MEASURING AND MANAGING RISK IN UK LISTED FIRMS

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Abstract

The last twenty years have seen sustained pressure on firms in the UK and globally to demonstrate good corporate governance and, in particular, to manage risk in an appropriate manner; the overall aim of this study is therefore to contribute to the understanding of how to measure and manage risk at the firm level more effectively. This involves three specific research objectives: to investigate the measurement properties of some of the most commonly used corporate risk measures; to investigate the relationship between risk and return at the firm level; and to investigate the drivers for the development of a risk management capability within firms. The research objectives were addressed in the context of UK firms, using accounting data from the FAME database and market data from Datastream. A particular criticism of previous research in these areas is the lack of consideration about how to handle extreme values in the distributions of risk measures; so a number of different techniques, specifically designed to be robust to outliers, are employed throughout this study.

The investigation of the measurement properties of a variety of corporate risk measures (Chapter Four) improves the overall understanding of what these different risk measures represent, how they are related and, crucially, that these relationships are not static but are functions of environmental uncertainty. The analysis also identifies a compact set of risk measures, relevant to specific stakeholder groups; that can be used by both researchers and practitioners. The investigation into the relationship between risk and performance (Chapter Five) finds a positive relationship between profit risk (variation in profitability) and subsequent profitability, as predicted; however, the relationship is mediated by both environmental conditions and the prior performance of the firm. The study also finds that the relationship between market risk and realised return is contingent on the overall performance of the market. Finally, the investigation into the drivers of the development of risk management capabilities (Chapter Six) provides evidence that, at least within this sample of large, listed UK firms; the desire on the part of managers to develop risk management capabilities is largely driven by traditional arguments based on protecting value for shareholders.

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Contents

List of Tables

List of Figures

Chapter 1 - Introduction

1.1 Overview

This introductory chapter aims to set the context for this study on the measurement and management of risk in UK listed firms. This includes describing the background to, and motivation for, the research; describing the research objectives; explaining the proposed contribution of the research; and outlining the structure of the rest of the thesis, including synopses of the three empirical chapters.

1.2 Background

Beck (1992, p.19) asserts that "...in the course of the exponentially growing productive forces in the modernization process, hazards and potential threats have been unleashed to an extent previously unknown". Whether or not one agrees with Beck's bleak, dystopian outlook on modern society, it is difficult to argue with Power's (2009, p.304) contention that "The period since 1995 has seen an explosion of efforts to codify and formalize principles of risk management…organizations must apply rational standards of knowledge and frame what they do in these terms in order to maintain legitimacy". Within the corporate sphere, these efforts to formalise risk management have included the development of a "Corporate Governance Code" in the UK (Turnbull (1999)); passing of the Sarbanes-Oxley Act in the US in 2002; and the adoption of Basel II (BIS (2006)) as an international regulatory framework for banks. Efforts have intensified since the onset of the financial crisis in 2008 with, for example, the adoption of Basel III (BIS (2011)) and the publication of three new editions of the Corporate Governance Code (FRC (2010, 2012, 2014)). These actions have all contributed to a growing need to measure and manage risk at the firm level: the overall aim of this study is to contribute to the understanding of how to do this more effectively.

This section begins by discussing risk in the most abstract terms, setting out the ontological and epistemological positions adopted in this study. This is followed by a discussion of contrasting definitions of risk; how these different definitions lead to the use of various risk measures; and the two schools of thought on probability (frequentist and Bayesian). The discussion thereafter focuses specifically on risk as it applies to commercial firms, beginning by looking at the interaction of organisational structure, firm strategy and the environment; and the nature of corporate risk management. The section concludes by summarising the important shortcomings in previous risk research.

1.2.1 Ontological and Epistemological Considerations

Risk is a highly contested construct with numerous different definitions in use. Underlying these differences is a gulf between conceiving risks to "pre-exist in nature, to be identifiable through scientific measurement, and to be controlled using such knowledge"; and considering that "Risk is never fully objective or knowable outside of belief systems and moral positions" (Gephart et al (2009, p.143-144)). The approach taken throughout this thesis is that, as risk is based on individual beliefs about future states of the world, it is inherently subjective: in any given situation, different groups of stakeholders may have very different beliefs about future state of the world. Moreover, different groups of stakeholders have different values; and will be impacted very differently by the various possible outcomes. As Beck (1992, p.28) puts it: "There are always competing and conflicting claims, interests and viewpoints of the various agents of modernity and affected groups, which are forced together in defining risks …"

However, whilst accepting that “Risk descriptions are thus always context-bound, reflecting the point of view of the person describing the risk” (Hermansson (2012, p.18)); a completely relativist approach is rejected in this thesis, and it is argued that the existence of “alternative risk descriptions to every risk does not mean that some are not better or worse than others”. Hermansson (2012, p.20) goes on to argue for the need to explicitly acknowledge, and critically examine, the values and background assumptions that have led to the use of specific risk descriptions in order to judge which are most useful in a given context; and to “include a number of different perspectives”. It is interesting to note that March and Shapira (1987, p.1408)) found an acceptance of such a plurality of risk descriptions amongst practising managers “…although quantities are used in discussing risk, and managers seek precision in estimating risk, most show little desire to reduce risk to a single quantifiable construct.” It is also interesting to note that Markovitz (1952, p.81) acknowledges the subjectivity of risk, emphasising that his “paper does not consider the difficult question of how investors do (or should) form their probability beliefs”.

In view of this, risk is discussed, throughout the thesis, in the context of the risk to specific defined groups of people, based on their values and assumptions; and there is no attempt to privilege a single risk description. In particular, there is a detailed discussion of the risks to the different stakeholders in the firm in Chapter Two; and a discussion about how different stakeholders use risk measures as mental models in Chapter Four. It is very important to stress though that accepting that different stakeholder groups will experience different risks, in no way diminishes the potential of individual risk descriptions to influence important discussions; as Burningham and Cooper (1999 p. 310) state in the context of the debate on environmental change “the acid test of one’s argument remains its plausibility and its ability to convince. All that has been removed is the capacity to ground one’s own argument in, or to discredit opposing arguments by comparing them unfavourably with, objective reality."

Having established this ontological and epistemological position, it is now possible to proceed to a discussion of risk, risk measures and probability.

1.2.2 Risk, Risk Measures and Probability

In common usage, the term "risk" is generally associated with negative outcomes and this definition has also been applied widely in the academic literature eg "Risk is expected harm" (Campbell (2005 p.569)) or "Risk is usually taken to indicate some degree of hazard" (Bettis (1982 p.22)). However, other writers, particularly in the practitioner literature, argue that risk concerns both gains and losses eg "Risk is defined as uncertainty of outcome, whether positive opportunity or negative threat" (Chittenden (2006, p.9)); or "Risk is the combination of the probability of an event and its consequences" (ISO (2002, p.2)). From the ontological and epistemological position outlined above, these very different uses of the term "risk" can be seen to arise simply from the different beliefs and values of the groups of people involved. As stated above, discussions of risk should therefore be conducted in the context of the risks to specific stakeholder groups: the risks to the main stakeholder groups in a firm are discussed in detail in the next chapter. The need for different stakeholder groups to describe risks as they affect them has given rise to numerous risk measures being developed and applied in both the academic and practitioner literatures.

A widespread concern with negative outcomes, as expressed in the quotes of Campbell (2005) and Bettis (1982) above, has led to the development of a range of measures of downside risk. Perhaps the most widely used of these measures is value-at-risk (G-30 (1993)), which is simply a percentile (typically 1% or 5%) from the left-hand tail of the expected profit and loss distribution for an activity over a specified time horizon. This concern with negative outcomes has also stimulated work, particularly in the insurance and banking sectors, on extreme value theory (see Embrechts et al (1997)); which seeks to specifically model the tails of distributions in order to accurately predict the likelihood of extreme events, even those events so extreme that they have not yet occurred. Clearly, outlying negative values in performance distributions (so long as these are valid observations and not erroneous) are critical to both the accurate calculation of value-at-risk (VAR) and the modelling of the tails of distributions in extreme value theory (EVT): exclusion of instances of extreme performance will severely impact upon the usefulness of these risk measures. The importance of including observations that exhibit extreme performance when calculating risk measures is a central theme throughout the thesis and is discussed in detail in Chapter Three.

By contrast, as an example of a symmetrical risk measure; risk to investors is often simply equated with variance of returns within the finance literature, without any perceived need for further explanation. This convention stems from Markowitz's (1952) work on efficient frontiers for investment portfolios, but it is important to point out that Markowitz himself merely stated (p.89) that "The concepts 'yield' and 'risk' appear frequently in financial writings. Usually if the term 'yield' were replaced by…'expected return' and 'risk' by 'variance of return', little change of apparent meaning would result." An extensive range of the risk measures used in previous empirical research are discussed in detail in Chapter Four.

It is also important to highlight a distinction between risk measures based on accounting data and those based on market data. Accounting data are, by definition, historical; so risk measures derived from them are essentially backward-looking. However, market data factor in investors' expectations for the future so that risk measures derived from them have a forward-looking element. This distinction will be developed further in Chapter Four.

The concern of many stakeholder groups with negative outcomes, has also led to the expression of risk in terms of the probabilities of certain events, it is therefore important to briefly mention the distinction between the frequentist and Bayesian schools of probability. Traditional statistical approaches have been based on frequentist probabilities, defined as "the fraction of times the event A occurs if the activity considered were repeated (hypothetically) an infinite number of times" (Aven (2011, p. 1519)); or "the limiting frequency of an event after repeated observations" (Berger (2010, p. 1045)). However, the appropriateness of such a definition of probability depends entirely on the type of risk being considered: in many cases sufficient relevant data are not available to estimate such a probability with any accuracy. By contrast, Bayesian frequencies are subjective and represent a "degree of belief" Aven (2011, p. 1518); which is constantly updated in the light of evidence. The foregoing discussion on the ontology of risk, is clearly consistent with a Bayesian interpretation of probability.

1.2.3 Corporate Risk

Turning to focus now on the specific area of risk with which this study is concerned; risk at the firm level is discussed extensively in both the strategy and financial economics literatures, but from very different perspectives. Within the strategy literature, the uncertainty about the future that gives rise to risks to the various stakeholder groups is primarily viewed as an input to the strategy-making process. Specifically, in the resource-based view (Barney (1991))[1]; uncertainty about which resources to acquire and how to bundle them into capabilities results in some firms achieving a sustained competitive advantage whilst others do not. Equally, in real options theory, it is uncertainty about the future that makes the opportunity to defer decisions valuable; and thus motivates the search for flexible strategies.

Conversely, in the financial economics literature, risk (to investors) is seen as a consequence of the strategy adopted by the firm's managers in the pursuit of profit. As well as acknowledging these two divergent viewpoints, it is also necessary to consider the influence of the environment in which the firm operates; and, drawing on the crisis management literature, the way in which organisational culture may mediate the relationships between strategy, the environment, risk and performance. The viewpoint taken throughout this thesis is that the risks to the various stakeholders in the firm arise from a complex interaction between the strategy adopted by the firm's managers, the environment in which the firm operates and the culture of the organisation.

[1] The resource-based view and the dynamic capabilities framework have become the dominant approach within the strategy literature to explaining sustained competitive advantage; they will be discussed in detail in Chapter Two and applied as analytical tools at various points throughout the thesis.

1.2.4 The Nature of Corporate Risk Management

This study is concerned not only with the measurement of corporate risk, but with its management too. The risks to a firm's stakeholders may be managed in a variety of ways, including the purchase of insurance and derivatives; the design of incentive packages for senior management; and the implementation of specific policies on, for example, security and health and safety. However, the extensive literature discussing how risk management can create value for shareholders has focused on two strategic issues: the importance of taking an integrated approach to risk management across the firm[2] (eg Merton (2005), Nocco and Stultz (2006)); and the importance of maintaining a consistent approach to risk management over time in order to reassure stakeholders (Shapiro and Titman (1986)), maintain stable cashflows (Lessard (1990), Froot, Scharfstein and Stein (1993)) and enable investors to accurately gauge performance (Meulbroek (2002), Rebonato (2007)).

This emphasis on the essential long-term nature of effective risk management is consistent with the resource-based view (RBV) of the firm; which asserts that it is the creation of "capabilities" through the effective combination of resources over an extended period of time, not the mere possession of individual resources, which leads to sustained competitive advantage (Grant (1991)). A focus on the long-term is also consistent with the crisis management literature (eg Pauchant and Mitroff (1988, 1992), Miller (1988)) which emphasises the effect of underlying organisational culture, another enduring characteristic of the firm, on both the incidence and severity of crises.

[2] This point will be revisited in Chapter Six in a detailed discussion of enterprise risk management (ERM).

