The Relationship Between Corporate Governance and Company Performance

New Factors, Models and Approaches to Causality

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Dedication

To my...

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Chapter 1

Introduction

This chapter forms the introduction to the current study, laying out its motivations and aims. We begin with a background of the domain, followed by the business motivation for this study. We follow this with a summary of the academic contribution, the research goals and scope and end with an outline of the document structure as a whole.

1.1 Background

This study is primarily concerned with the relationship between corporate governance and company performance, particularly with how the former can be optimised to positively influence the latter. Corporate governance is a widely discussed, debated and researched topic that is as relevant today as it has ever been. The governance of a company dictates it's policies and motivations, ensuring that all stakeholders [1] have input to how the company is run and share a vision of where it is going. Governance policy also acts to mitigate financial and ethical pitfalls, by setting clear standards. Thus it is fair to say that corporate governance has a wide ranging influence within and also outside the company.

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[1]A stakeholder is someone who has a stake, or a personal interest, in the company. Employees, the local community and the media are all stakeholders.

We frequently see instances of corporate governance failure, which can lead to disastrous consequences financially and reputationally. Reputation is often of high importance in both the public and private sectors, which can lead to a promotion of more ethical and fair behaviour in order to protect it. Instances where companies fail in this regard often make eye-catching headlines, for example McLaughlin (2017), McVeigh (2015) and Kirkpatrick (2009). In a hyperconnected world where news spreads quickly, the importance of a functioning governance structure is more important than ever.

The interests of different parties can conflict in any business, between entities such as the shareholders [2] or directors. There is much debate on how best to align these interests, with suggested initiatives like structuring executive compensation to be at least partly dependant on firm performance. Shareholder interests can also conflict with the interests of the wider public as a whole, or the stakeholders. This is especially true for companies that heavy rely on natural resources as a driver for business. In this case, sustainability not just of the company but of finite natural resources that the public depend on must be closely governed and managed. This is often the responsibility not just of those within the company, but those outside it too.

It is reasonable to argue that corporate governance influences all aspects of the company, not least its economic success. Moldovan and Mutu (2015) studied this relationship, collecting data on corporate governance and using it to predict corporate success as measured in various ways. They were able to learn models that did this successfully, resulting in a number of rules dictating governance of high performing companies. The current study uses this as a starting point, and looks to address some limitations within in a number of areas, outlined in section 1.4. Modern work around causation is also studied, with a view to applying it in this domain. This would act to strengthen previ-

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[2]A shareholder is often an investor who has equity in the company. They often have no personal interest in the company, solely financial.

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ously derived relationships, and presents an opportunity to study the deeper causal influencers of corporate economic success.

1.2   Business Motivation

Moldovan and Mutu (2015) state the conclusions they reached in their research, and point to the business significance of each. For example, they found that for US based companies the number of women on the board of directors was positively connected to company performance. They also found that in Western Europe, companies should employ larger audit teams that in turn lowers the risk of bankruptcy. In Eastern Europe, their main finding is that an independent chairman best influences economic success.

The business benefit of the above is obvious. By deriving a number of relationships between economic success and corporate governance, the authors first prove that a relationship does in fact exist in the first place. That is, high corporate governance performance is strongly linked with success. Secondly they are able to put forward recommendations for governance best practice and show what elements are most influential, with geographic context. A key element of management is identifying levers with which to effect outcomes in a positive way, which leads into the motivation for this research.

We look to first verify some of the above findings, but also look to find new influencers of economic success by expanding the research to include other predictors outside of governance features. This would in effect expand the array of tools available to corporations for effecting economic change. We also aim to strengthen these findings by seeking causal influencers, which would add a hierarchical element to the range of levers for change and direct efforts to spaces that are most likely to yield real success.

1.3   Academic Contribution

A key element of this study is the exploration of causal research and the application of these techniques in this domain. There is continual active research in this area, with interested parties offering new techniques and thought processes for making steps towards proving causation in a variety of domains. To our knowledge, causation research has not be applied in the area of corporate governance and its effect on outcomes, and thus would represent a novel endeavour that stands to contribute to the field in a meaningful way.

For example, the rules proposed by Moldovan and Mutu (2015) are backed by strong correlations drawn from highly accurate statistical model. They make no steps towards estimating a cause and effect element to those relationships, or any other type of deeper analysis. We propose that a significant academic contribution would be had by exploring how causality is reached and applying it here, to see if more can be said of the aforementioned rules.

As mentioned above, this study plans to expand the work of Moldovan and Mutu (2015) to include other types of company actions and activity. This would help gain a more wholistic view of how economic success can be promoted across all company functions.

1.4   Research Goals and Scope

There are a number of key goals that this study aims to achieve. They are presented below, along with a discussion of how success will be measured at each stage.

1. **Reproduce the findings of Moldovan and Mutu (2015).**
   As mentioned, Moldovan and Mutu (2015) made findings that point to interesting relationships between corporate governance and company performance. It would be useful to use similar data to reproduce some of these findings using the same techniques as the authors.

2. **Improve on these findings**

   Next, the aim is to improve on these results using three methods. The first involves considering other predictors of corporate success beyond governance, such as a company's social responsibility performance or their environmental impact. The second involves using alternative measures of corporate success itself, that may better reflect how successful a company is. These may take the form of more informative financial ratios etc. The third method involves using alternative statistical techniques with a view to improving model performance using the standard measures of model accuracy. There are a plethora of techniques and algorithms not considered in the original study that may prove useful. The way in which data is preprocessed may also be altered as part of this step. For example, the authors discretised corporate success and perform classification on the resulting data. It may be advantageous to perform regression analysis here to gain greater granularity.

3. **Apply modern work on causality.**

   A number of conclusions on the influence of corporate governance on company performance have been reached, using established statistical analysis and subsequently discovered correlation. In order to strengthen these findings and and gain deeper insight into the underlying mechanisms of the domain, modern work in causality will be applied. This will involve significant research into the ways in which this can be achieved, including data requirements and required pre-processing. The aim here is to gain a much deeper understanding of the casual influencers of corporate economic success, to drive best practice and contribute to knowledge base in this area.

