performance and market performance of Australian electricity generation firms?
6. Does the relationship between environmental performance of firms and their financial performance vary in different geographical regions?

The methodology adopted to answer these research questions was presented in Chapter 4. Initially, it presented the SEM design used in the study to address the above mentioned research questions in Section 4.2 followed by the development of hypotheses (which

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60 We have measured the moderating effect of firms’ internal operation on their environmental and hence, financial performance and market performance via their efficiency level.
have been tested through Chapter 5) in section 4.3. In order to measure the firms’ efficiency (applied as EF construct), the DEA methodology has been described in section 4.4 along with the specification of outputs (net profit) and inputs (capital and operating expenses) in line with the relevant literature (Halkos and Tzeremes 2009; Celen 2013; Pereira de Souza et al. 2014; Hon et al. 2014; Hirschhausen et al. 2006; Sanhueza et al. 2004). Section 4.5 presented the detailed description of the SEM methodology including the measurement and structural theories and assessment procedures of the estimated model.

The chapter also described the data used in the study to examine the underlined issues. Accordingly, the main financial data used for this study were obtained from the annual reports of the Australian electricity generating firms. The required environmental data were collected from the Australian National Pollutant Inventory (NPI) website as described through section 4.6. In order to estimate the evaluation model, the financial and environmental variables are defined and measured in section 4.7. Accordingly, the financial variables used in the study include gross profit margin (GPM), net profit margin (NPM), return on asset (ROA) and return on equity (ROE). They served as indicators of financial performance (FP) construct while the price-earning (PE) ratio served as an indicator of the market performance (MP) construct. The firm efficiency (allocative, scale and technical efficiency) and retention ratio (RR), risk, size and technology level served as indicators of internal operation (IO) construct of firms. To measure the environmental performance of firms, an index is introduced by the study which identifies the environmental pollution of firms by dividing the total emission amount of major pollutants (Carbon Monoxide, Oxide of Nitrogen and Sulphur Dioxide) times its score of dangerousness by the volume of electricity production (KWh). In fact, this index measures the polluting portion/ratio of the production process of firms which is a more accurate measure.

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61 The relative risk to the human health allied with a release of one pound of a chemical which is compared to the risk posed by release of a reference chemical according to the Scorecard (2017).
of pollution due to the normalisation of the emission amount of pollution in relation to the firms’ volume of production. In the context of the present study, we have measured the financial performance based on the non-polluting ratio of their production process (i.e. 1-EP Index). In summary, the relationships among the defined variables are illustrated via our proposed models in Figures 4.4 and 4.5 in section 4.7 while the hypotheses associated with each construct is illustrated in figure 4.6 in section 4.8.

Chapter 5 presented the assessment and validation of the PLS-SEM model discussed in the previous chapter and the analysis and interpretation of the results. The chapter commenced with the presentation of the efficiency analysis conducted using DEA in section 5.2. The results obtained from this analysis were then used to measure the latent variable of efficiency in the structural model. The chapter then presented analysis through sections 5.3 to 5.5 along with testing the hypotheses on the basis of the methodology and results (Chapter 4) in section 5.6. The obtained research results rejected null hypothesis 1-17 except for hypothesis 10 which was accepted rejecting the alternative hypotheses of positive relationship between Financial Performance and Market Performance of Australian electricity generation firms. The chapter concluded that the environmentally friendly performance of firms imposes negative impact on their financial performance in short-run but positive impact in the long-run as discussed via section 5.7. The hypothesis tested in the present study provided the answers to the research questions in the study as described in the following section.

6.3 Conclusions

As described above, this study attempted to answer six research questions through an analysis conducted on a Partial Least Squares Structural Equation Model. The results of this analysis were presented in Chapter 5. Based on the results and findings presented in the previous chapter, the following section makes conclusions in relations to each of six research questions of the study.
Research Question 1: What is the relationship between the firm efficiency, internal operations and the environmental performance of Australian electricity generation firms?