Approaching risk management as a capability has a number of practical implications for the design of research. Firstly, capabilities are, by definition, unobservable so one or more proxies must be used: the difficulties of "making intangibles tangible" are discussed in detail in Molloy et al (2011). The measurement of the performance effects of capabilities presents even more formidable methodological challenges. As will be discussed in Chapter Two, tests of the performance effects of capabilities are also confounded by both the selection of an appropriate dependent variable (Ray et al (2004)); and alternative explanations for superior performance (Denrell et al (2013)). The specific challenges of measuring the effect of risk management on performance are discussed in detail in Chapter Seven.

1.2.5 Shortcomings in Previous Research into Corporate Risk and Risk Management

This section highlights some important shortcomings in previous empirical work. The first two paragraphs look specifically at prior research into the relationship between risk and performance, and research into the adoption of risk management respectively. This is followed by a brief discussion of a critical shortcoming in both these areas of research: a lack of proper consideration in the handling of extreme outliers in the distributions of risk and performance data.

Probably the largest single area of corporate risk research concerns the relationship between risk and performance (eg Bowman (1980), Bettis (1982), Marsh and Swanson (1984), Fiegenbaum & Thomas (1988), Ruefli (1990), Miller & Bromiley (1990), Fama and French (1992), Miller & Leiblein (1996), Miller & Chen (2004), Alessandri & Khan (2006), Ang, Chen and Xing (2006), Andersen et al (2007), Bali et al (2009), Henkel (2009)). The most important shortcoming in this body of work is that most of the models only include a single measure of risk amongst the dependent variables[3]; implying that the risks to all the relevant stakeholder groups can be captured in a single measure. However, whilst the models used in most studies include only one risk measure, different studies use different measures; and there has been little discussion of why particular variables have been chosen, nor any agreement on what the best risk measures are: this represents another significant shortcoming of this whole area of research. Also, there is a general assumption that the relationships between measures of risk and performance are static; and no account is taken of the role of changing environmental conditions in mediating these relationships.

As regards research into risk management there are two main areas of interest, the drivers of risk management and the impact (on performance) of risk management. In addition to the fundamental problems of measuring the effect of risk management on performance, which were discussed in section 1.2.4; another shortcoming is evident in most previous studies in both areas: the use of inappropriate proxies for risk management. Early studies tended to use variables such as the possession of derivatives contracts (eg Nance et al (1993), Géczy et al (1997)) or levels of insurance coverage (eg Aunon-Nerin and Ehling (2008)), which simply indicate that certain specific risks are being mitigated, as the dependent variable. More recent studies have used measures such as the appointment of a Chief Risk Officer (CRO) (eg Liebenberg and Hoyt (2003)); or have searched media databases for phrases relating to risk management (eg Hoyt and Liebenberg (2011), Eckles et al (2014)). Whilst these represent attempts to proxy a firm's overall capability to manage risk, they are all reliant on what a firm says about risk management, which may simply be

[3] Miller and Bromiley (1990), Fama and French (1992) and Alessandri and Khan (2006) are notable exceptions to this pattern: Miller and Bromiley (1990) and Alessandri and Khan (2006) are discussed in detail in Chapter Four.

deliberate signals to the market, rather than evidence of a long-term commitment to developing a capability.

An additional, and very important, observation applies to both studies of risk and performance and studies of risk management. In so far as previous studies have engaged at all with the issue of outliers in the distribution of risk measures, they have done so by Winsorizing; that is simply removing a proportion of the most extreme values from the data set. Thus, following the argument set out in section 1.2.2, they have actually removed the data of most interest from the analysis. This issue is discussed in detail in Chapter Three. The more intelligent handling of extreme values, using a range of techniques that are specifically designed to be robust to outliers, is a central theme throughout the thesis.

1.3 Research Objectives

1.3.1 Investigating the Measurement Properties of Corporate Risk Measures

As discussed in section 1.2.2, risk is a highly contested construct with numerous definitions in use. In the context of corporate risk, this has given rise to a very wide range of measures being employed in previous empirical work; often with little explanation of why these particular variables have been chosen. The first objective of this research is to investigate the measurement properties of some of the most commonly used risk measures; bearing in mind that these properties may vary as the environment changes. This investigation contributes to the debate on the desirable properties of corporate risk measures, proposing a number of additional considerations for choosing a measure; and identifies a set of underlying risk components that can be used as risk measures, both by practitioners and in future academic research.

1.3.2 Investigating the Relationship between Risk and Performance

Utility theory (Bernoulli (1738)) predicts that people who are risk averse will require compensation to accept risk. Arguments based on risk aversion have been applied to explain the decisions of both investors and the managers of firms; and predict a straightforward positive relationship between risk and return regardless of environmental conditions, organisational culture or firm capabilities. Whilst early (market-based) empirical tests were generally supportive of this simple theory; more recently, numerous studies (eg Bowman (1980)), using both market and accounting data, have failed to find such a relationship (or have even found a significant negative relationship between risk and return). The second research objective of this study is therefore to investigate the relationship between risk and return, using both accounting and market-based measures; addressing both the epistemological and methodological shortcomings of previous empirical work. The contribution of this part of the study is to resolve the apparent paradox of a negative relationship between accounting measures of risk and return (Bowman's (1980) "paradox"); more broadly, this work points to a more nuanced understanding of the relationship between multiple risk measures and measures of performance, contingent upon environmental conditions.

1.3.3 Risk Management

Despite sustained pressure on firms to "...codify and formalize principles of risk management…" Power (2009, p.304), considerable heterogeneity persists in the maturity of risk management across firms. For instance, based on the data used in Chapter Six concerning the employment of risk management professionals, as of July 2011: 35 firms in the FTSE 350 had (or intended to develop) an enterprise risk management capability; 40 firms had a business continuity management capability; 15 had both capabilities and 206 had neither[4]. The third and final research objective is to investigate why some firms develop a risk management capability, whilst other firms do not. The contribution made by this part of the study is to understand if the desire to develop a risk management capability can be explained by rational arguments based on creating value for shareholders.

Each of the three research objectives is addressed in a separate chapter within the thesis, as described below in section 1.4.

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[4] A number of firms are excluded from the analysis (see Chapter Five) so the total does not add up to 350.

1.4 Thesis Structure

1.4.1 Outline

The remainder of the thesis is organised into six chapters as described below. The empirical work is conducted on UK firms over the period 2003-12 using accounting data from the FAME database (in certain instances where data were missing in FAME these were gathered from individual company annual reports) and market data from Datastream[5]. It is important to note that this period covers the onset of the global financial crisis in 2008, which was characterised by immediate significant falls in UK GDP growth and market returns, together with substantial increases in the volatility of both measures.

Chapter Two introduces and critiques the diverse literature that underpins the whole thesis, the four main strands of literature discussed are: strategy; the risks to different stakeholder groups; the origins of corporate risk; and corporate risk management. Chapter Three begins by describing in detail the data sources used for the study; highlighting some of the statistical issues involved in dealing with such data; and critiquing the attempts of previous empirical researchers to address these issues. This is followed by a discussion of a number of analytical methods that are robust to outliers, including: estimators of location, dispersion and correlation; robust regression techniques; and robust principal component analysis. Chapter Four is the first empirical chapter, which investigates the measurement properties of a number of widely-used measures of corporate risk; Chapters Five investigates the relationship between risk and return; and Chapter Six investigates why some firms develop specific risk management capabilities. Chapter Seven concludes by reviewing the empirical results as a whole; summarising the contributions to theory;

[5] All data were downloaded from FAME between 1st October 2013 and 17th January 2014; data were downloaded from Datastream between 4th October 2013 and 24th January 2014.

making recommendations for policy and practice; acknowledging the limitations of the current research; and proposing productive avenues for further work. The three empirical chapters, Chapters Four Five and Six, are summarised below.

1.4.2 Chapter Four - Measuring Corporate Risk

The first research objective of the study is to investigate the measurement properties of some of the most commonly used corporate risk measures in previous research: this is the subject of Chapter Four. Building on the conceptual discussions of risk in the first two chapters, the chapter begins by discussing how observable risk measures can be translated into predictions about future states of the world by way of a range of mental models. The extant literature on the desirable properties of corporate risk measures is then reviewed and some additional criteria are proposed. A range of corporate risk measures that have been used in previous empirical work are assessed against these desirable properties, but it is impossible to select a preferred set of measures purely on this basis.

An alternative approach is therefore taken, in which a principal component analysis (PCA) is conducted on a set of corporate risk measures in order to try to identify the underlying, unobservable, dimensions of risk. Whilst the overall approach is based on that of Miller and Bromiley (1990) and Alessandri and Khan (2006), this study improves on previous work by using a wider range of risk measures, including measures of cashflow risk; and by taking a rigorous, exploratory approach that does not allow any preconceptions about the number or nature of components. As mentioned previously, one of the key issues in risk research is the handling of outlying values of risk measures: these outliers have the potential to cause serious bias to the variance-covariance matrix upon which the standard PCA technique is based, as the elements of the matrix are calculated from the squares of residuals.

The study therefore also makes use of a robust PCA technique, based on the use of the minimum covariance determinant method of Rousseeuw (1984)[6], to minimise the influence of outliers in the distributions of risk measures without simply deleting observations from the sample.

Nineteen separate corporate risk measures are estimated for all listed firms in the UK: in common with previous work[7], risk measures are estimated over five-year periods. Risk measures are estimated over six overlapping periods from 2003-2007 to 2008-12: the number of sample firms varies from 963 (2003-07) to 1347 (2007-11). As expected, the distributions of a number of these risk measures contain some extreme outliers. It is clear from a preliminary analysis that the results from the standard (non-robust) PCAs are strongly affected by the inclusion or exclusion of these outliers, so all subsequent work is conducted using the robust PCA method.

Three components relating to variability in profits, variability in share price and variability in cashflow are retained in each five-year period: these are interpreted as "profit risk", "market risk" and "cashflow risk" respectively. These three components constitute a compact set of risk measures that can potentially be used both by practitioners and in academic research. However, it is interesting to note that the component structures are not the same in each time period; indeed in both 2003-07 and 2008-12 an additional component is retained. This is at variance with the findings of Miller and Bromiley (1990), who found a consistent component structure across two non-overlapping five-year periods. The findings of this study suggest that the relationships between different risk measures are not fixed, but are mediated by changes in environmental uncertainty: as environmental uncertainty changes, and the more forward-looking risk measures react to this new information, the long-term

[6] The technique is described in detail in Chapter Three.
[7] Dating back at least as far as Fama and MacBeth (1973) for market-based measures; and Bowman (1980) for accounting-based measures.

relationships with more backward-looking measures are temporarily disturbed until a new equilibrium is established. As well as the theoretical contribution of this chapter, the components resulting from the robust PCA are used as risk measures in the subsequent empirical chapters.

1.4.3 Chapter Five - The Relationship between Risk and Performance

Chapter Five is concerned with measuring the relationship between risk and subsequent performance; using accounting, market-based and hybrid measures for performance, and multiple risk measures. The chapter begins by continuing the discussion about the relationship between corporate risk and performance that was initiated in Chapter Two; in particular, the mediating effect of prior performance on the risk-performance relationship is explored, and prior empirical work on the relationship between risk and performance is reviewed and critiqued. This discussion leads to a number of predictions concerning: the relationship between market risk and future returns to shareholders; the relationship between profit risk and future profitability; the relationship between cashflow risk and future profitability; and the mediating effect of prior performance on the relationship between profit risk and future profitability. The same data set is used as for the previous chapter, so the same issues of extreme outliers are present. Risk measures and other control variables are estimated over five overlapping five-year periods (2003-07 to 2007-11); and performance is generally measured over a single year following the end of each estimation period.

In order to make a direct comparison with early empirical work, a number of univariate tests of the relationship between accounting measures of risk and return are carried out. The first set of tests makes a direct comparison with Bowman (1980) and Fiegnebaum and Thomas (1988) by examining the correlation between the standard deviation of ROA and the average ROA over the same five-year period and, in common with the earlier studies, finds significant negative correlation coefficients in all time periods. Given the many criticisms of this approach (eg Marsh and Swanson (1984), Ruefli (1990)), the correlations between standard deviation of ROA and ROA for the year following the five-year period over which the standard deviation was estimated were then examined: significant negative correlations are still observed in all time periods. Bowman (1980) suggested that a possible explanation of the observed negative relationship between accounting measures of risk and return was that well-managed firms may be able to combine high profitability with low variability in profits: Andersen et al (2007) subsequently demonstrated mathematically that a "strategic responsiveness" capability gives rise to a negative association between risk and return. The correlation tests were therefore repeated with first-differenced values of ROA and the standard deviation of ROA (to remove firm fixed effects): the correlation coefficients with these first-differenced variables were either positive or insignificant in all time periods.