It is equally important to discuss what is out of the scope of this study. A distinction is not made in this study between public and private companies, although regulations dictating how public companies must govern are often more stringent and strictly enforced than private companies. Regulations include preventative measures for avoiding bankruptcy etc. Privately held firms often how more freedom and flexibility here. This can be especially true when

dealing with audits and so on.

Further, regulatory differences from country to country are not considered. Some countries may introduce certain taxation and laws that influence the decisions made by local companies, like a carbon emissions tax that may make companies take their environmental footprint more seriously.

1.5   Document Outline

This document is laid out as follows. Chapter 2 contains a brief literature review of this topic including how corporate success can be measured, other predictive corporate features that may be included, a review of other similar studies and concludes with a summary of research in the area of causation. Chapter 3 contains details of this studies methodology, including a summary of the data used and its pre-processing, algorithms used and methodology around applying casual techniques. Chapter 4 contains the results of this study. Included in chapter 5 is a discussion of these results, with some concluding remarks and opportunities for future research outlined in chapter 6.

Chapter 2

Literature Review

2.1 Introduction

It is natural in business to seek to optimise all aspects of corporate activity, with a view to positively effecting the bottom line. This is reflected in the literature on this domain, which considers the problem in a number of different forms, following a wide range of methodologies and researching often quite different results. We review a snapshot of this literature here.

We first present some of the ways that corporate success can be quantified. We look at how it is defined by Moldovan and Mutu (2015), as well as by others whose approaches may benefit this study. Also included here is a discussion of various fronts on which companies act, such as their corporate social responsibility commitments, with a view to including these aspects in this analysis as independent explanatory features. This is followed by an analysis of existing literature on the relationship between corporate governance and company performance, again including the work of Moldovan and Mutu (2015) as well as other relevant studies. We then explore the literature regarding causation and the statistical techniques used to infer causation, with consideration of how these can be realised in this domain. There is also discussion on the issues that arise in attempting to do so, and how they can be addressed. This

chapter finishes with a summary of the research gap that this study aims to address.

2.2 Company Performance - Measures and Influencers

2.2.1 Introduction

Among the key aspects of this study is the quantifying of corporate success, in a way that accurately represents "good" and "bad" corporate performance. There are many ways to do this, one of the most simple of which is to use financial ratios. Uncountable ratios have developed, each attempting to assign numerical performance ratings to companies and differing from one another by the accounting indictors considered and the aggregation of these indicators. Eidleman (1995) outlines the patterns that ratios tend to follow. He states that these ratios are mostly created by academic researchers, who constantly derive new ways of combining individual metrics together to facilitate meaningful comparison between companies. First, researchers find a sample of companies that meet some predetermined criterion of failure, as well as another sample of comparable firms (size, industry etc) that differ only in financial health. A number of ratios are developed and tested against this dataset to determine which returns values that are consistently and significantly different for each group. Those which do so successfully are kept, the rest are discarded. Weights are assigned to each ratio to reach an aggregate equation. New firms are scored, and real-world performance recorded to measure how useful the new ratios are in practice.

This study primarily considers corporate governance features as predictors of corporate economic success. This follows the lead of Moldovan and Mutu (2015) who do the same. Having said this, an aim of this study is to expand the range of predictors considered, and to this end we discuss alternative sources of company data that can be incorporated into the model. Perhaps the in-

clusion of more varied and diverse independent features, such as a companies social responsibility commitments or their impact on the environment can enhance overall understanding in this domain. These areas are discussed in this chapter.

2.2.2 Financial Ratios

Some financial ratios are more useful than others, varying significantly in complexity, in what particular aspects of a company they consider and also in how they combine those measures. This section includes a discussion of some of the most commonly used ratios, with comments on how best they can be used and in what context they are most powerful.

One of the indicators of corporate economic performance used by Moldovan and Mutu (2015) is Tobin's Q score. This measure was devised by Tobin (1969) who postulated that the combined market value of a given company should be equal to their replacement costs. When a companies replacement cost is equal to its market value, it is said to be in an ideal state. Any deviation either way, a ratio above or below 1, indicates future investment or the selling of assets respectively. Moldovan and Mutu (2015) argue that the Q score allows the estimation of intangible assets, and is thus a worthy inclusion as a dependant measure of corporate success. Intangible assets drive market value up, rising the Q score.

The use of this measure is well established in the literature, by Chung and Pruitt (1994), Bhagat and Bolton (2008) and Bolton *et al.* (2011). Chung and Pruitt (1994) state that Tobin's Q plays an important part in financial interactions, and is employed to explain diverse corporate phenomena during the decision making process for investment opportunities. Bolton *et al.* (2011) used Tobin's Q to propose a model for dynamic investment and risk management and found that investment is best driven by an aggreagte model of which the Q score plays an important role.

The formal definition of Tobin's Q is presented by Chung and Pruitt (1994), along side a much more simplified and conservative approximation of the authors making. This less complex definition is seen commonly in literature, for example by Wahba (2008). This formulation is given below as;

$$(Approximate) \quad q = \frac{MVE + PS + DEBT}{TA} \tag{2.2.1}$$

Here, MVE represents the product of a companies share price and count of common outstanding stock shares. PS represents the liquidating value of the companies preferred stock. $DEBT$ represents the companies short-term liabilities minus its assets, also short-term. Finally, TA represents the book value of the total assets of the company. In layman terms, assets that cannot be easily quantified can not always be entered in a companies books, but do always contribute to the share price of that company. Thus, a firm with lots of this type of asset will have a high Q score, and those without will have a low score.

There is debate as to the practically of the Q score. Intuitively, the Q score places a very high importance on one specific aspect of a business. For example, before WhatApp was acquired by Facebook it had very little concrete physical assets (i.e. those that could be recorded in their accounts). Rather, it had a platform with approximately 400million users, and a very high Q score. After purchase, the Q score would have dropped significantly since the amount Facebook paid would become the concrete asset recorded in their books. This is not to say that the Q score is a bad success indicator, but rather it may not fully represent the real value of a company at a given time.