The results of this study showed that the level of efficiency of the Australian electricity generating firms which was calculated by means of the DEA method has been the key contributing factor in improving the environmental performance of these firms. The answer to this question is grounded on the RBV theory which claims that firms’ resources enable them to be competitive and sustainable. Of all resources owned by businesses, advanced technology will increase the efficiency level of firms via effective consumption of resources. As a result of higher efficiency of firms, their environmental performance and financial performance will be improved (Salem et al. 2012; Cui et al. 2016). The structural relationship between the EF, IO and EP examined through PLS-SEM model showed that while efficiency directly contributes to the improvement of environmental performance, it contributes indirectly to enhancing the environmental performance through the improvement in the internal operations of firms. The relationship between the efficiency level of firms and the internal operation (IO) was found to be positive and statistically significant while its relationship with the environmental performance was also found to be positive and statistically significant. The internal operation of firms, which is reflected by their technology level, risk, size\textsuperscript{62} and retention ratio, shows a significant positive relationship with the environmental performance of the firms. The strength of this relationship is further enhanced when efficiency is functioning as a moderating factor. When we examined the relationship between firms’ internal operation and their environmental performance, taking efficiency as the moderating factor, we found a positive significant effect. This result indicates that higher the efficiency, bigger the impact of

\textsuperscript{62} Size indicator was removed through the data analysis due to its low reliability and significance in the PLS-SEM model (Chapter 5 of the present thesis).
internal operation of firms on their environmental performance. It highlights the significance of efficiency on firms’ environmental performance. The level of pollution identified in electricity generation firms is a “by-product” of energy generation. Hence, it is relational to the volume of production input which is an effective factor of efficiency\(^63\) (Cui et al. 2016, p.450). Therefore, electricity producing firms with higher level of efficiency would emit lower level of pollution to the environment and this is achievable by means of enhanced and relevant technology. These facts and the findings of the present study which are in line with the studies Busch et al. (2011) and Galdeano-Gomez (2008), provide incentives for the Australian electricity producing firms to adopt advanced technology to operate with cleaner approaches of energy generation in order to improve their environmental performance.

**Research Question 2: What is the relationship between the efficiency and financial performance of Australian electricity generation firms?**

The efficiency level of the Australian electricity generation firms, measured by DEA analysis, is reflected by the EF construct of the PLS-SEM model of the present study. The efficiency level (EF) of firms is found to have a significant positive relationship with the financial performance (FP) of electricity generating firms which is supported by the RBV theory\(^64\).

Firms in possession of a resource, or mix of resources that are rare among competitors, are said to have a comparative advantage. This comparative advantage enables firms to produce marketing offerings that either (a) are perceived as having superior value or (b) can be produced at lower costs. Therefore, a comparative advantage in resources can lead to a competitive advantage in market position. This conclusion supports the resource-based view (RBV) theory which claims that the firm’s performance is shaped significantly by the resources that firms possess. It also claims that firms accumulate critical resources, organizational skills and

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63 An efficient producer can produce bigger quantity of output with the same amount of input comparing to the less efficient or inefficient producer (Cui et al. 2016).

64 RBV theory claims that firms’ efficiency level is a vital factor of improving their environmental and financial performance (Salem et al. 2012).
capabilities during their history of existence, which in turn exert significant influence on firm’s
growth strategies and organizational structure.

The findings of this study show that Australian electricity generating firms have been
able to utilise their resources to effectively enhance the level of efficiency of their operations
and thereby to improve their financial performance. As stated by the previous studies,
efficiency is a determinant of firms’ profitability since it indicates efficient use of resources
and capital (Galdeano-Gomez 2008). Considering these results and arguments of the RBV
theory, it can be concluded that improvement in the level of efficiency of the Australian
electricity generating firms is a key determinant of their financial performance. Therefore, such
firms need to make an effort to augment their operational efficiency level (optimal consumption
level of available resources in the electricity generation) to attain short-term and long-term
financial advantages confirming the findings of Clarkson et al. (2011), Darnall et al. (2008),

Research Question 3: What is the relationship between the environmental
performance and financial performance of Australian electricity generation firms?

After having examined the relationship between the environmental performance and financial
performance of the Australian electricity generation firms for the period 2006 to 2017, the
present study concludes that environmental performance of these firms, in particular, indicators
of 2nd and 3rd lagged years of the EP index, makes a significant positive impact on both financial
and market performance of the firms. The obtained results and the answer to this question are
grounded on the RBV as well as the Stakeholder theory both of which highlight the crucial
impact of firms’ resources on their financial performance. According to the RBV theory,
advanced technology will enhance firms’ operational efficiency which will increase firms’