A series of cross-sectional regressions were then estimated in order to investigate the relationship between risk and performance in more detail. As explained in the previous paragraph, a first-differenced regression model is used[8] to remove unobservable firm fixed effects; however this has the unfortunate consequence of also removing firms' risk management capabilities (this issue will be discussed in more detail in Chapter Seven). Regression models are developed with return on book value of equity and ROA as the dependent variable and profit risk, cashflow risk and market risk as explanatory variables; but it is not possible to estimate these. Return on market value of equity is therefore used as an alternative dependent

[8] There are alternative ways of removing firm fixed effects, such as de-meaning and de-medianing; but these lead to more intractable endogeneity issues in the subsequent regression analysis.

variable, but the use of a hybrid performance measure introduces issues in the interpretation of the results. Models with return on market value of equity and returns to shareholders as the dependent variable were estimated using OLS and three different robust regression techniques. The results of the different regression techniques are broadly consistent within each model; it is also noticeable that both models perform best in the first time-period, which uses data from before the onset of the financial crisis in 2008, and have less explanatory power in the more turbulent conditions of later time periods.

The results of the regressions with return on market value of equity as the dependent variable support the prediction of a positive relationship with profit risk for high-performing (above median) firms in both pre and post-crisis conditions (although the size of the effect was much reduced post-crisis). As regards low-performing (below median) firms, there is a positive association between profit risk and subsequent profitability pre-crisis, but a negative association post-crisis: this is consistent with arguments based on the behavioural theory of the firm (Cyert and March (1992)). The results of the regressions with returns to shareholders as the dependent variable confirm that the relationship between market risk and returns to shareholders is contingent on overall market returns (consistent with Pettengill (1995)); this finding can be observed even without the removal of firm fixed effects. The results of some of the regressions also suggest that measures of profit risk and cashflow risk can influence future returns to shareholders; whilst market risk can influence future profitability.

1.4.4 Chapter Six - Risk Management Capabilities in UK FTSE 350 Companies

The finding in Chapter Five of a positive association between profit risk and return (at least in normal market conditions) implies that a firm's capability to manage risk can create value: Chapter Six investigates why some firms develop specific risk management capabilities, whilst other firms appear not to. The study uses novel measures, based on the employment of risk management professionals, as a proxy for the desire to develop a risk management capability.

The chapter begins by developing the "'managerial' concept of risk management" (Power (2007, p.3)), looking specifically at two formalised approaches to risk management: enterprise risk management (ERM) and business continuity management (BCM); previous empirical tests on the adoption of risk management (measured in a number of ways) are also reviewed. As well as publicly-available accounting and market data, the study uses membership databases supplied by the Institute of Risk Management (IRM) and Business Continuity Institute (BCI): it is believed that this is the first time that such data have been used in an academic study of risk management. Risk measures and other explanatory variables are estimated over the period 2006-10 and membership data were provided as at July 2011.

Two separate analyses were conducted on each data set (IRM members and BCI members): a binary-outcome model, with the employment of one or more members of the relevant institute as the dependent variable; and a count-data model, using the actual number of members employed as the dependent variable. Both models include a range of explanatory variables that have been commonly used in previous work (eg Nance et al (1993), Géczy et al (1997), Liebenberg and Hoyt (2003), Hoyt and Liebenberg (2011), Eckles et al (2014)), as well as novel measures for the proportion of tangible assets and exposure to profit risk, market risk and cashflow risk.

All the regressions show support for the argument that managers' desire to develop a risk management capability is driven by considerations of protecting shareholder value. The regressions also show support for the idea that the proportion of tangible assets in the firm, and the proportion of institutional ownership, are both drivers for the development of an ERM capability. As regards risk exposure, there was no evidence that profit risk or cashflow risk were significant drivers of the decision to develop either risk management capability; however, there was evidence of a negative association between market risk and the development of a BCM capability. Firms with greater market risk have a higher cost of capital so the managers in these firms will require a higher expected return for projects: it is therefore less likely that risk management projects will be approved.

1.5 Summary

This chapter has described the background to the study and, in particular, identified four key issues for the conduct of corporate risk research: that different stakeholder groups experience different risks; that corporate risks arise from the complex interrelationship of strategy, environment and organisational culture; that risk management is fundamentally a long-term activity; and that the extreme values in distributions of risk measures need to be handled with great care. Awareness of these issues highlighted a number of important shortcomings in previous research into corporate risk and risk management which have motivated the current investigation. The three specific research objectives of the study were then outlined and these are repeated below.

1. To investigate the measurement properties of some of the most commonly used corporate risk measures; bearing in mind that these properties may vary as the environment changes.
2. To investigate the relationship between risk and return, addressing both the epistemological and methodological shortcomings of previous empirical work.
3. To investigate the drivers for the development of a risk management capability.

The chapter concluded by outlining the structure of the rest of the thesis, including synopses of the three empirical chapters.

Chapter 2 - Strategy, Risk and Risk Management

2.1 Introduction

The overall aim of this chapter is to introduce, critique, compare and contrast theories and associated empirical research concerning strategy, risk and risk management from a variety of different academic literatures; in order to develop an overall theoretical framework upon which the subsequent empirical chapters are based. The chapter is organised in four main sections: strategy; risks to different stakeholder groups; the origins of corporate risk; and corporate risk management.

The chapter begins by introducing two important theoretical frameworks from the strategy literature that will be applied at various points throughout the thesis; the resource based view and the dynamic capabilities framework. It becomes clear from the discussion that risk is rather on the periphery of the development of these frameworks; but this first section of the chapter concludes by looking at an area of the strategy literature where risk is absolutely central: the theory of real options. An important theme throughout the thesis is the acknowledgement that different stakeholder groups experience different risks; and the next section of the chapter draws on various different literatures to discuss the risks to owners, managers, lenders and other stakeholders in the firm. The existence of tensions between these different stakeholder groups leads to a short discussion of agency costs, which will be relevant at various points throughout the empirical chapters.

Section 2.4 examines the various origins of corporate risk. Risk at the firm level has most widely been discussed in the past as a necessary consequence of taking business decisions with uncertain outcomes in the hope of generating profits; this has led to long-standing debates about the relationship between risk and return in both the financial economics and strategy literatures. A shortcoming of both of these literatures is that they tend to ignore the context within which businesses operate: more recently though, there has been growing interest in the relationship between macroeconomic factors and risk at the firm level. This topic is of particular importance to the empirical work in this thesis because of the highly unusual global economic conditions that existed over the study period, which included the financial crisis beginning in 2008. Aside from the strategic decisions that are taken, and wider environmental issues, some firms appear to be more prone to poor outcomes than others, and a significant strand of research within the crisis management literature concerns the organisational factors that predispose organisations to crises. Drawing together these different perspectives on the origins of risk, the final part of this section critiques the ways in which a number of previous authors have sought to classify and categorise risks in order to enable better research and risk management practice.

Section 2.5 discusses corporate risk management; the section begins by looking at the historical origins of risk management and, in particular, some important recent advances in practice. This is followed by an explanation of why, contrary to the CAPM (Sharpe (1964)), the appropriate management of idiosyncratic risks can create value for shareholders; and a discussion of why managers may choose to manage risk independently of considerations of shareholder value. The penultimate section attempts to integrate the various strands of literature discussed so far; and the chapter concludes with a short summary.

2.2 Strategy

This section discusses three important theoretical frameworks within the strategy literature: the resource based view (RBV); the dynamic capabilities framework[9]; and real options. The section begins by introducing the closely-related concepts of the RBV and the dynamic capabilities framework; this is followed by some comments on previous empirical tests of these theories. Risk has not been central to the development of either literature, but some examples where the role of risk has been highlighted are then discussed. The section concludes with a brief discussion of the theory of real options, in which risk is very much at the core. All of these topics will be developed in more detail in the empirical chapters, in the context of specific research objectives.

2.2.1 The Resource Based View

The RBV has become, since its inception in the late 1980s, the dominant approach within the strategy literature to explaining sustained competitive advantage. Remarkably though, for such an influential theory, its foundations lack precision; and key definitions have evolved somewhat over the years. According to one of the leading early contributions to the RBV debate, sustained competitive advantage is derived from the possession of resources that have "value" and "rareness"; whilst lacking "imitability" and "substitutability" (Barney (1991, p. 99)). Specifically, a firm's ability to gain a competitive advantage depends upon having specific "Physical capital resources", "Human capital resources" and/or "Organizational capital resources" (p. 101). However, Peteraf (1993, p.179) expresses things rather differently "…four conditions underlie competitive advantage, all of which must be

[9] The RBV and dynamic capabilities framework are also closely related to the strategic factors market literature: see Leiblein (2011) for a detailed analysis.

met. These include superior resources (heterogeneity within an industry), ex post limits to competition, imperfect resource mobility and ex ante limits to competition."

Foss and Knudsen (2003) subsequently tried to integrate the two approaches, and improve precision, by separating out the necessary and additional conditions for a sustained competitive advantage. They concluded that the only necessary conditions were "immobility" and "uncertainty"[10]: "all other conditions are additional in the sense that they: (1) are somehow derived from uncertainty and immobility… or, (2) serve to lend a particular form of expression to SCA [sustainable competitive advantage]…" (p.299)." Meanwhile (Grant (1991, p. 122)) stresses that individual resources themselves do not directly create competitive advantage; rather it is the creation of capabilities, that is, "Complex patterns of coordination between people and between people and other resources" which drive competitive advantage. Becerra (2008, p.1121) shares this focus on how resources are combined and concludes that "a collection of resources may generate above-normal profits" when the following conditions are met: "value uncertainty, resources specificity and firm-level innovation" (p.1122).

The development of the RBV to date has resulted in two classes of specific, testable predictions, these concern: "…the relationship between firm performance [competitive advantage] and the possession of identifiable and imperfectly imitable resources/capabilities/ competences"; and "…whether the prior possession of such resources shapes the subsequent development of the firm" (Lockett et al (2009, p. 18)). Whilst the RBV has gained widespread acceptance and stimulated much fruitful strategy research, it is important to note that it is not without its critics. Many of these criticisms centre around the tautology contained in Barney's (1991, p.101)

[10] This constitutes a fundamental link between strategy, as expressed in the RBV, and risk; the interaction of the two literatures is discussed further in section 2.6.

original definition of resources as "...all assets, capabilities and organizational processes, firm attributes...that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness." In particular, Toms (2010) and others highlight the lack of a theoretical basis for ascertaining the value of a resource. However, as Kraaijenbrink et al (2010, p.357) point out; even without resolving this issue RBV may still have value "...as a heuristic for managers...rather than as a theory..." Other critics (eg Hoopes et al (2003)) have argued that resources and capabilities are only a partial explanation for persistent differences in performance, and have proposed a broader theory of competitive heterogeneity.

2.2.2 The Dynamic Capabilities Framework

Teece and Pisano (1994) introduced the dynamic capabilities framework in order to address the perceived failure of the RBV to explain why many historically successful firms fail as the environment changes. Building on the RBV construct of capabilities, Teece et al (1997, p.516) defined "Dynamic capabilities as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments." Many other authors offered their own definitions over the next few years, such as: "the process to integrate, reconfigure, gain and release resources – to match and even create market change" (Eisenhardt and Martin (2000, p. 1107)).

Reviewing the literature up to that point, Ambrosini and Bowman (2009, p.33) concluded that "...there generally is consensus about the dynamic capabilities construct. These definitions reflect that dynamic capabilities are organizational processes in the most general sense and that their role is to change the firm's resource base." The authors also offer a number of specific examples of dynamic processes such as: R&D, acquisition, product innovation, absorptive capacity, organizational structure reconfiguration and resource divestment. Teece (2012, p.1396) proceeds to divide dynamic capabilities "...into three clusters of activities and adjustments: (1) identification and assessment of an opportunity (sensing); (2) mobilization of resources to address an opportunity and to capture value from doing so (seizing); and (3) continued renewal (transforming)." He also makes clear the important distinction between ordinary capabilities, which are routed in routines; and dynamic capabilities which "...may be based on the skills and knowledge of one or a few executives..." (p.1395).

2.2.3 Empirical Tests of the RBV and Dynamic Capabilities Framework

One of the principal criticisms of the RBV is the lack of empirical support; indeed, as discussed above, some critics argue that the tautological nature of the definition of resources means that the claims of RBV are inherently unfalsifiable. Even when this tautology is addressed (eg by applying the resource value-resource risk perspective (Toms (2010))), empirical tests of the central prediction of the RBV, that the possession of resources and/or (dynamic) capabilities leads to superior performance, are confounded by three factors: the difficulty of operationalising resource and capability constructs; the selection of an appropriate dependent variable; and the existence of alternative explanations for superior performance. These issues are described in more detail below; this is followed by a brief summary of the findings of a systematic review of empirical tests of the predictions of the RBV that had been published up to 2005.