Chung and Pruitt (1994) state in their research that the Q score is often neglected in real-world situations. One of the reasons they give for this is the complexity of the necessary calculations, and a potential unfamiliarity with its operational intricacies. Another reason is the unavailability of relevant data, particularly of sufficiently high accuracy and instantaneous availability. To counteract this, they worked to create and test an accurate approximation of

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Tobin's Q that utilises only basic financial information, show in equation 2.2.1. They conclude that their approximation is close enough to the more formal definition to be used where more exhaustive calculations are not possible.

Another measure of corporate success used by Moldovan and Mutu (2015) is the Altman Z score, which can be used as a probabilistic measure of whether a company will fall into bankruptcy within the next two years. It can also be used more generally as a financial distress measure and to predict corporate defaults. The authors point out that there is much advocacy in the literature for using this measure, and this study was unable to find any that strongly reject its usefulness. The Altman Z score is given as;

$$
\begin{aligned}
Z\ Score \quad = \quad & 1.2\left(\frac{Working\ Capital}{Total\ Assets}\right) + \\[2ex]
& 1.4\left(\frac{Retained\ Earnings}{Total\ Assets}\right) + \\[2ex]
& 3.3\left(\frac{Earnings\ before\ Interest\ and\ Tax}{Total\ Assets}\right) + \qquad (2.2.2) \\[2ex]
& 0.6\left(\frac{Market\ Value\ of\ Equity}{Total\ Liabilities}\right) + \\[2ex]
& 1.0\left(\frac{Sales}{Total\ Assets}\right)
\end{aligned}
$$

Among those that support this scores use is Eidleman (1995), who discusses its use in practice. He begins by highlighting Altman's own tests using the Z score which involved predicting 72% of bankruptcies two years prior to the event, although the sample size or companies involved are not mentioned. Eidleman argues that the Z score is tried and tested, and;

> It has been demonstrated to be quite reliable in a variety of contexts and countries.

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— Eidleman (1995)

Eidleman also outlines circumstances that warrant corrections and alterations to equation 2.2.2, in order to generalise it beyond its originally intended means. He argues that before being able to use the Z score, one must ensure the company in question is comparable to those involved in Altman's original study. Altman considered manufacturing and small firms in his original analysis, thus corrections must be made before scoring companies in different industries. Eidelman points to two specific circumstances here.

The first considers privately held companies, whose stocks are no publicly traded meaning term four of equation 2.2.2 cannot be calculated. To correct for this, the Z score can be re-estimated using book values of equity. In other words, details from balance sheets published by private firms voluntarily can be used rather than details gleamed from the stock market. Certainly a work-around here is to consider solely publicly traded companies. A consequence of this is that such an analysis would only include companies that are bound by the the corporate governance code in their jurisdiction, which would need to be taken into account in studies such as this one.

Eidleman's second consideration is for non-manufacturing firms. The fifth term of equation 2.2.2, according to Eidleman, varies significantly by industry. He argues that merchandise firms for example, are significantly less capital intense and thus are much more likely to enjoy higher asset turnover and consequently Z-Scores. Z scores then would be likely to under-predict bankruptcy in these cases. In order to correct for this, a recommendation comes from Altman to eliminate the fifth term and adjust the weights.

The adjusted equation 2.2.3 is shown below;

$$Z\ Score \quad = \quad 6.56\left(\frac{Working\ Capital}{Total\ Assets}\right) +$$

$$3.26\left(\frac{Retained\ Earnings}{Total\ Assets}\right) +$$

$$6.72\left(\frac{Earnings\ before\ Interest\ and\ Tax}{Total\ Assets}\right) + \quad (2.2.3)$$

$$1.05\left(\frac{Market\ Value\ of\ Equity}{Total\ Liabilities}\right)$$

Overall, the Altman Z score seems a highly appropriate indicator of corporate financial strength and thus success, and one that should be considered in this study. Consideration will need to be had for the type of industry included in this analysis, that will inform the exact calculation of the Z score itself.

2.2.3 Environmental Considerations

As mentioned previously, there is likely much room for improvement in the range of predictors of success considered in this analysis. One potentially useful area to consider is the environmental performance of the company, studied by Schaltegger and Synnestvedt (2002). The authors primary focus is on environmental management, specifically as a vehicle for corporate success. It is assumed here that environmental management and performance relate to the controlling of costs relating perhaps to the mining of natural resources. This may also refer to fines, penalties or taxes that are incurred due to harmful emissions, which must be carefully managed within a company to mitigate against.

The authors present two conflicting viewpoints in this space. The first states

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that improved environmental performance predominantly causes an increase in operating costs, due to investment and so on which in turn negatively effects the profitability of the company. The second viewpoint states the opposite; improving a firms environmental performance in fact induces cost savings, which drives increases in profitability. Interestingly, the authors present opinions that environmental investment often both negatively increases costs and positively increases income. Having said this, they argue that such a direct link is not present in practice, and that instead it is the identification and management of the relationship that is more important. The conflicting viewpoints are visualised in figure 2.1.
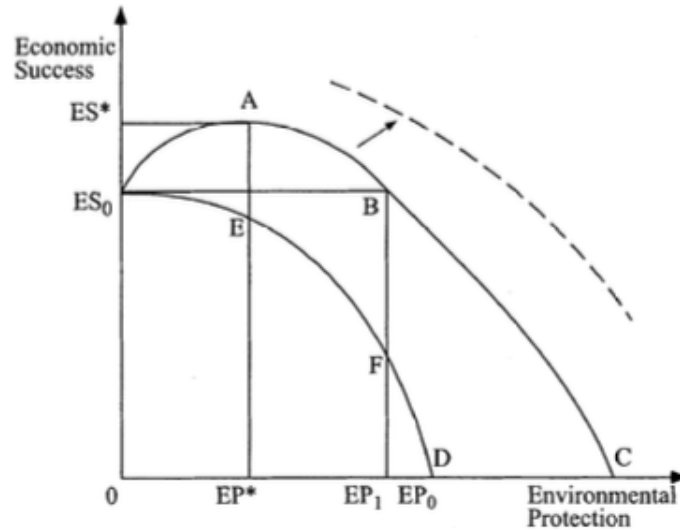
Figure 2.1: Correlation between corporate environmental protection spending and economic success.