65 The environmental performance applied as the EP construct in the PLS-SEM model represents the non-polluting
ratio of the firms’ production process which is achieved by reducing the environmental performance measurement
index (proposed in Chapter 4 of the present thesis) from 1; i.e. EP construct=1-EP Index.
competitiveness and hence, financial performance (Salem et al. 2012). Also, stakeholders are considered as resources attainable by firms and their attitude towards firms (influenced by firms’ environmental and social activities) will result in higher profitability (improved financial performance) of firms (Abolghasemi et al. 2018; Gooyert et al. 2017). Considering the fact that firms avoid the replacement of the conventional electricity generation (fossil fuel energy generation) with the advanced clean technology (renewable resources to produce electricity) due to its inherent high costs (Nelson et al. 2017), this result confirms that amidst the criticism of lack of effort for transition to renewable energy sources for electricity generation, Australian electricity producers have been able to achieve significant environmental performance to enhance their financial performance and wealth of the shareholders of these firms through enhanced market performance. This result further confirms the results obtained by a number of previous studies such as Yang et al. (2018), Herremans et al. (2016), Kumarasiri (2017) Lin et al. (2009), Horváthová (2012), Nollet et al. (2016) and Delmas et al. (2015).

**Research Question 4: What impact environmental standards have on the relationship between the environmental performance and financial performance of Australian electricity generation firms?**

The environmental framework (ISO 14000 series) of Australian electricity generating firms is expected to play a significant role in enhancing the environmental performance of these firms. The expectation was that the firms fully compliant with the environmental framework are able to significantly enhance their environmental performance in comparison to the firms not fully compliant with these standards. This result and the answer to this question is supported by the legitimacy theory which believes in the significance of firms’ response to social concerns and expectations in achieving legitimate image and ascertain sustainability which is also in line with the stakeholder theory (Sulaiman et al. 2014). Based on the results of this study, we can conclude that firms which are fully compliant with the environmental framework have
demonstrated a significantly higher environmental performance through reduction in emissions and as such it has positively contributed to their financial and market performance (considering the positive relationship between the environmental performance of firms and their financial performance resulting from our analysis). This is in accordance with the legitimacy theory which acknowledges the firms’ credibility and financial performance are lied in their level of legitimacy (Perera et al. 2019). This result emphasises the need to enforce the compliance of these standard as a means to enhance the environmental performance of Australian electricity producers confirming the results of previous literature such as Maso et al. (2018), Qian and Schaltegger (2017) and Magness (2006).

**Research Question 5: What is the relationship between the financial performance and market performance of Australian electricity generation firms?**

The ultimate objective of a company is to create shareholder value of a company. Electricity generating companies are no exception. One of the main questions that we examined in this study is whether the improved financial performance achieved by Australian electricity producers through improved efficiency, international operations and environmental performance, contributes to the improvement in shareholder value.

The results of the SEM analysis showed a very small and insignificant effect of the financial performance (accounting-based measures) of the Australian electricity generation firms on their market performance (market-based measures). Accordingly, the conclusion that we can draw from this finding is that the improvement of financial performance of Australian electricity producers is not directly improving shareholder value. However, it must be noted that the improvements in environmental performance has a positive significant effect of improving shareholder value as well as financial performance. Our results are in line with the study conducted by Semenova et al. (2010) and is confirmed by the stakeholder theory which
emphasizes the crucial impact of stakeholders’ attitude towards firms on the firms’ environmental performance and hence, profitability.

However, despite not showing a link between the financial performance and market performance, it is important to note that we took a narrow view of market performance by measuring the market performance using P/E ratio as a market performance measure. However, as many researchers have pointed out this line of thinking is overly simplified and has a narrowed focus on economic returns of a company. More appropriate view would have been provided by Stakeholder theory, one that takes into consideration a more complex perspective of the value that stakeholders seek. Therefore, future studies could examine this relationship from a border perspective of stakeholder theory since such a framework may help explain the correlations between social (and environmental) disclosures and performance including economic performance of firms that various stakeholder seek.

Research Question 6: Does the relationship between environmental performance of firms and their financial performance vary in different geographical regions?

Australia is a large country with a complex administrative system. The states and territories are the first-level administrative divisions of the Commonwealth of Australia. They are the second level of government in Australia, located between the federal and local government tiers. As such, companies operating in different states are subjected to different rules and regulations depending on the state where the company operates. In the present study, we also examined whether the environmental performance of our sample firms differ significantly across other states due to the unique regional dereferences. As such, the environmental performance of each state in the country is tested against the rest of the country to see whether the regional factors had made an impact of environmental performance of our firm.