Much of the theoretical focus of the RBV is on a firms' possession of intangible resources and capabilities which, by definition, cannot be directly measured. Reviewing a number of previous RBV studies, Molloy et al (2011, p.1496) conclude that: "...the dominant approach to measuring intangibles is mechanical and unidisciplinary (ie rooted in either economics or psychology)..."; and, in particular, "...economists often use 'coarse' measures (ie single-item proxies) which threaten internal validity" (p.1500). The authors proceed to advocate the use of a "Multidisciplinary Assessment Process" (p.1507), involving: clearly defining constructs; embedding the construct within the RBV; selecting appropriate indicators; and a multidisciplinary validity argument.

Whilst Molloy et al focused on issues with the right-hand-side variables, Ray et al (2004) highlight the importance of the correct choice of dependent variable. They argue that "If competitive advantages in one business process are offset by competitive disadvantages in other business processes, of if any profits generated...are appropriated by a firm's stakeholders and not reflected in a firm's overall performance, there may be no relationship between...resources and capabilities...and a firm's overall performance" (p.34). Toms (2010, p.660) makes a similar point: "Where accountability mechanisms are ineffective, rents accrue to insiders...Reported profits are normal...". Ray et al (2004) therefore advocate the consideration of more direct measures of the effectiveness of business processes as alternatives to overall firm performance, and illustrate this with an example where multiple measures of customer service performance are used as the dependent variable. Likewise, Leiblein (2011, p.912) argues that: "…the appropriate level of analysis for resource and capability-based logic is at the level of the resource, not the level of the firm".

Finally, Denrell et al (2013) caution about inferring causal relationships from any association between superior capabilities and sustained high performance. Using a Bayesian approach the authors demonstrate that, unless successive competitive contests in an industry are truly independent; “chance events have enduring consequences” (p.184), and it is very dangerous to infer anything simply from the observation of sustained superior performance.

Concerns about the level of empirical support for the RBV were confirmed by Newbert’s (2007, p.121) review of 55 articles published between 1994 and 2005 which found that “...the RBV has received only modest support overall and that this support varies considerably with the independent variable and theoretical approach employed.” In particular, he found that tests using capabilities as explanatory variables have proven to be much more likely to yield significant results in support of the RBV than tests using resources. As Lockett et al (2009) observe, even these low levels of support for the RBV are probably inflated by the publication bias towards significant results. Similarly, Arend and Bromiley (2009, p.75) conclude that the dynamic capabilities framework enjoys only “weak empirical support”. In view of these many concerns it is important to stress that, whilst the RBV and dynamic capabilities framework are used throughout this thesis as a basis for integrating risk and risk management into the wider discussion of firm strategy; no reliance is made on its central predictions.

2.2.4 Real Options

Real options are analogous to financial options, in that they confer the right but not the obligation to take some action in the future; but they are different in that they concern investment in real assets (eg buildings, plant, patents) rather than financial ones. The emergence of a specific real options literature can be traced back to the early 1990s with articles such as Trigeordis (1993) and Dixit and Pindyck (1995); but the basic idea has much earlier origins. Myers and Turnbull (1977 p.331-332) suggested that firms derive value from "options to purchase additional units of productive capacity in future periods"; and, even before Black and Scholes' (1973) seminal article on option valuation, Miller and Modigliani (1961) had observed that growth opportunities contribute significantly to firm value.

Reviewing the literature up to that point, Trigeordis (1993) identified six specific types of real option: the option to defer, the option to alter operating scale, the option to abandon, the option to switch inputs or outputs, growth options and multiple interacting options. Since then, the literature has evolved along a number of distinct paths; in their later review, McGrath et al (2004, p.87) noted that four distinct strands had emerged: "(1) the idea of option value as a component of the total value of the firm...(2) a specific investment with option-like properties; (3) choices that might pertain to one or more proposals; and (4) the use of options reasoning as a heuristic for strategy." Building on the fourth strand, and of particular relevance to this study, Tong and Reuer (2007, p.19) argue that "...real options theory can offer a more positive view of uncertainty and a more constructive view of managerial discretion..." The discussion below begins by considering the application of real option theory to the valuation of specific investments with option-like properties, before proceeding to consider the application of most interest for this study: the use of options logic as a heuristic for strategy.

2.2.4.1 Real Option Valuation of Investment Opportunities

In the context of valuing a specific investment opportunity, the real options approach improves upon net present value (NPV) in two important ways: it recognises that many decisions are irreversible, ie expenditures cannot be fully recovered later if conditions change; and, in most cases, the decision does not have to be taken immediately (Dixit and Pindyck (1995)). Recognition of these factors has the immediate practical implication that, even if an NPV analysis concludes that the project is worth pursuing, greater value may be created for the firm's owners by delaying a decision until more information is available. Delaying the decision is conceptualised as a "real option" and, by analogy with financial options, the value of this option increases with the uncertainty in future cashflows. Conversely, even if the output of an NPV analysis is negative, it may still be worth pursuing a course of action (eg some R&D activity) because of the options that it generates; once again, the value of these options will increase with the uncertainty in the future value of the underlying assets. Options may also be generated by, for example, investments in land, buildings and equipment; or entry into a new market. This rationale for valuing specific investments can (with one very important caveat, discussed below) be extended to the valuation of firms by considering the portfolio of options that a firm owns.

Whilst clearly representing an advance on the NPV valuation of investments, it is important to highlight some limitations of the real options approach. Fundamentally, and in common with the RBV and dynamic capabilities framework, risk (or uncertainty) is viewed purely as an input to the strategy process; the output of which is some measure of expected value. Also, the analogy with financial options has to be treated with considerable caution: upon exercise of a financial option one owns a (presumably) liquid security which can be sold immediately and the funds invested in risk-free assets; by contrast, exercising a real option confers ownership of an irreversible asset with an associated long-term revenue stream which is, itself, subject to uncertainty. This observation addresses the counter-intuitive prediction of real options theory, that uncertainty can increase firm value: in reality firms cannot own options in isolation, but will always have a mixture of options and actual assets.

There are also a number of practical problems in applying formal options valuation approaches to real projects, as highlighted by Bowman and Moskowitz (2001). Using a case study of a real options-based project appraisal carried out by Merck, the authors highlight the following issues: the inability to observe the value of the underlying asset; the assumption of a particular distribution of the value of the underlying asset (typically log normal) as a function of time; the lack of data with which to estimate historic volatility; and the lack of a fixed time to expiration of the option. In some cases there is the additional complication that the exercise price is not fixed; for example in joint ventures there may be an option for one partner to buy out the other based on fair market value at that future time. The authors therefore conclude that real options theory is most applicable as a heuristic for strategy, rather than as a quantitative tool: this is the approach taken throughout this thesis.

2.2.4.2 Real Options Logic as a Heuristic for Strategy

In attempting to clearly distinguish strategic approaches based on real options logic from others, Klingebiel and Adner (2015, p.221) delinetated "three dimensions of resource allocation behaviour...sequencing, low initial commitment and reallocation". Whilst sequencing is fundamental to real options logic, it is also a feature of other resource allocation regimes; likewise, low initial commitment is a necessary but not sufficient condition to classify a strategy as being based on real options logic. The authors argue that a strategy is based on real options logic only when these two features are accompanied by evidence that resources are systematically reallocated from failing projects to winning projects. The authors proceeded to measure the effect of each of these three dimensions of resource allocation on innovation performance, operationalised as "the proportion of firms' turnover that pertains to new products" (p.229). They find a significant positive effect of sequencing on innovation performance; but neither low initial commitment, nor reallocation, show individual direct effects. However, a correct fit between low initial commitment and reallocation (either both or neither) does have a significant positive effect. Thus, whilst they conclude that dynamic resource allocation regimes are superior to static ones, and superior to those involving low initial commitment but no effective reallocation of resources between projects; they cannot say if strategies based on real options logic perform better than those that simply commit to specific projects at the outset.

2.2.5 Real Options, the Resource-Based View and the Dynamic Capabilities Framework

It is important to stress that the real options and the resource based view approaches are not mutually exclusive, but complementary. Dixit and Pindyck (1995, p.111) hinted at a link in a discussion of real options, stating that "investment opportunities flow from a company's managerial resources, technological knowledge...Such resources enable the company to undertake in a productive way investments that individuals or other companies cannot undertake." Returning to the example in the previous paragraph of R&D activity having value because of the options that it creates; from a RBV stance, R&D activity has a value because it enables a firm to more accurately assess the value of a particular resource in a factor market.

Kogut and Kulatilaka (2001, p.747) made an explicit link in the title of their paper "Capabilities as Real Options", in which they define a resource as "a scarce factor...that embeds complex options on future opportunities". The authors proceed to explain capabilities in terms very similar to Teece et al's (1997) definition of "dynamic capabilities"; and Andersen et al's (2007) definition of a "strategic responsiveness" capability: "...we define core competence as the choice of capabilities that permits the firm to make the best response to market opportunities" (p.744). Looking to the future, Tong and Reuer (2007, p.21) specifically highlight the value of combining the two theoretical approaches: "Connecting real options analysis with the resource-based view has the potential to improve the analysis of firms' corporate development trajectories...Incorporating the resource-based view...also holds the potential to explain the heterogeneous expectations and investment behaviours of firms facing the same external uncertainty."

That concludes this brief introduction to three very important concepts from the strategy literature; once again, it is important to stress that the RBV, dynamic capabilities framework and real options logic are primarily applied as heuristics for decision making. In the course of the preceding review of the strategy literature, there has been some mention of risk in a rather vague sense. In keeping with the discussion of the ontology of risk in Chapter One, it is now necessary to consider the specific risks to different stakeholder groups: this is the subject of the next section.

2.3 Risks to Different Stakeholder Groups

As highlighted in Chapter One, the key question in any discussion of risk is "risk to whom?": within the ontological framework outlined in that chapter, it is meaningless to talk about risk to an inanimate entity such as the firm itself. As Holton (2004, p.22) puts it "Risk is a condition of individuals – humans and animals – that are self-aware. Organizations are not self-aware, so they are incapable of being at risk." Following the chronological development of theory, this section begins by looking at the risks to shareholders, before considering the risks to three other key groups: lenders, senior managers and society at large. The section concludes by relating the tensions between different stakeholder groups back to the broader discussion of agency issues.

2.3.1 Risks to Shareholders, Managers, Lenders and Society

The discussion of risk within the financial economics literature has traditionally focused on the interests of shareholders, who are concerned about the uncertainty in the future returns on their investment portfolios. In particular, early work focused on the risks to idealised well-diversified shareholders investing in an efficient market who, according to the Capital Assets Pricing Model (Sharpe (1964)), are only concerned with that component of the variability in returns from their portfolio of stocks that is correlated with fluctuations in the market as a whole (in this model the effects of idiosyncratic variability can be mitigated, without cost, by diversification).

However, more recent work has highlighted a number of other risks to shareholders, for example: Smith and Stultz (1985) explain how, with a convex tax function, variability in earnings increases the overall proportion of profit paid in tax; whilst Miller and Bromiley (1990) discuss the direct "adjustment costs" of constantly having to increase and decrease capacity. It follows from these arguments that shareholders will be interested in both positive and negative fluctuations in performance and will therefore perceive risk in a symmetrical fashion. However, Smith and Stultz (1985) also argue that uncertainty in earnings increases the expected direct costs of bankruptcy; and Lessard (1990) and Froot, Scharfstein and Stein (1993) argue that uncertainty in cash flows means that funds may not always be available when required to exploit value-creating opportunities: there is thus a compelling argument that shareholders may also be concerned specifically with negative outcomes.

It is misleading though to consider the risks to shareholders in isolation. Within an efficient market, any risk averse stakeholder in the firm will have to be paid compensation to bear risk: ultimately this will reduce returns, so shareholders should actually be concerned with the risks to all shareholder groups. In the absence of an efficient market, risks to other stakeholders represent important externalities which may attract the attention of government and regulators. Risks to stakeholders can also create indirect costs for the firm, for instance McNamara and Bromiley (1999) found that an increased probability of default was associated with more restrictive loan conditions. More generally, Shapiro and Titman (1986) highlighted that uncertainty in the ability of a firm to honour its obligations in the future impacts negatively on relationships with customers, suppliers and other key stakeholders: an important source of sustained competitive advantage according to the RBV, and one that is particularly difficult for competitors to imitate (Delmas (2001)). In the next two paragraphs the risks to managers, lenders and society at large are therefore considered.