ES_0 on the vertical axis represents the current level of economic success, described by the authors a certain shareholder value. According the the pessimistic view of environmental spending, this value decreases as spending in environmental protection increases (through points E and F, to D where non profit can be made). That is, spending in this space reduces profit making ability to eventual zero. The more optimistic view is represented by the path from ES_0 through points A and B to point C (again where no profit is possi-

ble). This represents the ideology that some economic gain can be achieved, at least to some degree before tailing off, by being environmentally conscious. Of course, even in this situation there is an optimal investment level, after which profit making ability decreases.

The authors draw point to two important ideas, derived from figure 2.1. First, they argue that environmental performance can vary at a given level of economic success. It is both possible to be equally successful by being either environmental friendly or harmful. This indicates that investment in this space does not necessarily mean poor economic performance. Secondly, the reverse; that economic success can vary for a given level of environmental protection. That is, being environmentally conscious is no guarantee of economic benefit. The authors reiterate that the correlation between economic and environmental performance depends on not just company externalities but internal variables which are influenced by management. It is firm management, who moderate this relationship, that must be optimised in order to gain economically. The authors put this forward as an group of explanatory covariates not considered in the literature to this point.

It is natural then to ask how environmental management can be quantified in data for analysis. Schaltegger and Synnestvedt (2002) suggest two cases for deriving data. The first relates to the firms ability to utilise to the full the economic benefits of environmental protection measures. This may materialise in R&D spending, or other marketing positioning that communicates their efforts and establishes the company as industry leaders. They are seen as quality leaders, with their environmental management policies a significant driver of this. The second case relates to how this reputation is achieved in practice, by realising the optimal environmental performance for maximum economic success. This can take the form of identifying and implementing optimise production processes for example, facilitated by the identification of opportunities and "eco-efficiency potentials".

Wahba (2008) also performs research in this area, studying whether the mar-

ket values corporate environmental responsibility, specifically in an Egyptian context. Similarly to Schaltegger and Synnestvedt (2002), the author acknowledges divided and inconclusive literature on this topic, stating an aim to present empirical evidence on how engagement with environmental responsibility can positively influence corporate market value. This analysis looks at a sample of 156 firms across 19 industries, using the market value of a firm as the dependant variable (interestingly, quantified by Tobin's Q score mentioned previously). Important to note is the authors use of ISO 14000/14001 certification as a proxy for environmental performance. This is recognised by the authors as non-ideal, however this may still have some utility in future research to address the difficulty in quantifying performance in this area.

An interesting and important consideration is made by Wahba (2008). She states that companies with greater economic success have a greater ability to invest in environmental endeavours, leading to a theory that the two may be jointly determined. This theory is tested before regression analysis run. To do this, the author uses the specification test of Hausman (1978) to test for endogeneity. Endogeneity occurs in econometrics when an explanatory variable correlates with the error term, rather than some other feature. Wahba (2008) states that the result of this analysis is that endogeneity is not occurring, but points to an important consideration that the current study may need to take into account. One of the common causes of this is a causal loop between an independent and a dependant variable, and can obviously lead to wildly inaccurate results.

Wahba (2008) state that the overall finding of this research is that the market does in fact reward firms for their environmental efforts, by positively influencing that firms Tobin's Q score, but do point to similar issues raised by Schaltegger and Synnestvedt (2002). Namely, that a companies decision to reduce their impact on the environment comes with significant cost and that if this is not managed correctly, the economic benefits evaporate.

There is clear support in the literature for the presence of a relationship be-

tween corporate economic success and environmental performance. Schaltegger and Synnestvedt (2002) suggest it is the firm management of environmental considerations that influences success, and put this forward as an explanatory variable not yet considered in literature. This theory is supported by Wahba (2008), who find a strong relationship in this space but with a caveat that management plays a significant role in realising benefits. It remains to be seen exactly how this can be realised in data analysis, and what family of covariates could be incorporated into the model.

2.2.4   Corporate Social Responsibility

Corporate social responsibility, or CSR, is defined by the European Commission as "the responsibility of enterprises for their impacts on society". This is similar to being conscious of environmental impact, but is more generalised to include compliance with established ethical standards and national and international norms. Central to CSR is the creation of shared value between themselves, their stakeholders and larger society as well as mitigating possible adverse events with those groups. It is natural to consider elements of CSR then, when discussing predictors of firm success.

Orlitzky *et al.* (2003) perform meta-analysis in the link between corporate social and financial performance. They begin by stating;

> Most theorising on the relationship between corporate social / environmental performance (CSP) and corporate financial performance (CFP) assumes that the current evidence is too fractured or too variable to draw any generalisable conclusions.
>
> — Orlitzky *et al.* (2003)

Their research aims to show this claim is unfounded, and that it is indeed possible to derive insight in this space by providing a more rigorous methodology for drawing such conclusions. They argue that researchers have attempted to find causal relationships between CSP and CSR, but have failed in part due to

a failure to see vital differences between theory and operational applications. They also state that an aim of their research is to aggregate knowledge in the area, and highlight important findings they believe to be overlooked. This type of meta-analysis have been proven to provide value by considering a number of disparate and conflicting results holistically, by reaching an aggregate conclusion.

They present a number of hypotheses about the influence of CSP. They first state that CSP and CFP are positively related, regardless of industry and the context of the given study relating the two. They base this on a number of studies, stating that CSP is a vital form of "good management theory" that boasts competitive advantage by addressing stakeholder concerns quickly and fairly. Secondly, they hypothesise on the temporal nature of this relationship, and further that there is a bidirectional causality between CSR and CFP. That is, there is a circular and virtuous casual relationship that governs performance in each area. This is supported by the idea that prior success in CFP facilitates positive engagement in CSP, due to increased responsibility and freedom at the managerial level. This conclusion mirrors that seen in section 2.2.3, where it was theorised that increased economic success drives better environmental performance.