Based on the results presented in Chapter 5, we conclude that the regional factors did matter in determining level of environmental performance of firms in each of the six states. We
observed a positive relationship between regional factors and the environmental performance in Northern Territory, Tasmania, South Australia, New South Wales and Victoria respectively. The lowest significance level is reported in Queensland while the negative but small level of significance is reported in Western Australia. This result indicates the need to examine the impact of various rules and regulations governing the environmental activities of electricity generating firms to understand what specific factors have contributed to achieving the significantly different environmental outcomes in different states. Such an examination may provide a basis to develop a solid and effective environmental framework to achieve better outcome universally across the country.

6.4 Research Contribution to the Literature

The present study makes the following theoretical and practical contributions through the findings and conclusions stated above.

6.4.1 Theoretical Contribution

This study developed a Partial least squares structural equation model to establish the relationship between the environmental performance, financial and market performance for Australian electricity producing firms. In establishing this model, it takes into consideration the theoretical underpinning of three popular theories: Resource based view (RBV), stakeholder theory, and Legitimacy theory.

First, based on the Resource-based view (RBV) which elaborates on the relationship between firms’ resources and competitiveness with the underlying assumption of helping corporations effectively compete in the existence of uneven distribution of resources across corporations (Salem et al. 2012) and the findings of a number of prior studies that examined the EP-FP relationships a relationship between three latent constructs of EF, IO and EP were built. The reflective measures of internal operation construct was based on Marie et al (2014) with measures of retention ratio, technology level, risk (Busch et al. 2011, Nollet et al. 2016

Second, based on the legitimacy theory which is concerned about the firms’ legitimate business image in the society attained via public disclosure of firms’ operations addressing social values on the basis of relevant regulatory frameworks (Magness 2006; Sulaiman et al. 2014; Misani and Pogutz 2015; Gonene and Scholters 2017; Heras-Saizarbitoria et al. 2011), we incorporated two other latent constructs—environmental standards and regional factors—into the model to indicate the impact of the environmental standards and regional factors on the performance of the Australian electricity generating firms.

Third, based on the stakeholder theory, which states that the purpose of a business is to create value for stakeholders which includes needs of shareholders, customers, suppliers, employees, and communities, we incorporated a market performance measure into the model.

In addition, the model developed in the present study establishes the complex relationship between key variables that play a significant role in explaining the EF-FP relationship. The results obtained from our analysis confirm the significant impact of the variables applied on the ground of these theories. Therefore, we believe that this study makes a theoretical contribution to the academic literature by extending the current understanding of the complex EF-FP relationship based on the theoretical underpinning provided by the three theories: stakeholder, Resource-based view (RBV) and legitimacy.

### 6.4.2 Empirical Contributions

Firstly, this study provides conclusive evidence on the impact of environmental performance of firms on their market and financial performance. It measured the performance of firms using a large number of reflective performance indicators such as gross profit margin, net profit.
margin, return on assets and return on equity (all accounting-based measures) as well as P/E ratio (a market based performance measure).

Secondly, it examines the impact of environmental activities of firms on their market performance and financial performance separately during a 5-year period which is considerably longer than the periods studied in the literature. It enabled this study to examine the effect of EF-FP relationship in the short term as well as in the long term and to provide a better explanation about the relationship compared to the ones provided in the literature.

Thirdly, the PLS-SEM model developed by the present study is broader than the previous models found in the literature as it incorporates broader range of key applied factors/variables which were selected on the basis of three major theories as explained in the previous section. By inclusion of key determinants identified in the literature as variables that explain the EF-FP relationship, we have been able to provide more accurate estimates about the direct and indirect relationship between all latent constructs in the model.

Fourthly, the present study also provides an analysis on the level of efficiency of Australian electricity generating firms with a view to examine how it impacts directly and indirectly in determining the environmental performance, financial performance and market performance. Furthermore, the present study deviates from previous studies by decomposing the firms’ overall efficiency into technical, scale and allocative efficiency scores by means of Data Envelopment Analysis (DEA). This enabled us to measure firms’ efficiency more accurately in comparisons to the measurement of this construct in the prior literature. Therefore, the present study makes a significant contribution by measuring the level of efficiency and then testing it empirically to examine its relationship with other key variables.