The risk to senior managers in firms is rather nuanced. It has traditionally been theorised that managers are primarily concerned with specific negative outcomes such as loss of employment and/or damage to their reputation (Amihud and Lev (1981), Oswald and Jahera (1991)); and more generally, Libby and Fishburn (1977) found that managers conceptualised risk as the probability of failing to meet targets. Similarly, March and Shapira (1987 p.1407) found that "most managers do not treat uncertainty about positive outcomes as an important aspect of risk"; they also found that "risk is not primarily a probability concept...the magnitude of possible bad outcomes seemed more salient to them [managers interviewed]." However, DeMarzo and Duffie (1995) argue that managers may also experience other risks, specifically that volatility in performance may be taken to indicate poor managerial ability and reduce their value in the labour market. Moreover, in recent years much attention has been paid to aligning managers' interests with those of shareholders, through the design of equity-based compensation packages; which make managers undiversified shareholders in the firm who, according to the arguments in the previous paragraph, will be concerned with volatility.

By contrast, the risk to lenders is relatively straightforward. Lenders, and indeed individual bank lending officers, will be primarily concerned with specific negative outcomes, characterised by the probability of a default and the loss distribution given a default: lenders do not share in any positive outcomes so these are of no consequence to them. This particular relationship has been tested empirically by (amongst others) McNamara and Bromiley (1999), who found that bank lending officers did indeed adjust interest rates to reflect their judgements of the probability of default. National government, local government, regulators and society at large may also be concerned about the performance of firms where there are significant externalities, such as occurs in the financial services sector and industries that support critical national infrastructure: like lenders these stakeholders are primarily concerned with specific negative outcomes around the inability of firms to meet their obligations.

2.3.2 Agency Costs

The discussions above of the risks to different stakeholder groups highlighted various potential conflicts of interest. In particular, the conflict of interest between the shareholders and managers of a firm is a specific example of the more general problem of agency which arises "when one or more persons (the principal(s)) engages another person (the agent) to perform some service on their behalf which involves delegating some decision making authority to the agent" Jensen and Meckling (1976, p.308). In the context of the separation of ownership and control in a firm with outside investors, the problem of agency can be expressed in the following form "As managers gain control in the firm they may be able to pursue actions which benefit themselves, but not firm owners" (Dalton et al (1998, p.270)). In the context of this study, this could include managers pursuing actions to reduce the risks to their reputation and personal wealth which are detrimental to shareholders. Whilst, ideally, company directors would prevent managers taking decisions that benefitted them personally at the expense of shareholders; in practice, directors must balance any such "residual loss" against the "monitoring expenditures" incurred to optimise managers' decisions for shareholders in order to minimise the total "agency costs" (Jensen and Meckling (1976 p.308)).

Drawing on theories of agency, property rights and finance, Jensen and Meckling (1976, p.305) developed a new "theory of ownership structure for the firm" which "explains how the conflicting objectives of the individual participants are brought back into equilibrium so as to yield this result [maximisation of present value]" (p.307). This theory explains, amongst other things why "a manager or entrepreneur in a firm which has a mixed capital structure (containing both debt and outside equity claims) will choose a set of activities for the firm such that the total value of the firm is less than it would be if he were the sole owner" (p.306). Nevertheless, they stress that it is wrong to conclude from this that agency relationships are non-optimal because "benefits arise from the availability of profitable investments requiring capital investment in excess of the original owner's personal wealth" (p.328); similarly, Fama and Jensen (1983) conclude that the separation of ownership and management can provide a survival advantage because of the freedom it gives firms to employ the best managers, regardless of their ability and willingness to put their own personal wealth at risk.

It is difficult to directly test Jensen and Meckling's (1976) central prediction that firms with outside equity are less valuable, as firms with no outside equity would have very different characteristics (principally size) to firms with outside investors; moreover one would be restricted to accounting-based measures of firm value. Most empirical work has therefore been based on testing the related prediction that managerial share ownership aligns the interests of managers with those of outside investors, reduces agency costs, and hence maximises value for shareholders. Early tests (eg Lloyd et al (1986), Kesner (1987)) failed to find a significant relationship, possibly because of a failure to adjust for the different risk exposures across firms; but more recent tests have found significant positive relationship between share ownership and both accounting-based (Schellenger et al (1989)) and market-based measures of firm value (Kim et al (1988), Oswald and Jahera (1991)). As regards predictions about managers pursuing actions, such as implementing risk management systems, to reduce risk to their reputations and personal wealth; a detailed review of the numerous empirical studies on the relationship between managerial incentives and specific risk management activities is postponed until Chapter Six.

2.4 The Origins of Corporate Risk

In as much as risk has been discussed previously within the strategy literature (see section 2.2); it has generally been considered as exogenous, an input to the decision-making process rather than one of the outputs. This section begins by taking the diametrically opposite view; that is, looking at risk (to various stakeholder groups) as the inevitable consequence of making business decisions with uncertain outcomes: this is normally expressed in terms of a debate about the relationship between risk and return. The discussion then proceeds to consider the risks arising from the environment in which the firm operates; although it will be argued that it is incorrect to see these as truly exogenous. The mediating effects of organisational factors on the risks to the firm's stakeholders are then considered; and the section concludes by reviewing some previous attempts to categorise risks.

2.4.1 Corporate Risk and Return

Arguments about the relationship between risk and performance are generally based on the application of Utility Theory (Bernoulli (1738)), which predicts that risk averse individuals will require compensation to bear risk. This sub-section considers how this general argument has been applied firstly in the context of market risk and returns, and then in the context of accounting risk and returns.

2.4.1.1 Market Risk and Return

The concept of risk aversion, or at least variance aversion, was developed in the specific context of the stock market by Markowitz (1952, p.77); who argued that investors "consider expected return a desirable thing and variance of return an undesirable thing." He then demonstrated geometrically (p.82) that this gives rise to a range of "efficient combinations" of investments that have the lowest variance for a given expected return. It is important to note though that Markowitz (1952) does not equate variance with risk, in fact all he says (p.89) is that "The concepts 'yield' and 'risk' appear frequently in financial writings. Usually if the term 'yield' were replaced by…'expected return' and 'risk' by 'variance of return', little change of apparent meaning would result." Building on this argument, and using the term 'risk' explicitly, Sharpe (1964) then showed in the Capital Assets Pricing Model (CAPM) that well-diversified investors are unconcerned with unsystematic risk, but will require higher returns as compensation for bearing systematic risk; that is the variation in return that is correlated with the overall movement of the stock market. This predicts a very simple positive relationship between systematic risk (beta) and expected returns on a portfolio, as follows:

$$E(R_p) = R_f + \beta_p * (E(R_m) - R_f) \qquad (2.1)$$

Where: R_p is the return on a portfolio, R_f is the risk-free rate of return, β_p is the beta for the portfolio and R_m is the return to a market portfolio.

The CAPM received initial support from a number of early empirical studies, such as Fama and Macbeth's (1973) analysis of monthly returns on US stocks over the period 1935-68, which found a statistically significant positive relationship between beta and returns. However, over the next twenty years, the model was challenged by both repeated failures to find a positive relationship between beta and returns in other time periods; and the finding of significant relationships between a number of idiosyncratic variables and returns, such as: size (Banz (1981), Lakonishok and Shapiro (1986)), leverage (Bhandari (1988)) and book-to-market value of equity (Stattman (1980)). Building on this whole body of work, Fama and French (1992) tested a wide variety of models for market returns, using monthly data for US stocks from 1963-90: their key finding was that a parsimonious model using only size and book-to-market value of equity effectively explained the cross-sectional variation in average stock returns. They find that the size effect is negative and significant over the period 1963-90 (but insignificant in the sub-periods 1963-76 and 1977-90); whilst the book-to-market effect is positive and significant over all three periods. Importantly, beta was insignificant over the period 1963-90, and indeed when the period was extended to 1926-90.

Despite not providing any convincing interpretation of the size and book-to-market variables, and indeed acknowledging that their results were not "economically satisfying" (Fama and French (1992, p.450)); the "three-factor" model became very widely adopted[11]. However, only three years later, Pettengill et al (1995) identified a fundamental flaw in all the previous empirical tests of market risk and return; in that the models are based on expected returns but the factors are actually estimated using realised returns[12], as follows:

$$R_p = R_f + \hat{\beta}_p * (R_m - R_f) + \varepsilon_p \qquad (2.2)$$

There is a non-zero probability that the realised market return will be less than the risk-free rate, in which case there is a negative risk premium. Thus the relation between beta and returns "is conditional on the market excess returns when realised returns are used for tests" (Pettengill et al (1995, p.115)); with "a positive relation during positive market excess return periods and a negative relation during negative market excess return periods" (p.105). The authors go on to argue that the failure to find a significant relationship between beta and returns in previous tests arises because periods when a positive relationship is expected have been aggregated with periods when a negative relationship is expected. Separating out months with

[11] The article had been cited over 2000 times by June 2015 and was still being cited at a rate of ten citations per month (based on Web of Science™ database).
[12] The "Implied Cost of Capital" literature also highlights the problems of using realised returns as an estimator of expected returns (see for example Gebhardt et al (2001, p.136)); but takes a very different approach to addressing the issue.

positive and negative market returns[13], Pettengill et al (1995) find highly significant parameter estimates (positive in periods of positive market excess returns and negative in periods of negative excess market returns) for beta[14] over the period 1936-90 and in three sub-periods (1936-50, 1951-70, and 1971-90). Despite the compelling simplicity of this argument, the model has not been widely used[15]. However, both Morelli (2011) and Cotter et al (2015) have confirmed the conditionality of the relationship between beta and returns using data from the UK stock market (over the periods 1980-2006 and 1990-2009 respectively). Cotter et al (2015) also found a conditional relationship (positive when excess market returns are positive and negative when market excess returns are negative) between idiosyncratic risk and returns.

2.4.1.2 Accounting Risk and Return

Similar arguments based on risk aversion have also been applied to the relationship between accounting measures of risk and return, suggesting that managers require increased expected (accounting) return in order to invest in projects with greater uncertainty in outcomes: extending this argument to the level of the firm would imply a positive relationship between variability in profits and the profitability of firms. Bowman (1980, p.17) appears to imply that this behaviour is driven by the interests of managers themselves, stating that "The argument for economic rationality suggests that because the typical business executive is risk averse, the higher risk project/investment will require a higher expected return…" This risk aversion could arise because executive pay is often explicitly linked to accounting

[13] There are 380 months in which the market excess return is positive and 280 in which it is negative.
[14] Pettengill et al (1995) do not consider the impact of size, book-to-market value of equity or any other factors in their regressions.
[15] The article had been cited only 55 times by June 2015 (based on Web of Science™ database).

performance; or, more generally, because accounting performance influences job security and career prospects. Contrary to Bowman (1980), Marsh and Swanson (1984, p.35) argue that managers are actually acting on the behalf of shareholders, suggesting that managers factor the relationship between risk and return in the stock market[16] directly into investment decisions: "In the absence of some impediment, an equilibrium should be reached in which the positive relation between risk and return on stocks reflects the relation between risk and return on firms' marginal projects".

However there are also a number of arguments for a negative relationship between accounting measures of risk and return. Firstly, the market-based argument completely omits the quality of managerial decision making, and it is entirely possible that good management teams could simultaneously deliver high profitability and low variability in profits; indeed Andersen et al (2007) define a "strategic responsiveness" construct and demonstrate mathematically that this leads to a negative relationship between the average performance and standard deviation of performance of firms. More broadly, according to the RBV, firms could derive sustained competitive advantage from possession of a number of different (dynamic) capabilities. In addition size and/or market dominance could allow individual firms to combine high profitability with low profit variability, even without superior capabilities (that is, the firm's market power is also an omitted variable issue in studies such as Bowman (1980)).

Empirical attempts to test these competing theories of the relationship between accounting risk and return are frustrated by a very significant practical issue, as highlighted by Miller and Leiblein (1996 p.100): "Although it has been widely argued that risk affects return and vice versa, one of the difficulties in specifying a model of

[16] Obviously this predates Pettengill et al (1995), so assumes a positive risk-return relationship in the market.

risk-return relations is inadequate understanding of the timing of these effects." Projects will typically be characterised by significant cash outflows (hence reduced profitability) and high uncertainty in the early stages, followed by lower uncertainty and, hopefully, positive cash flows later on; but the timescale of this process could vary widely from project to project. Unsurprisingly, the results of different empirical tests of the relationship between accounting measures of risk and performance have been very mixed: these studies are discussed in detail in Chapter Five.

2.4.2 Corporate Risk and the Environment

The discussion of the relationship between risk and return outlined above implies that firms operate in complete isolation, and that the only risks that stakeholders face derive from the managers of the firm voluntarily engaging in projects with uncertain outcomes; whereas "A more complete perspective on organizational risk would acknowledge that risks can occur that are environmentally determined and result in deviations from managers' risk preferences" (Miller and Leiblein (1996, p.116)). The interaction between risk and the environment is very complex: whilst all risks that the firm faces are ultimately the result of the corporate strategy adopted, and are in that sense endogenous; it is important to acknowledge that there are "market factors beyond management control" (Andersen (2008 p.155)). It is also necessary to consider the way in which the environment affects decision-making at all levels within the firm.