The third hypothesis put forward by Orlitzky *et al.* (2003) involves the underlying logic behind the correlation between CSP and CFP. The first is that CSP boasts managerial competencies and organisational efficiency, by enabling shared knowledge of the firm's market as well as social and political environments. Secondly they suggest that CSP is a driving factor behind the firm's reputation, and thus elicits significant goodwill from stakeholders.

The fourth and final hypothesis put forward involves the methodology used by previous studies to draw conclusions from. The authors here suggest that the variance in results seen across studies can be explained by sampling or measurement error, for example.

In order to support these claims, Orlitzky *et al.* (2003) perform a meta-analysis involving 52 studies across both CSP and CFP, resulting in a total sample size of 33,878 observations on which they perform their analysis. This analysis involves a statistical aggregation technique to be applied, which calculates the cumulative correlations across studies, correcting for variable elements of those studies to reach one "true score correlation (ρ)". Using this technique, the authors were able to explain 24% of the cross-study variance in relation to the observed r value, which they suggest is significant. That is, by controlling for sampling and measurement errors across multiple studies, they could reduce the variation in results by 25%. They suggest that this, strengthened with other analysis, supports their collection of hypotheses.

The authors compare their results with others who performed similar research. Key to this comparison is a discussion regarding the linkage between CSP and CFP. That state that other researchers have traditionally been concerned with the "Halo effect". That is, that correlation found (that CSP influences CFP) are due to the experimental procedure or are spuriously perceived. The authors here dismiss this, stating that the only logical halo link would be in the reverse direction. That is, that a company who are high financially successful may be scored highly in CSP regardless of factual information in that regard. They go further, and state that even this hypothetical (but more logical) argument is debunked by their meta-analysis which shows a strong directional (or temporal) link between CSP and CFP.

As as with environmental performance, there is clear evidence that corporate social performance (or perhaps more commonly, responsibility) is a worthy addition to this study. Along side governance features and the aforementioned environmental performance features, there is evidence that CSP can enhance predictive power and understanding in this domain.

2.3 Corporate Governance and Company Performance

2.3.1 Introduction

In this chapter, we explore research that directly attempts to answer similar questions as the current study. That is, other works that look at the relationship between corporate governance and company performance, and attempt to characterise that relationship. This includes the work of Moldovan and Mutu (2015), whose research forms the basis for the current study. An analysis is made of their methodology and conclusions, as well as a deeper analysis of what areas can be improved upon.

2.3.2 Existing research

Moldovan and Mutu (2015) made an attempt to find relationships between how a company governs and its economic success, using data mining techniques. They derived a dataset from the Bloomberg financial system, containing 50 independent corporate governance features on areas such as board room structure and the companies yearly tax and interest liabilities. They considered three stock indexes; S&P 500 (a collection of 500 American companies), STOXX Europe 600 and STOXX Eastern Europe 300. They complimented this with two dependant, target variables measuring corporate success. Those measures are Tobin's Q and the Altman Z Score, the details of which are outlined in section 2.2. Using the aforementioned governance variables, they learned statistical models to predict "good" and "bad" company performance.

Interestingly, Moldovan and Mutu (2015) decided to discretise Tobin's Q into two classes, either "good" for high scores or "bad" for low scores. The threshold used here was the the median Q score of the entire dataset. They carry out similar preprocessing on the Altman Z score, creating three classes and allocating observations to each based on performance before using a classification algorithm for learning purposes. While the authors cite this methodology

in previous literature, it may prove interesting to carry out regression on the real-valued scores as well. We believe this alternative methodology may yield positive results, that would perhaps be more granular and more appropriate for this data.

The formulation of the Altman Z score use by Moldovan and Mutu (2015) is also an area for potential concern. As discussed in section 2.2.2, Altman presents an alternative formulation for non-manufacturing companies, that prevents the under estimation of bankruptcy likelihood associated with using the score for such companies. It remains to be seen what kind of companies are included in the analysis of Moldovan and Mutu (2015), although should a significant number fall outside of the manufacturing industry then perhaps the alternative formulation should be used in the current study.

Using a number of different algorithms, Moldovan and Mutu (2015) were able to predict with accuracy corporate outcomes using governance features. Interestingly, all algorithms performed equally well for American and European datasets, indicating a low level of model dependance here. Results from the Eastern European dataset were less consistent across algorithms, attributed to missing data on the governance side.

As mentioned previously, the authors here were able to present some simple rules based on their models for corporate governance best practice. For example, they conclude that there is a positive correlation between a female presence on the board of directors in American companies, thresholding on 20% presence for the benefits to be detected. An independent lead director in the same dataset was shown to incur a higher risk of bankruptcy as measured by the Altman Z score. In Europe, the authors came to a similar conclusion, stating that the presence of an independent lead director or former CEO on the board of directors resulted in poorer Tobin Q scores. Interestingly and contrary to the case in America, the presence of women on the board was negatively linked to performance. Finally, in Eastern Europe Moldovan and Mutu (2015) found that a smaller director age range was positively related

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with performance. Altman Z scores improve significantly with an independent chairman, or female CEO.

Papers left to review here

1. Bauer *et al.* (2008)

2. Creamer and Freund (2010)

3. Chen *et al.* (2015)

2.4 Inferring Causation

2.4.1 Introduction

It is stated ad nauseum in scientific and popular literature that *"Correlation does not imply causation"* or similar. In statistical analysis, it is tempting to infer causal relationships between features where only correlation has been proven and indeed a significant amount of literature seems to do exactly this. For example, the study of Moldovan and Mutu (2015) on which the current study is based, makes strong claims as to the relationship between corporate governance and company success. In reality, the authors perform insufficient analysis to support causal inference, instead finding correlations worthy of further investigation.

Interestingly, there is a significant body of research that argues that it is impossible to prove causation in any case. It is said that if all variables that could possibly be causal are considered, causation can be reliably inferred. Of course in practice this is almost never fully the case, and so it may be that advanced techniques are required to move towards this case as much as possible to overcome this issue.