66 Efficiency has been measured by means of ratios (Giovanni and Vinzi 2012) or considered as an element of management system; i.e. the designed environmental management system is assumed to promote efficiency without separately measuring the efficiency in the study of Marie et al. (2014).
It has also been able to identify the moderating effect of efficiency\textsuperscript{67} which highlights the significance of firms’ efficiency for their performance (from both environmental and financial aspects).

Fifthly, the present study examined the underlying research issues using a second-generation multivariate method of Partial Least Square Structural Equation Modelling (PLS-SEM). This method is realised to be superior to the traditional regression\textsuperscript{68} which is mostly applied by the previous EP-FP studies. SEM method is capable to evaluate causal relationships among dependant and independent variables with minimum bias through repeated data measurement process. Hence, the present study was able to develop the evaluation model by means of the largest range of variables (comparing to the literature) on the theoretical underpinning of a number of key theories. This method also facilitated effective detection of mediation results (the moderating effect of IO construct). The use of SEM makes a contribution to the existing literature by providing a methodological approach for examining the relationship between environmental performance of firms and their financial performance with higher reliability and validity of results.

Sixthly, this study contributes to the literature by providing a novel way of measuring environmental performance of firms. Previous studies have mostly used information released by ranking authorities and surveys for assessing the environmental performance of firms while the present study devised an index to precisely measure the environmental performance in relation to their electricity production. This index normalises the emitted amount of pollutants based on their level of dangerousness for all Australian electricity producing firm in the sample. The index devised in the present study indicates the polluting ratio of the firms’ operation process (emitted amounts in relation to the production volume) and the present study presented

\textsuperscript{67} Alternative hypothesis number 4 which is accepted because of significant impact of the moderating effect of IO construct on EP via EF construct as discussed in Chapter 5, section 5.6.

\textsuperscript{68} Concluded by the reviewed literature through Chapter 3 of the present study.
the inverse of the ratio to make a positive outcome that industries strive for. We expect this new measurement approach to be applicable to future studies in this area both nationally and internationally in the case of developed and developing countries.

Seventhly, another major contribution of this study is that it provides evidence on the impact of environmental performance on the financial performance over the short- and long-term time span. This deviates from the past studies such as Horváthová (2012), Lin et al. (2009), Nollet et al. (2016) and Delmas et al. (2015) who have examined the relationship between environmental performance and financial performance of firms within a short-run and 2-year lagged period. In contrast, this study extends the time span covered in previous studies by extending the time span (2006-2017) and covering a 5-year lagged period to examine the impact of environmental effect. The longer study period plus the longer lagged period exhibit a broader trend of the relationship between environmental performance and financial performance of firms.

In addition to the theoretical and practical contributions discussed through this section, the present study will also recommend some policy implications through section 6.5 as follows.

6.5 Policy Implications

Australia’s industrial and commercial prosperity relies on accessible quality electricity supply. The Australian electricity generation sector has historically employed variety of energy production resources mostly coal and gas. However, the economic life of several fossil fuel power plants will come to an end during the next decade and the country needs to reconsider the energy production mix (Engineers Australia 2017). Also, according to the Australian Energy Statistics (AES) (2018), the electricity supply sector is accounting for the highest level of energy consumption. On the other hand, Australia’s target is to reduce the greenhouse gas emission level by 26-28 per cent below the 2005 level which is mainly projected to achieve

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69 28 per cent of the total energy consumption in Australia during 2016-17 (AES 2018).
through the emission reduction by the electricity sectors. Emissions resulted from the electricity sector is due to the fuel consumption for the electricity generation which is projected to a 7 per cent decline by 2020 and another 4 per cent by 2030. However, it is anticipated that demand for electricity will increase from mid-2020 leading to increased electricity generation which may cause a small growth in the GHG emissions by 2030 (though the emission level will be still lower than the 2005 level) (Department of Environment and Energy 2018).

Given this background, improvement in the environmental performance of Australian electricity producers has become a key challenge for Australia in its effort to enhance overall environmental performance of the country. It remains a priority of electricity producers to replace the aged power plants with plants that use modern technology for energy generation which use renewable resources instead of coal. However, considering the substantially high costs involved in the transition from the coal-fired energy generation to renewable resources, the electricity generating firms continue to be persistent against such change (Nelson et al. 2017). The efficiency improvement in existing electricity generating firms leading to improvement of the environmental performance of these companies has become the most viable option in the short run to address this critical issue. In this context, the present study provides insights for Australian electricity producers to undertake actions that lead to improvement of firm’s environmental performance leading to better financial and market performances. Given that the results of this study clearly indicate that improvement in the level of efficiency is a key factor for improvement in both environmental performance and market performance, managers of the firms need to look into ways that improve both technical and scale efficiency level of firms.