In order to understand the relationship between risk and the environment better, it is useful to introduce the concept of "environmental uncertainty" as a generalisation of the concepts of "environmental variability" (Andersen (2008)) and "macroeconomic uncertainty" (Calmes and Theoret (2014)); which changes over time. The construct can be operationalised in various ways, including "The volatility of stock market or GDP…forecaster disagreement, mentions of uncertainty in news, and the dispersion of productivity shocks to firms" (Bloom (2014 p.154)).

In the absence of agency issues, and within the limits of "bounded rationality" (Simon (1955)), the managers of firms should set a corporate strategy which aims to deliver an appropriate expected return to shareholders for the risks that they bear[17], and hence the environmental uncertainty at that time must be a consideration in strategy-setting. Evidence that environmental uncertainty is indeed a consideration in setting corporate strategy comes from numerous sources such as Miller and Friesen's (1983) finding that successful firms adapt their strategy-making process in light of "environmental dynamism"; and Calmes and Theoret's (2014) finding that the cross-sectional homogeneity of asset allocation within banks increases with "macroeconomic uncertainty." However, according to the RBV (see section 2.2.1), strategy is implemented through the building up of resources and capabilities over an extended period of time: when the level of environmental uncertainty changes there is inevitably a lag before the firm's managers can decide upon, and implement, a new strategy with the desired risk-return relationship. Thus, changes in environmental uncertainty will have an effect on the risks to the firm's stakeholders, if only whilst a new equilibrium is established; indeed Andersen et al (2007) specifically investigate a "strategic responsiveness" construct as a possible explanation for Bowman's (1980) risk-return paradox.[18].

Environmental uncertainty may also affect the risks to firms' stakeholders through the way in which it affects managers' decisions about the treatment of "passive

[17] According to the CAPM, well-diversified investors need only be compensated for systematic risk but, as discussed previously, there are a number of reasons why they may also be concerned with unsystematic risks.
[18] It is interesting to note that whilst Andersen et al (2007 p.415) mention "dynamic environmental change", their modelling is actually conducted under the assumption of stable conditions.

risks" Merton (2005), or "non-core risks" Nocco and Stultz (2006). Ultimately these risks arise from the strategy that the firm pursues and specific investments that are taken (eg a decision to invest in new plant and machinery leads to an increase in the potential loss from a fire or flood), but they are distinguished by the fact that the firm has no comparative advantage in bearing these risks and, following Merton (2005) should therefore seek to transfer these to other parties. Merton's (2005) admonition to transfer all "passive risks" is somewhat simplistic as many of them cannot be transferred through established mechanisms such as the purchase of derivatives and insurance; but many of these risks can be effectively mitigated contractually or through management processes such as quality management, physical security, IT security and risk management. It is argued that the prevailing level of environmental uncertainty affects both managers' desire to mitigate these risks and the cost of doing so if they should choose to.

2.4.3 The Impact of Organisational Factors

Whilst accepting that risks fundamentally arise from an interaction between the decisions made by the firm's managers and the environment; it is important to note that a number of organisational factors can significantly affect both the likelihood of these risks materialising and the impact if they should do so. The "Onion Model of Crisis Management" (Pauchant and Mitroff (1992)) provides a useful framework for analysing the issues that predispose organisations to crises. The model suggests that the crisis-proneness of an organisation is the result of a combination of four factors: "organisational strategies"; "organisational structures"; "organisational culture" and "character of the individuals working in the organisation." Each of these factors represents a deeper layer of the "onion", less accessible to observation. Within this overall framework, the approaches of four groups of researchers are described below.

Pauchant and Mitroff (1988) focused specifically on issues concerning "organisational culture", analysing it along five dimensions to identify "healthy" and "unhealthy" companies. These dimensions are: "humanity's relation to nature"; "the nature of reality and truth"; "the nature of human nature"; "the nature of human activities" and "the nature of human relationship." "Unhealthy" companies were characterised by: viewing nature as a resource to be exploited; use of denial and disavowal; classifying people simplistically as either "good" or "bad"; fatalism and a competitive and individualistic outlook. Miller (1988) also focuses on issues concerning "organisational culture" and identifies five types of "pathological" organisation that he asserts are prone to crises. "Compulsive organisations" are rule-based and hierarchical whilst "depressive organisations" are bureaucratic, conservative and lack confidence: both types of firm are therefore slow to react to the changing environment in which they operate and therefore susceptible to being overtaken by events. The managers in "Dramatic organisations" are impulsive and overly ambitious which can lead to them over-reaching themselves and/or being caught out by a neglect of detail. In "detached organisations" there is a leadership vacuum at the top, resulting in poor coordination between different functions in the company which lays them open to potentially dangerous mistakes in the execution of their corporate strategy. Finally, the managers in "suspicious organisations" devote so much attention to obsessing about external conspiracies that they tend to miss the really important hazards.

By contrast, Greening and Johnson (1996), in their quantitative study of the incidence of crises, looked primarily at issues of "organisational structure". This consisted of examining six characteristics of the top management team of corporations: functional background heterogeneity; education; organisation tenure; organisation tenure heterogeneity; age and age heterogeneity. They also looked at two factors related to “organisational strategies”: the number of acquisitions (in the last two years) and the level of diversification. Of these factors, the following were found to be significantly related to the likelihood of an organisational crisis: functional background heterogeneity; education; organisation tenure and number of acquisitions.

Meanwhile researchers in the “High Reliability Organisations” (HRO) school, which has contributed much to the crisis management literature; have taken yet another approach, based on painstaking ethnographic research. Whilst, like Pauchant and Mitroff (1988) and Miller (1988), these researchers are primarily concerned with organisational culture; rather than looking at the factors that predispose organisations to crises, they focus on what enables organisations operating in obviously risky environments (eg nuclear power and the military) to function safely over extended periods. Summarising this whole body of work, Weick and Sutcliffe (2007) outline the five principles underlying HROs as: “preoccupation with failure”, “reluctance to simplify”, “sensitivity to operations”, “commitment to resilience” and “deference to expertise”.

The critical role of organisational culture, evident in the studies discussed above, has important implications for any quantitative risk research, as the difficulty of observing culture presents the significant possibility of omitted variables in any regression models. There is also an important overlap with the study of corporate risk management; this will be discussed further in section 2.5.4.

2.4.4 Categorising Corporate Risks

It is clear from the above discussion that there are numerous different sources of risk to the stakeholders of firms. In order to make the problem of understanding and, indeed, managing this diverse range of risks more tractable; much previous work has been devoted to devising meaningful categorisations of these risks. Given the practical imperative to categorise risks in order to manage them effectively, much of this work appears in the practitioner literature (eg IRM (2002), ISO (2009)); but the focus here is on the more theoretical contributions within various academic literatures. The discussion begins by looking at two categorisations of risks that were developed in the crisis management literature; this is followed by a brief comparison of various categorisations that have been developed in the strategy and financial economics literatures. The section concludes by summarising the key themes that are common to multiple categorisations.

Mitroff et al (1988) developed a categorisation of threats to organisations (not necessarily firms), in which threats were analysed along two, orthogonal, dimensions. One dimension concerns whether events are primarily "technical/economic" in nature (eg IT systems failures); or essentially "human, social or organisational" in nature (eg industrial action). The other dimension is concerned with whether the event is internally or externally triggered: this distinction is potentially problematic, given the complex relationship between the risks to the firm's stakeholders and the environment in which it operates, as discussed in section 2.4.2. Gundel (2005) addressed this issue in his categorisation of threats, also based on two orthogonal dimensions, by considering the degree to which a threat can be "influenced" (the other dimension was the extent to which an event is "predictable").

The importance of considering the degree to which threats can be influenced (Gundel (2005)), has particular resonance in the context of the firm, the fundamental purpose of which is to take (appropriate) risks in pursuit of profits. The taking of risk in pursuit of profit has formed the basis of a variety of categorisations of risks in the strategy and financial economics literature: the categories used in five important articles are summarised in table 2.1. Within this sample of articles there is a broad consensus for a dichotomy between risks that are taken deliberately, in the hope of achieving superior returns, and those that are an unavoidable consequence of the firm's operations. However, as stated in the previous paragraph, interpreting this as a division between exogenous and endogenous risks is misleading. A more interesting distinction arising from the sample of previous articles is that between "risks where the firm has a comparative advantage in risk-bearing" (Nocco and Stultz (2006)); and those where the firm has none. Moreover this distinction has an important practical value in terms of identifying those areas where conventional risk management activities (eg hedging or purchase of insurance) can be applied.

Table 2.1 – Categorisations of Risks

Reference	Categories of Risk	Definition	Suggested Approaches to Managing Risk
Chatterjee et al (1999)	Strategic risk	Probability that a firm can isolate its earnings from macroeconomic and industry-specific disturbances	
	Tactical risk	Uncertainty in a firm's expected returns that managers can reduce	Financial tactics Hedges Real options
	Normative risk	Risk premium that a firm incurs for failing to comply with any of its institutionally expected norms	
Palmer and Wiseman (1999)	Managerial risk	Management's proactive strategic choices involving the allocation of resources	
	Organizational risk	Characteristic of organizations experiencing volatile income streams	
Merton (2005)	Value-adding risks	Risks associated with positive-net-present-value activities in which the company has a competitive advantage	
	Passive risks	All other risks	Hedging Insurance
Nocco and Stultz (2006)	Strategic and Business Risks	Risks where the firm has a comparative advantage in risk-bearing	
	Non-core Risks	All other risks	Hedging Insurance
Kaplan and Mikes (2012)	Strategy Risks	Risks taken for superior strategic returns	Rules-based compliance approach
	Preventable Risks	Risks arising from within the company that generate no strategic benefits	Risk management system designed to reduce the probability that threats materialise and to improve the company's ability to manage or contain the impact should they occur
	External Risks	External, uncontrollable risks	Identification and mitigation of their impact

As mentioned above, the identification and categorisation of risks is primarily motivated by a desire to manage them better. Continuing this theme, the next section looks at the emergence of risk management as a discipline, and examines its appeal from the point of view of both shareholders and managers.

2.5 Corporate Risk Management

This section begins by looking at the historical origins of risk management and, in particular, some important recent advances in practice; such as the use of derivatives and the emergence of formalised approaches to managing risk. This is followed by an explanation of why, contrary to the CAPM (Sharpe (1964)), the appropriate management of idiosyncratic risks can create value for shareholders; and, drawing on both agency theory (Jensen and Meckling (1976)) and the behavioural theory of the firm (Cyert and March (1992)), a discussion of why managers may choose to manage risk independently of considerations of shareholder value. The section concludes by briefly discussing the relationship between organisational culture and corporate risk management.

2.5.1 The History of Risk Management

The practice of risk management can be traced back to at least 1800 BC in the form of insurance for ship owners (Bernstein (1996)); and as recently as "Twenty years ago, the job of the corporate risk manager…involved mainly the purchase of insurance" (Nocco and Stultz (2006, p. 8)). The main advance in risk management over the next four millennia was the emergence of the legal form of the corporation as a means of investors limiting their risk; whilst providing equity capital that acts as an "All-purpose risk cushion" (Meulbroek (2001, p.69)) for management. This use of legal mechanisms to manage risk was subsequently extended to the setting up of individual corporate vehicles to ring-fence the risk of specific projects. In recent years though, the nature of corporate risk management has changed significantly, in two distinct ways. Firstly, following important theoretical advances in the pricing of derivatives (Black and Scholes (1973)); an obvious change has been the availability of capital market solutions to transfer risk. In some instances this simply provides an alternative to traditional forms of insurance (eg “catastrophe bonds”); but the existence of these solutions has also allowed firms to transfer risk in areas where this was previously not possible, such as currency risk and interest rate risk.

Driven by a number of high-profile corporate failures, the other main change in this period has been a move towards formalised, auditable processes for managing risk, as Power et al (2009, p. 304) put it “The period since 1995 has seen an explosion of efforts to codify and formalize principles of risk management…organizations must apply rational standards of knowledge and frame what they do in these terms in order to maintain legitimacy”. This particular development is of direct relevance to this thesis: as well as being the focus of the study of risk management capabilities in Chapter Six, the adoption of formalised risk management processes has stimulated the debate about how to measure corporate risk which motivates the study in Chapter Four. The validity of Power’s (2009) assertion is demonstrated by the proliferation of guidance on corporate governance and internal control in recent years such as COSO (1992, 2004) and various versions of the “Corporate Governance Code” in the UK (Turnbull (1999), FRC (2010, 2012, 2014)); the passing of the Sarbane-Oxley Act in the US in 2002; and the adoption of Basel II (BIS (2006)) and Basel III (BIS (2011)) as international regulatory frameworks for banks. Power (2007, p.3) summarises the change in approach to risk management over this period as follows: “...the dominant discourse on risk management has shifted from the logic of calculation to that of organization and accountability.” Power’s (2009) assertion is also supported by the emergence of a number of new professional groups with accompanying professional institutions: two of these, the Institute of Risk Management and the Business Continuity Institute, will be discussed in more detail in Chapter Six where they are directly relevant.