One of the major issues with applying causal research in this domain is the study design. Many studies, particularly in the medical field, are able to take advantage of robust experimental design standards that facilitate a deep and accurate exploration of results. They are able to control for unobserved covariates using randomised trials, and generally have a large degree of control over the statistical parameters of the study. Study methodology here often follows a procedure of maintaining a treatment and control group. Researchers can then estimate the presence and magnitude of the effect the treatment has on particular outcomes.

Outside of such highly controlled experimental environments, causal inference becomes more difficult since we begin to deal with observational studies. The work of Moldovan and Mutu (2015) is such a study, where the authors extracted historical data that was generated outside of their control and tried to uncover relationships within. Esarey (2015) identifies an interesting problem with this type of work. The author argues that often observations (whether they be people, organisations or events of some kind) self-select to be treated which has a significant effect on outcomes. He gives the example of education; those who choose to complete higher education may be those who stand to gain from it the most, and so it is difficult to estimate educations effect on income. If only those who really need education attend, then its positive influence on outcomes (a persons salary for example) would be skewed. Similarly in the study of Moldovan and Mutu (2015), it is difficult to assess the benefit of various elements of corporate governance on firm performance due to a possible self-selecting process undertaken by those who perform well in the former.

This is a highly complex space, and one that certainly calls for advanced techniques that can mitigate the issues outlined above. The remainder of this section is dedicated to some of these techniques, with discussion of their technicalities and practical applications.

2.4.2 Matching

One approach to bridging the gap between experimental and non-experimental studies is matching, outlined by Stuart (2010) who considers studies that use observational data that can be divided into treated and non-treated cases. Matching is then used to study the effects of this treatment on some outcome, in a very similar way to standard experimental trials in the medical field for example. He describes first how one of the biggest benefits of randomised experimental studies is that the treated and un-treated groups are guaranteed to be randomly different from one another, on both observed and unobserved covariates (or features that may influence the outcome). That is, such experiments are able to control for factors that have not been explicitly designed for in the experiment. Statistical matching aims to imitate this for observational studies in which such design is very diffuclt, by balancing the distribution of potentially useful features in the treated and control groups. This is achieved by identifying observations that differ only in treated status, facilitating the analysis of the causal effect of that treatment. In effect this ignores un-observed features, and aims to reduce bias in the distribution of observed features as much as possible. The concept of *strong ignorability* is heavy relied upon here, which is to say that it is assumed that all feature that may influence the outcome are being considered. As mentioned previously, this is very difficult to achieve in practice.

Stuart (2010) states that matching is a potentially useful mechanism in supervised learning, where the outcome is known and the goal is to estimate its effect. Thus, matching is considered in this study where the treatment can be quantified as fluctuations in various explanatory corporate governance variables (among others) which in turn influence the a firms outcome.

Stuart (2010) sets out four key stages in the matching process. They are;

1. Defining the measure of *closeness* between observations.

2. Choosing an appropriate matching method.

3. Quality assessment of matched samples, returning to step 1 depending on results.

4. Treatment analysis, given the results of Step 3.

A measure of closeness quantifiably determines whether an observation is a good match for another. This is a crucial aspect to matching, and can be subdivided into two parts. The first involves pruning the dataset features for those to include, taking into consideration the concept of *strong ignorability* mentioned earlier. Stuart (2010) points out that poor results are expected from using small sets of features, particularly those that pertain solely to a narrow view of that observation (for example, demographic details of individuals). He states that there is little disadvantage in including features that are not actually associated with outcome, albeit a slight increase in variance is expected. Conversely, neglecting a feature that is associated with outcome is very costly, and so it is recommended to include as many features as is practical as a precaution. In could be argued that this contradicts the authors earlier statements about ignorability, and so in this study some testing and iteration here is perhaps required. The authors also recommends to carry this out without relying on observed outcomes, and instead make decisions based on domain knowledge. This represents a trend in causal analysis, in that domain knowledge is heavily relied upon to strengthen correlation's rather than depending on deeper statistical analysis.

The second aspect to closeness is the measure of distance itself, or the similarity between two observations in the data. There are many ways to do this, that vary in the exactness of the match required. Stuart (2010) argues that exact matching is ideal, but very often unattainable especially with high dimensional data. Requiring a very high degree of exactness leads to observations remaining unmatched which then fall out of consideration, a phenomenon that in turn can lead to more bias than if the matching measure required less exactness. A way to address this is to categorise continuous features, a practice used in calculating the Mahalanobis distance for example which works well with low dimensionality, but poorly with highly non-uniformly distributed features.

The next stage in the matching process is the choose of matching method, which uses the closeness distance to create the matches themselves. The motivation behind using one method over another lies in the number of observations that remain after matching has taken place, and the relative weights that different individuals receive. One such method is nearest neighbour matching (NNM), which is stated as the most common, most understandable and easiest to implement methods available by Stuart (2010). In essence, this method couples a treated and un-treated observation, minimising the distance between the two. Controls can be put in place to dictate the exactness of each match, potentially discarding treated cases if a suitable match is not found. This helps to prevent bad matches, but leads to difficulties in interpreting results. What results from NNM is a data set of similar dimension to the amount of treated cases, which arguably reduces the power of the data. Stuart (2010) states in response to this that model precision is effected most by the smaller group size in any dataset, and so balancing observations down to this smaller group size should not in fact dramatically reduce it power.

The third stage of the matching process is a quality assessment of the matched samples, which is the most important step according to Stuart (2010). The aim here is to rate how balanced the matches set is, where balance refers to the similarity of feature distributions, and the independence of features and treatment status. Poor results here calls for alternative distance measures and matching methods, and so iteration is often required to find the optimal methodology. Stuart (2010) proposes numerical diagnostics to achieve this step. This involves the inspection of the difference in means of each feature, divided by the standard deviation which gives the *standard bias*. This is performed for each feature, as well as their two-way interactions and squares. The author discards other common tests here such as hypothesis tests, due to contextual issues and how balance is interpreted by those tests.