The result of the present study also shows that from the stock market investor’s perspective, the combination of financial and environmental information can lead to decisions with proper future growth, whereas regulating authorities and managers can adopt useful
policies for sustainable development. The positive impact of environmental performance of electricity generating firms on their future financial performance and market performance should be incentives for the firms to bear the initial high costs of improving technical efficiencies within their factories as such an investment leads to better financial outcomes for the firms.

As revealed from the findings of the present study, the improvement of technical and scale efficiencies in the electricity producers will help formulating “energy efficiency policies” that would encourage emission reduction and energy productivity of the electricity producers. The transition of the electricity generation from coal-fired approaches towards the renewable resources in electricity supply will be essential for Australia to address its international commitments (e.g. Paris COP21). However, while taking decisive actions in implementing this long term goal, Australian electricity generating firms can incorporate new technologies that enhance their internal business operations to take advantage of the mediating effect they have on firm performance. In order to enhance the electricity generation technology from traditional coal-fired production to the green production, firms could be benefited by the relevant financial and investment policies affecting their size and capital structure. These types of policies support the capital-intensive productions and indirectly enable the technical transition and replacing aged power plants by the green ones by the electricity producers. The capital investment decisions that firms are making in this regard need to be supported by public financing. These kinds of financial policies could be essentially supportive to the electricity producers who play a greater role in the electricity generation sector of the country (Best 2017).

The uncertainty surrounding the policy settings in relation to energy mix in Australia has resulted setting environmental standards that lack direction as to which path to follow in the effort to improve environmental performance of electricity producers. This has allowed firms in the industry to follow the environmental standards just to fulfil the minimum regulative
commitments without fully committing to a transition from coal-producing energy to the green and renewable resources of electricity production in the long run. However, as evidence from the results of this study suggests, firms can achieve substantial financial benefits if they invest in appropriate technology to enhance the efficiencies in relation to electricity generation and internal operations. Therefore, attention should also be paid to identify the appropriate technologies that would provide such efficiencies and then to enforce the use of such technologies in the industry through legislations and environmental standard that follows. Although there are costs associated with the environmental policies as the regulated markets tend to increase the electricity production costs and, hence, the consumer prices, the gain that could be realised from technological improvements could outweigh such negative effects. In order to maintain stable prices, choices of policies would be required to reduce production costs by balancing the advantages of economies of scale and sales revenue\(^{70}\) (Nepal and Menezes 2017).

Policy makers need to take note of the fact that as the result of this study suggests that the benefits of improved environmental performance will deliver the financial benefits in the long run. Any technological changes that are made to enhance the environmental improvements are costly at the beginning but will deliver financial benefits after two accounting periods because of the competitive advantages gain by the firms through the technological improvements. Therefore, any policies developed to address the underlined issues need to take a longer-term view.

### 6.6 Limitations of the Study

The results of the present study should be interpreted in light of several limitations.

Firstly, the sample of the study is limited to 13 Australian electricity generating companies. Although the sample of the study covers a third of the total population and

\(^{70}\) Such as implementation of price cap or pricing structure regulations
sufficient to draw conclusions on the issues examined, given the diversity of the industry a bigger sample is more likely to strengthen conclusions made.

Secondly, the present study focuses only on one industrial sector of the economy to examine the EP-FP relationship. Nevertheless, underlined issues are applicable to many other industries which aim to improve their environmental performance.

Thirdly, measuring the environmental performance is a key challenge for the present study and it was dealt with in an innovative way. However, the number of pollutants included in the EP measurement index was limited to 3 pollutants (Carbon Monoxide, Oxides of Nitrogen and Sulphur Dioxide). It was not possible to include all other type of pollutants due to the fact that Australian National Pollutant Inventory (NPI), which was our source, has not released the emission information about all types of pollutants.