2.5.2 Risk Management as a Value-Creating Activity

The potential for risk management to create value for shareholders is challenged by a simplistic interpretation of Sharpe's (1964) Capital Assets Pricing Model (CAPM); which suggests that all investors are able to mitigate firm-specific risks in the firms that they invest in, for free, simply by diversifying their portfolios. It follows that firms should not divert resources into managing these risks if investors can achieve the same effect themselves without incurring any cost. The CAPM is, of course, an idealised picture, containing a range of assumptions about how markets work so its predictions are, in reality, only approximations. There are, in fact, a number of compelling theoretical arguments why appropriate investments in risk management can create value for shareholders: these are outlined below.

Arguably the most important function of risk management is to reduce the likelihood of financial distress. Building on the previous literature on drivers for corporate insurance (eg Mayers and Smith (1982)), Smith and Stultz (1985) also argued that risk management adds value to the firm by increasing debt capacity (with the associated tax-shield effect); reducing the cost of debt; and lowering the expected tax liability. Shapiro and Titman (1986) subsequently highlighted an additional, related benefit in that reducing the likelihood of financial distress improves relationships with customers, suppliers and other key stakeholders: the RBV argues that relationships with such stakeholders are critical to developing lasting competitive advantage (Delmas (2001)). Lessard (1990) and Froot, Scharfstein and Stein (1993) subsequently extended this line of thinking: rather than being simply a means of avoiding bankruptcy, risk management is valued as a way of maintaining sufficiently stable cash flows to ensure that funds are always available to invest in valuable opportunities as they arise. The logic is straightforward in that if external finance is more expensive than internally-generated funds, then any temporary shortfall in internally-generated funds may result in attractive opportunities not being pursued. On a more practical level, Miller and Bromiley (1990, p.765) argued that firms incur “adjustment costs” if activity continually increases and decreases. Finally, in most jurisdictions, effective marginal tax rates are an increasing function of pre-tax earnings; in such circumstances, reducing the volatility of earnings will reduce average tax liabilities.

More recently, Meulbroek (2002) has suggested some more subtle ways in which risk management adds value; for instance managing risk enables investors to estimate beta more accurately, and to measure performance more easily. Rebonato (2007 p.111) develops the latter point in the specific context of the valuation of growth firms: underlying growth is not directly observable and has to be inferred from periodic accounting snapshots, but volatility in earnings confounds attempts to estimate the underlying growth with any accuracy and may therefore result in a company being undervalued. It follows from all of the above arguments that managers in firms that have a greater probability of financial distress; firms operating in sectors where the costs of bankruptcy are inherently high; and firms that have greater growth opportunities are more likely to choose to actively manage risks. The effect of firm size on the propensity manage risk is unclear: the proportional cost of bankruptcy is greater and tax functions are usually more convex for smaller firms; but larger size is generally associated with greater complexity (Gatzert and Martin (2015)), and larger firms have more resources with which to implement ERM (Beasley et al (2005)) or alternative formal approaches to risk management.

2.5.3 Managerial Perspectives on Risk Management

The arguments introduced above can be applied, in principle, to predict the behaviour of the owners of firms of all sizes from small privately-held companies to large public corporations. However, in the large, publicly-quoted firms that are the subject of this study, most decisions are taken by professional managers who are not normally (major) shareholders; so one cannot automatically assume that they will maximise value for shareholders. One important issue, as discussed in section 2.3.1 above, is that different stakeholders in the firm experience different risks: presenting the potential for conflicts of interests. Agency theory (Jensen and Meckling (1976)), as a framework for dealing with such conflicts of interest, was introduced in section 2.3.2; and its specific application to risk management is discussed further below. Equally, managers may not make economically optimal decisions because of "bounded rationality" (Simon (1955)); it is therefore also relevant to discuss the behavioural theory of the firm (Cyert and March (1992)), a set of rules derived from extensive empirical work about how managers in large firms operating under uncertainty actually make decisions.

2.5.3.1 Application of Agency Theory to Risk Management

The most widespread application of agency theory to risk management is in studies of the effect of managerial compensation. Managers usually receive pay-rises and bonuses based on performance (typically benchmarked against their peer group of firms); and are often awarded shares in the company which constitute a large part of their total wealth: it is therefore impossible for these individuals to simply diversify away the firm-specific risks related to their employment. Furthermore they may suffer very significant financial and reputational loss if the firm should fail and they lose their jobs (although job security is presumably a factor in the overall determination of remuneration: if managers fear that the company is likely to go bankrupt they will demand higher pay[19]). Managers may therefore be inclined to engage in risk mitigation activities, over and above those which increase firm value, purely to reduce the risk to themselves. DeMarzo and Duffie (1995) suggest another personal motivation for managers to engage in specific risk management activities. They hypothesise that managers use financial hedging to reduce volatility of earnings in an attempt to demonstrate how well the firm is being managed; thereby making themselves more valuable in the labour market. Following this line of argument, managers who are in the relatively early stages of their career, or who tend to change jobs frequently, may be more inclined to invest in risk management. In considering these arguments though, it should be remembered that the purpose of risk management is not to reduce risk per se; rather it is about mitigating "passive" (Merton (2005)) or "non-core" (Nocco and Stultz (2006)) risks to other parties so as the firm can take on additional "value-adding" (Merton (2005)) risks.

It is equally important to recognise that managers who are incentivised against short-term goals, or who hold large quantities of share options, may not invest enough in risk management. Indeed Mayers and Smith (1982) specifically argue that one of the benefits of insurance is that the insurance company performs a monitoring role on behalf of shareholders to ensure that managers are engaging in appropriate risk management activities to protect long-term value.

The previous two paragraphs focused on the nature of management, but the nature of ownership (ie individual or institutional shareholders) may also be important: Pagach and Warr (2011 p. 201) suggest that there is "an institutional desire for greater risk management." Even if institutional investors do not value reduction in the firm's idiosyncratic risk per se (as would be predicted by the CAPM); they are

[19] Peters and Wagner (2014) studied a related issue, that of dismissal risk; and found that for a one percent increase in the risk of dismissal, CEOs received on average a 7% increase in compensation.

likely to encourage managers to adopt good practice in corporate governance, of which formalised processes for risk management are a core component (Power (2007)).

Agency theory has also been used to explain the voluntary disclosure of risk information (eg Deumes and Knechel (2008), Höring and Gründl (2011)) and similar logic can be applied as an additional argument for adopting formalised approaches to risk management. The adoption of such a system, particularly one that is widely used (such as enterprise risk management), should reduce the monitoring costs for owners by making risk information more readily accessible and understandable (Meulbroek (2002)). Following this line of argument, managers of firms where the monitoring costs are high may choose to implement formal risk management processes in order to reduce efficiency losses. It would be expected that this effect would be most pronounced in firms which have a large number of small shareholders for whom the monitoring costs are disproportionately high relative to the value of their shareholdings. Of course this effect would be in the opposite direction to the effect hypothesised in the previous paragraph of large institutional owners demanding formal risk management approaches.

2.5.3.2 The Behavioural Theory of the Firm

Numerous aspects of the behavioural theory of the firm (Cyert and March (1992)) can usefully be applied to better understand the decision by the managers of firms to adopt risk management. Perhaps most importantly the concept of "problemistic search" (p.169), wherein innovation is triggered by the failure to meet organisational goals; suggests that managers are generally driven to explore new ideas (such as risk management) by specific negative events (eg failure to meet targets), rather than broader considerations of value maximisation. Meanwhile, consideration of how such searches are conducted, particularly the concepts of “local rationality” (p.165) and “simple-minded search” (p.170); would imply that risk management will only be identified as a possible solution to the perceived problem if it happens to be readily visible to those people closest to the negative event that triggered the search in the first place. In addition, the application of “acceptable level decision rules” (p.165) may mean that an inferior, but adequate, solution is adopted simply because it is identified more quickly. The concept of the “negotiated environment” (p.168), part of a broader idea of “uncertainty avoidance”; argues that there are unwritten, industry-wide conventions on good practice: it is perfectly plausible that these may include conventions on appropriate approaches to risk management, leading to inter-sector variations in the adoption of specific approaches. Cyert and March (1992) also draw attention to a tendency towards inertia in allocating funds to activities where the link to organisational goals is hard to establish; they cite the specific example of R&D but this could equally well be applied to risk management.

2.5.4 Corporate Risk Management and Organisational Culture

As alluded to in section 2.4.3, there is clearly a complex interrelationship between organisational culture, as discussed extensively in the crisis management literature, and corporate risk management. On the one hand, certain organisational cultures may be more suited to the implementation of formal risk management systems: Kimborough and Componation (2009) specifically highlighted the importance of organisational culture as a factor in the successful implementation of enterprise risk management in their survey of 116 internal audit executives. Alternatively, an appropriate organisational culture may actually be a partial substitute for formal, rules-based risk management. Ultimately, an effective risk management capability is based on a combination of individual beliefs, organisational routines and external networks developed over a period of time; so, to an extent, the two literatures are investigating the same underlying characteristics of the organisation.

2.6 Integrating the Strategy and Risk Management Literatures

Notwithstanding the fundamental connection between strategy and risk, highlighted by Foss and Knudsen's (2003) identification of "uncertainty" as one of the two necessary conditions for sustained competitive advantage; the RBV, dynamic capabilities and real options literatures have developed quite separately from those concerning risk management. However, there are a few interesting examples where the different literatures have interacted, if only indirectly.

One area in which overlap has occurred is in the discussion of the influence of risk on strategy formulation. Preble (1997) explicitly identified risk management (or "crisis management") as an important input in his proposed model of the strategic management process; but he made no reference to the RBV (although it was well established by that time), and the model that he developed now appears rather dated. More recently, Sirmon et al's (2007) seminal paper on dynamic capabilities highlights the influence of "environmental uncertainty" on the resource management process. The authors' focus is specifically on the epistemic uncertainty concerning which resources firms should acquire, which capabilities to bundle them into and which market demands to attempt to satisfy: this type of uncertainty relates to the "value adding" risks (Merton (2005)), or "strategic and business risks" (Nocco and Stultz (2006)) that can only really be managed by maintaining debt capacity and liquidity. However, the same thinking could also be applied to the aleatory uncertainty inherent in the resource management process; in order to develop the theory of risk management within the dynamic capabilities framework.

Constructs closely related to risk have also been advanced as mediating factors in the relationship between the firm's possession of capabilities and subsequent performance. Reinforcing the importance of distinguishing between ordinary capabilities and dynamic capabilities; Drnevich and Kriauciunas (2011) found that higher degrees of "environmental dynamism" reduced the contribution of ordinary capabilities to firms' relative performance, but increased the contribution of dynamic capabilities. However Schilke (2014, p.182) subsequently argued that "Although highly dynamic environments provide ample opportunity for resource reconfigurations, the high frequency of novel situations and the necessity to bring about discontinuous organizational change in these settings makes the routine-based mechanisms dynamic capabilities rest on comparatively less appropriate..." [20] This led him to hypothesise that "the relationship between [dynamic capabilities] and competitive advantage is strongest under intermediate levels of environmental dynamism" (p.185): tests using alliance management and product development as examples of dynamic capabilities were both supportive of his hypothesis.

It should also be noted that the RBV has been directly applied in two areas that are, in some ways, analogous to risk management: quality management and environmental management. Quality was specifically cited as an example of a capability or "competence" by Teece et al (1997); although it is important to note that only one of the eight empirical tests reported by Newbert (2007) that used "quality" as an explanatory variable provided statistically significant support for the theoretical predictions of the RBV. Meanwhile Delmas (2001, p.348) applied the RBV to the adoption of environmental management systems, specifically certification to ISO 14001, hypothesising that "…involvement of stakeholders in the design and structure of ISO 14001 sets up a path dependency process generating the sort of causal ambiguity just described and, with it, increases the difficulty of imitating the process for other competing firms." This hypothesis is supported by the results of

[20] This statement suggests a lack of consensus on what constitutes a dynamic capability: Teece (2012) argues that, by their very nature, dynamic capabilities tend to be less rooted in routines than ordinary capabilities (see section 2.2.2).

structural equation modelling, which shows that the involvement of external stakeholders in the design of the system had the greatest effect on firms' competitive advantage; much more so than the involvement of employees.