The fourth and final step of the matching process as outlined by Stuart (2010) is outcome analysis. It should be noted that matching is not actually a tool

used for inferring causation, but rather presents a new dataset that is treated as if sourced through randomised methods.

King *et al.* (2014) also characterise the trade-off between matched sample sizes and the balance between classes into the matched subset, identified above by Stuart (2010). While Stuart (2010) argued that any negative effects of sample reduction were offset by the increased balance between groups, King *et al.* (2014) argues the opposite. They claim that practitioners often do see sample reduction as an issue, citing manual tweaking that research cary out in an effort to optimise sample size as well as balance, or their tendency to settle for suboptimal solutions. King *et al.* (2014) argue that optimising only one of these parameters is not a viable solution nor a necessary one, but that current solutions available for optimising both require significant manual intervention which is time consuming and usually suboptimal. In response to this, they propose a new approach that they claim address a number of issues.

The so called *matching frontier* is a methodology that the authors claim fully characterises the trade-off between dataset imbalance and matched sample size, allowing researchers to visually inspect where the optimal solution lies for a given dataset. Each location along the frontier is denoted by the resultant matched sample. Moving along this frontier (i.e. varying sample size), the frontier returns a data subset such that no other subset of the same size has more optimal class balance characteristics. That is, the returned matched dataset is optimally balanced for its size. The implications of this for researchers are obvious. Using this method, one has much finer control over the matching process than is apparent in the work of Stuart (2010). The latter provides a framework that involves significant manual iteration, which is shown to be suboptimal and unnecessary by King *et al.* (2014).

———————————

More to be said of work of King *et al.* (2014)

———————————

2.4.3   Minimal-Model Semantics

Pearl and Verma (1995) present a highly influential theory of causation, and guidelines on how to make the step from strong correlation towards inferring casual relationships. This is certainly one of the more influential studies in this space, and approaches the problem of causation slightly differently to matching laid out in section 2.4.2. The authors here propose what they refer to as *a minimal-model semantics of causation*, which they claim debunks the myth that casual influences cannot be distinguished from illegitimate covariation. They argue such a distinction is possible by using inductive reasoning.

They begin by stating generalities of proving causation, and of causal systems. Firstly, they state that intelligent systems that aim to learn about their environment and act on that knowledge cannot rely solely on preprogrammed causal knowledge (derived from human knowledge and experience). Rather, it must be able to transform observable phenomenon into cause and effect relationships. This is a key point, and speaks to the statements of other authors who state domain knowledge is vital for causal inference. They argue further that when causal relationships are stated in ordinary conversation, they reflect probabilities of event occurring rather than absolutes. Thus, probability theory should be sufficient to identify such relationships. It is clear that the authors place a large degree of faith in the abilities of ordinary people, going as far as to say of peoples ability to perceive causal relationships; *"..we must find a computational model that emulates this perception"*.

Key to the model proposed by Pearl and Verma (1995) is the notion of a directed acyclic graph (DAG). The authors theorise that fundamentally, all processes in nature are controlled by casual mechanisms that govern how observable and unobservable variables interact. In general, they state that;

> A casual model of a set of variables U is a directed acyclic graph (DAG), in which each node corresponds to a distinct element of U.
>
> — Pearl and Verma (1995)

Variables are represented as nodes, with edges representing casual influences between those variables. Using this model, it becomes clear how the influence of parent variables on child variables can be found. One of the issues that has been raised in this chapter previously is that of the influence of unobservable factors, which are impossible to eliminate in observational studies in practice. The authors here model these factors as probabilistic disturbances to the DAG, that perturbs the relationships within. By stating assumption of independence of parent and child nodes (or features), the authors state that the disturbances are local to that pairing. This is certainly a novel approach, and presents a theoretical framework for dealing with inevitable externalities.

Pearl and Verma (1995) on go to discuss the question of model structure and choice. Logically, since the model U is not bounded by any predetermined constraint (i.e. inputted casual knowledge or otherwise) there in an infinite amount of models that could be fitted to a given distribution. Each would create different causal relationships with a different set of probabilistic disturbances. The authors call on inductive reasoning here, arguing that any model can be removed if there is a more simple alternative that is as consistent with the data. Models not removed are referred to as *minimal models*, and are used to reach the authors definition of inferred causation.

> A variable X is said to have a casual influence on a variable Y if a strictly directed path from X to Y exists in every minimal model consistent with the data.
>
> — Pearl and Verma (1995)

Much more to review in this paper including:

1. More on the DAG structure - independence of parent / child

2. Stability - Computational Practicality

3. Latent Structures

4. Non-temporal causation

5. Attached algorithm to make this happen - see forked project at `https://github.com/ReidConor/causality`

_____

2.5   Research Gap

Over the course of this literature review we have present a snapshot of existing studies in this domain, and discuss their implications for the current research. It is clear that a large body of work exists in this space, that has promoted an ever deeper understanding of the drivers of economic success. Having said this, there are certainly gaps in this research left to be explored. In this chapter, we discuss the gaps that this study aims to address.

Firstly, it is clear that there is a wide range of plausible contributing factors to corporate economic success. We have seen evidence that governance, environmental investment and corporate social responsibility are all linked with success at least to some degree. However, we have not seen a study that collates these factors together in one study with a view to performing statistical analysis and deriving a much more diverse model. The literature contains numerous instances where the same measures of corporate success are relied upon, although there is questionable logic behind the decision to use them. Both of these points are addressed in this study; we attempt to consider as many potential predictors for success as is reasonable, as well as investigating measures of economic success that better represent what a successful or unsuccessful company is.

Perhaps the more significant gap that this research aims to address is that of the identification of causal relationships. Much work has gone into establishing correlative links between company behaviour and success, that are often reenforced with domain specific knowledge or simply accepted due to their

plausibility by practitioners. The current research aims to negate the need for domain specific knowledge, by using cutting edge casual learning theory to pick out the correlations that in fact have casual elements to them. Such a study has not yet been carried out, and so the potential contribution to the field is significant.