Fourthly, the measurements of some of our latent variables could have been improved if we could obtain some financial information on all firms. For example, there were a significant number of missing data in relation to dividends due to the fact that either dividend was not paid every year, or the dividend was not publicly available. Furthermore, due to pragmatic reasons, our examination of EF-FP relationship was limited to time span of 5 years and inclusion of variables that we considered the most appropriate to model this relationship. Therefore, the results of this study may have been somewhat constrained by these limitations.

Fifthly, when calculating environmental performance data, we were constrained by the complex transformation that some of our sample firms have gone through during the sample period. Specially, the acquisition71 occurring during the study period has resulted firms to issue merged financial statements while but environmental reports were available for individual companies. This required us to make an additional computation process which affected the quality of the data we collected.

71 The Duet Group acquired the EDL in 2016.
Sixthly, our ES construct is compiled on the basis of the application of ISO14000 series, which is a global environmental framework, by the Australian electricity firms in the sample. Since most of these companies operate in more than one state or territory, we were unable to distinguish the state standards from national ones. Instead, the model controlled for the regional factors as discussed through chapters 4 (Section 4.6) and 5 (Subsection 5.6.4) of the present thesis.

Seventhly, our measurement for market performance was limited to one indicator which captures the financial implications as well as the market response to company’s performance. This was due to unavailability of data for other suitable measures in publicly available sources. Our ability to select more suitable measurements for these variable and other key variables was limited by the fact that we had to rely on the publicly available data for our variables and measurements. As a result, in relation to some variables we had to take somewhat simplified and narrowed focus with their definitions.

6.7 Future Research Avenues

The present study provides an analysis of the financial and market implications of the environmental performance of the Australian electricity producers through improved environmental performance using a Partial Least Square Structural equation model. Future studies may extend the scope of this study with a large sample and longer time span to examine the EF-FP performance in much broader perspective. Future studies may also look into extending the scope of this study by examining this relationship in the context of other industries which are identified as highly polluting industries such as Aluminium industry. This may enable researchers to examine whether the findings of the present study are generalizable to other industries. Another way to extend the scope of the present study is to replicate this study in the context of electricity producing sector in other countries. This would facilitate a
comparative study between countries and to examine whether the relationship established in this study would hold in the different economic, social and cultural settings.

Future studies may also consider replicating the present study incorporating newer key variables and measurements indicators that have not been examined here. For example, measurements for financial performance of this study could be improved with the inclusion of more measures of financial performance (such as sales growth and return on investment (Saeidi et al. 2015); cash flow to sales ratio (Chen et al. 2015)) and environmental performance (such as environmental management practices) (Lucas and Noordewier 2016); ethical dimensions (Saeidi et al. 2015); and disclosure scores (Nollet et al. 2016)). This would help broaden our understanding of the relationship between the key variables examined in the present study. Since the selection of appropriate measurement indicators was limited in our study due to our dependence on the publicly available data, we suggest the surveys as a means to gather information on the measurements of key variables. For example, survey would have been able to gather more detailed data on financial situation, impact of the changing energy mix, the impact of these on their stakeholders’ attitudes, etc. As for the measurement of market performance, future studies could consider examining this relationship from a border perspective of stakeholder theory as such a framework may help to explain the correlations between social (and environmental) disclosures and performance including economic performance of firms that various stakeholder seek.

Our examination of the impact of regional factors on the firms’ environmental performance presented significant results indicating the importance of the condition in which a firm operates on its environmental performance and financial performance. These outcomes highlight the necessity of specific environmental policies in every region considering the regional characteristics and conditions. On the other hand, Nelson et al. (2017) discussed that while some Australian states have implemented their own environmental regulations, the
country still suffers from a national set of environmental legislation. In order to meet the international environmental commitments, we recommend integration between the national environmental policies to be implemented by the federal government along with integration with the regional policies set by states governments. Further studies are recommended to investigate the detailed regional factors influencing the firms’ environmental performance and hence, financial performance and relevant environmental policies\textsuperscript{72} for every state and territory. We also recommend an analysis on the suitable environmental policies in the national level and their impact and incorporation with the policies set by the state governments.

\textsuperscript{72} For instance, we may refer to the Energy efficiency policies (Engineers Australia 2017, p.9) as discussed through the policy implication section of this chapter. The Engineers Australia (2017) suggest that one of the relevant and required environmental legislation in Australia are concerned with the energy efficiency to provide a transition plan (Engineers Australia 2017, p.9) for the firms from the coal-fired energy production to the green ones which is another fruitful ground for future studies.