Chapter 3

Methodology

3.1 Introduction

This chapter outlines the method followed during this analysis, with a view to explaining the detailed steps taken from stage to stage. The KDD process as outlined by Fayyad *et al.* (1996) was followed where possible, as a well established end-to-end framework for deriving knowledge from raw data. To that end, we first discuss data acquisition and the raw data characteristics. This is followed by a discussion of the preprocessing and reduction required to make this data useable. This includes how missing data and outliers are handled. We then outlined the data mining techniques used, including analysis of the advantages and disadvantages of the various statistical methods and associated software packages available. Following this, we outline in detail the steps taken for each element of this study. That is, the replication of and expansion on the work by Moldovan and Mutu (2015) and the application of casual research in this domain. We finish by comparing the ways in which results can be interpreted, including what measures of algorithmic success should be used and so on. Overall, this chapter represents the technical aspect of this study and aims to facilitate the replication of this analysis by future researchers.

GitHub is used during this study as a version control and task tracking tool.

All code modules written in fulfilment of this study, including all source files of this report, are available at `https://github.com/ReidConor/dissertation`. Using source control has various uses, not least acting as a cloud storage mechanism in case of local machine failure. In addition, changes to the project over time can be much more easily managed, including changes to the datasets used. Making this code available on GitHub also facilitates collaboration and the communication of ideas between collaborators.

3.2   Data Acquisition

3.2.1   Core Data

The primary source of data for this study comes from the authors of the paper it extends. Darie Moldovan and Simona Mutu were kind enough to provide us with the data they used in their analysis, sending the complete set and granting permission to use it for out analysis. This has a duel benefit. Firstly, the results from the current analysis can be placed in a much clearer context, since we can directly and numerically identify wether or not the inclusion of auxiliary features or different measures of corporate success pose an advantage. In other words, we do not need to worry about data dependance when comparing the results of this study and the study it seeks to improve on. Secondly, being granted access to a purpose built dataset prior to undertaking this analysis represents a significant catalyst for progress, and surely expedites the process of gaining greater understanding in this domain.

3.2.2   Corporate Social Responsibility

The dataset provided by Darie Moldovan and Simona Mutu contains records of 1400 companies, with 52 features. As mentioned previously, these features consider solely corporate governance as a predictor for success, and this study aims to extend this to consider other areas. One such area is corporate social responsibility (CSR).

—————— Potential Sources of Data

1. Bloomberg?
   `https://www.library.hbs.edu/docs/bloomberg%20esg%20functionality%20map.pdf`

2. `https://www.csrhub.com/csrhub-meets-your-sustainability-needs/`

3. `https://www.researchgate.net/post/Are_there_any_publically_available_data_sets_or_sources_that_provide_Corporate_Social_Responsibility_CSR_scores_of_companies2`

4. Rahdari and Rostamy (2015)

5. `http://financial.thomsonreuters.com/content/dam/openweb/documents/pdf/tr-com-financial/methodology/corporate-responsibility-ratings.pdf`

3.2.3 Environmental Performance

Another area shown to be promising in terms of predicting corporate economic success is the environmental performance of a company. in other words, the measures put in place by a company and efforts made to reduce their footprint on the natural environment may be a good indicator of how successful that company is.

—————— Potential Sources of Data

1. Bloomberg?
   `https://www.library.hbs.edu/docs/bloomberg%20esg%20functionality%20map.pdf`
   "Bloomberg for Environmental, social and governance data"
   Looks like you can get "Emissions and Energy Markets" data.

Only research I've read is theoretical. Need to investigate further where data is going to come from here.

3.3 Data Pre-Processing and Reduction

Interestingly, Moldovan and Mutu (2015) made the decision to remove any observations in their data that had missing values, or not enough information to calculate key metrics. These emissions are likely justified, since incomplete data (and especially miscalculated metrics) would unfairly skew the properties of that observation and misrepresent it in the data. Any conclusions that were made using these observations could be fundamentally flawed. In the current study, if data cannot be found to complete these records a similar approach will be used.

Moldovan and Mutu (2015) also state that they remove outliers in the data, citing a desire to prevent "data errors". We feel they do not provide convincing evidence that the outliers are fair emissions. It is generally accepted that outliers must be proven to be mistakes at the data collection stage, or invalid in some other way to justify leaving them out of the analysis. Without such justification, outliers are valid data points and may prove crucial to the formulation of a faithful model. While they state that removal in total only discounts 122 observations, this amounts to roughly 8% of the original dataset. The current study carries out analysis with and without outliers, with a view to inspecting their influence.

3.4 Data Mining, Algorithms and Software

Notes

Here, discuss what data mining approaches I'm going to use. Mention using classification algorithms as an alternative to what MM used, and also regression on real-valued Q and Z score.

- Use similar to MM - Adaboost M1, J48, Simple Logistic regression, ADTree on same data (and new dataset with other params)

- Don't bin Q and Z score into categories, instead leave as real value. Use regression (Kernel regression?).

- Look into neural nets?

- For casual research
  `https://github.com/akelleh/causality` for the algorithm shown in Pearl and Verma (1995) `http://projects.iq.harvard.edu/frontier` for matching method in King *et al.* (2014)

3.5   Implementation

3.5.1   Replication and Expanding the Research

3.5.2   Causation

3.6   Interpretation

Notes

Here, discuss how I'm going to interpret results. What measures of algorithm performance to use, what weighting's to give to each etc.

- Use similar metric to MM?
  ie use precision, sensitivity and specificity, ROC (Receiver operating characteristic) curve.

- Confusion matrixes

Chapter 4

Results

4.1 Introduction

The results . . .

Chapter 5

Discussion

5.1   Introduction

In this chapter we examine ...

Chapter 6

Conclusions and Future Research

6.1 Introduction

Program code

Insert snippets of important code here

Point to github where code can be found

`https://github.com/ReidConor/dissertation`

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List of Notation

Entries are listed in the order of appearance. The "Ref" is the number of the section, definition, etc., in which the notation is explained.

Symbol	Description	Ref
$PREFST$	The liquidating value of a firm's preferred stock	