2.7 Summary

This chapter began by introducing three important approaches from the strategy literature: the RBV, the dynamic capabilities framework and real options. Given the reservations discussed about the accuracy of specific predictions from these theories, it is important to stress that all three approaches are used primarily as heuristics in this thesis. Crucially it was argued that these approaches were complementary, not mutually exclusive, so they can be applied singly or in combination as appropriate. The RBV and dynamic capabilities framework are applied in Chapter Four, in discussing the relationship between strategy and corporate risk; and in Chapter Five, in the development of a model relating risk and performance. The RBV is also invoked in a discussion of how risk management might lead to superior performance in Chapter Six; and real options theory is applied directly in the development of the empirical model in that chapter. However, all of these approaches from the strategy literature have two important limitations in the context of discussing corporate risk; so a number of other literatures have been introduced.

Firstly, there is an assumption that corporate risk is a one-dimensional concept; indeed, in the case of valuing real options, it is assumed that risk can be reduced to a single number derived from the uncertainty in future cashflows. It became clear though, from the discussion of the risks to different stakeholder groups, that this is a crude over-simplification. The approach adopted throughout this thesis is therefore to always use multiple risk measures, as proxies for the risks to the different stakeholder groups. Secondly, the strategy literature generally considers corporate risk as simply one of a number of exogenous inputs to the decision-making process; whereas it is clear from the discussion of the origins of corporate risk in section 2.4, that both strategic decisions and organisational factors are actually important sources of risk. It is therefore misleading to consider any form of risk as truly exogenous: rather corporate risk arises from the complex interrelationship between the environment and decisions made at various levels within the firm. This theme will be explored in much more detail in Chapter Four, in the context of measuring risk; and again in Chapter Five, which investigates the relationship between risk and performance.

Chapter 3 - Issues in the Estimation of Corporate Risk

3.1 Overview

Distributions of real firm-level data will often contain extreme values. These values may arise for a variety of different reasons including accounting idiosyncrasies, errors at some stage in the processing of the data or genuinely extreme performance by some firms; but it is frequently not possible to determine the cause for individual data points. Given the potential for small numbers of outliers to disproportionately affect the results of any statistical analysis, it is very common in empirical work to simply exclude the most extreme values: a process called Winsorization. But this approach implicitly treats all outliers as errors, when we know that this is not necessarily the case. Deleting instances of genuinely extreme performance may not be a major problem in many fields of research, where these observations are of no more significance than any other points in the distribution; but, as discussed in Chapter One, extreme (negative) performance is an important component of the risk to many stakeholder groups, so the deletion of outlying values destroys some of the most valuable information. There are now a rich range of techniques specifically designed to mitigate the effects of outliers without simply discarding data: the application of these techniques to risk research is the subject of this chapter.

This chapter begins by describing the data sources used in this study. Section 3.3 outlines the problem to be addressed, discussing: the distributions of performance data, in particular their skewness and kurtosis; the distributions of risk measures; the implications of skewness and kurtosis for the conduct of risk research; and how these issues have been addressed in previous empirical work. The next section introduces some measures of location, dispersion and correlation that are specifically designed to be robust to outliers, many of these are used throughout the empirical chapters; this is followed by a detailed discussion of various robust regression techniques, which are applied specifically in Chapter Five. The chapter concludes by introducing the technique of principal component analysis and, in particular, describing a robust version which is applied in the empirical study in the next chapter.

3.2 Data Sources for the Study

The study is based on a sample of listed UK firms over a ten-year period: accounting periods ending between 1st April 2003 and 31st March 2004 are denoted "2003"; through to accounting periods ending between 1st April 2012 and 31st March 2013, which are denoted "2012". Accounting data are taken from the FAME database (in certain instances where data were missing in FAME these were gathered from individual company annual reports) and market data from Datastream[21]. In common with previous work[22] risk measures (and a number of other variables) were estimated over a five-year period; and to be considered valid in an estimation period, firms had to have a positive figure for turnover and to have at least one employee in the last financial year of that period. The number of valid firms for each estimation period in the study is shown in table 3.1.

Table 3.1 – Number of Valid Firms by Estimation Period

Estimation Period	Sample Size
2008-12	1300[23]
2007-11	1347
2006-10	1258
2005-09	1056
2004-08	1005
2003-07	963

In order to minimise the incidence of erroneous extreme values, firms that had irregular accounting periods were excluded from the sample; as this may be indicative of major restructuring. In addition firms that listed or de-listed during any five-year period will automatically be excluded from the sample for that period.

[21] All data were downloaded from FAME between 1st October 2013 and 17th January 2014; data were downloaded from Datastream between 4th October 2013 and 24th January 2014.
[22] Dating back at least as far as Fama and MacBeth (1973) for market-based measures; and Bowman (1980) for accounting-based measures.
[23] The apparent fall in the number of valid firms in the final period is believed to be due to the delay between firms publishing accounts and them being uploaded onto the FAME database: 72 firms did not have data for an accounting period ending between 1st April 2012 and 31st March 2013 at the time of the download.

3.3 Statistical Issues with Corporate Risk Measures

The majority of risk measures at the firm level are derived from performance data; in this section two such measures, that have been widely used in previous empirical work, will be used to illustrate some more general issues in the distributions of risk measures. The risk measures used are the (longitudinal) standard deviation of ROE (as used, for example, in Fiegenbaum and Thomas (1988), Miller and Bromiley (1990), Alessandri and Khan (2006)) and standard deviation of ROA (as used, for example, in Bettis (1982), Miller and Bromiley (1990), Miller and Leiblein (1996), Miller and Chen (2004), Alessandri and Khan (2006), Andersen et al (2007)). The discussion will begin by looking at the performance data themselves, ROE[24] and ROA; before characterising the distributions of the risk measures derived from them and discussing the implications for risk research.

3.3.1 Distributions of Performance Measures

As stated above, the standard deviations of ROE and ROA have been widely used as risk measures in previous research: in order to understand the distributions of these variables, it is necessary to first understand the distributions of the underlying performance data. Descriptive statistics for ROE and ROA in both 2008 and 2009 are shown in table 3.2.

[24] Return on market value of equity is used throughout the thesis; the choice of this definition of ROE is explained in section 4.3.1.

Table 3.2 – Descriptive Statistics for ROE and ROA (2008 and 2009)

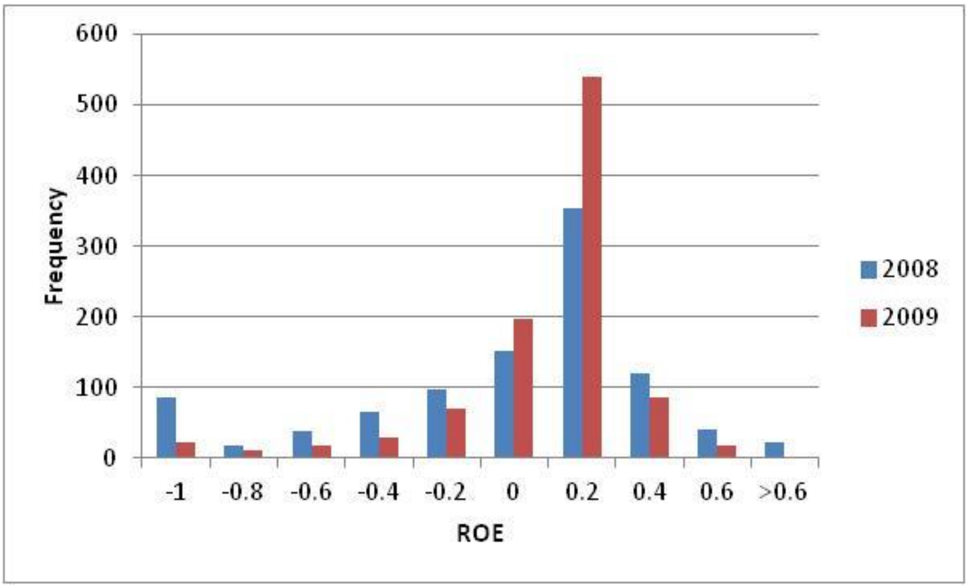
	N[25]	Mean	Median	Min	Max	SD	Skewness	Kurtosis
ROE (2009)	994	-0.0365	0.0533	-10.4	1.21	0.485	-11.3	212
ROE (2008)	994	-0.333	0.0388	-57.2	2.92	0.241	-16.1	335
ROA (2009)	994	-0.0300	0.0291	-8.23	0.519	0.460	-11.9	187
ROA (2008)	994	-0.0824	0.0149	-8.68	1.12	0.421	-9.89	179

There is a similar pattern in each of the four distributions which is characterised by high (negative) skewness and high (positive) kurtosis. Skewness is a measure of how symmetrical a distribution is: a perfectly symmetrical distribution has a skewness of zero and a distribution with skewness of magnitude greater than 1 is generally regarded as highly skewed (Lewis (2004 p.54)). The extremely large negative values observed in these samples mean that large negative values of ROE and ROA occur much more frequently than large positive values: this is intuitively reasonable, as it means that extreme losses occurred more often than extremely high profits in this period. Kurtosis is a measure of the heaviness of the tails of the distribution: the normal distribution has a kurtosis of 3 and the very high values observed here[26] mean that extreme values occur much more frequently than would be the case in the normal distribution. The financial crisis starting in 2008 has stimulated considerable interest in the study of extreme events, and there is a growing awareness of "fat tails" in the distributions of many financial data such as (log) share returns (Kemp (2011 p.30)). Fat tails may arise, contrary to the Central Limit Theorem, for a number of reasons including (Kemp (2011 p.35)): lack of diversification; multiple distributions; and distributions with infinite variance. At an individual level, the data points in the tails represent firms exhibiting extremes of

[25] There were 994 firms for which the data to calculate all of the risk measures used in Chapter Four were available for the period 2008-12.
[26] There is no upper bound on kurtosis.

performance; in particular, those in the left-hand tail relate to firms with a high likelihood of financial distress, an important component of the risk to both managers and lenders. In addition, it can be seen from table 3.2 that the mean (and to a lesser extent the median) values vary markedly from year to year. All of these points are illustrated further in fig. 3.1 which shows the distributions of ROE in 2008 and 2009.

Fig. 3.1 – ROE in 2008 and 2009



3.3.2 Distributions of Corporate Risk Measures

In line with a significant body of previous research[27], the sample standard deviations of ROE and ROA were then estimated from five annual values of ROE and ROA: clearly estimates based on only five observations will be very susceptible to being influenced by outliers. Given the skewness and kurtosis of the performance data highlighted above, it is not surprising that the distributions of these risk measures are also far from the normal distribution. Descriptive statistics for the standard deviations of ROE and ROA in the period 2008-12 are shown in table 3.3.

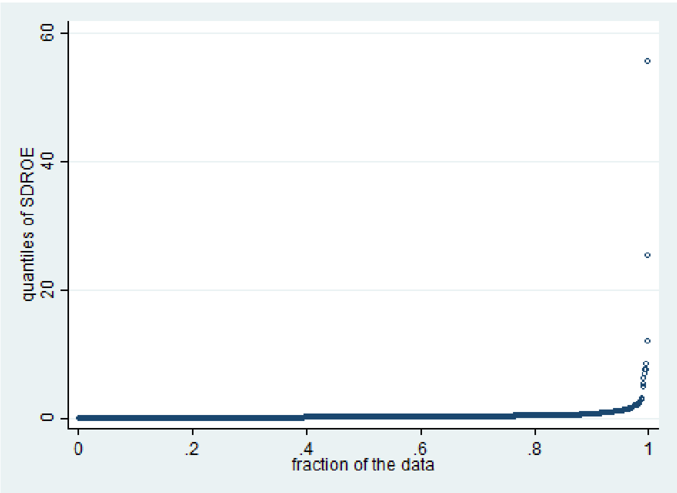
[27] Dating back at least as far as Bowman (1980).

Table 3.3 – Descriptive Statistics of Standard Deviation for ROE and ROA (2008-12)

	N	Mean	Median	Min	Max	SD	Skewness	Kurtosis
SD of ROE	994	0.389	0.123	0.00143	55.5	2.07	21.3	534
SD of ROA	994	0.128	0.063	0.000462	4.03	0.268	9.73	127

Both of these distributions also exhibit very high skewness; although the distributions of the standard deviations are positively skewed, meaning that very high values of the standard deviations of ROE and ROA occur much more frequently than very low values (of course, by definition, all values must be positive). Both distributions also exhibit very high kurtosis, ie extreme values of these risk measures occur much more frequently than would be the case in the normal distribution: the fat tail in the distribution of the standard deviation of ROE is very clearly visible in the quantile plot shown in fig. 3.2.

Fig. 3.2 – Quantile Plot of Standard Deviation of ROE

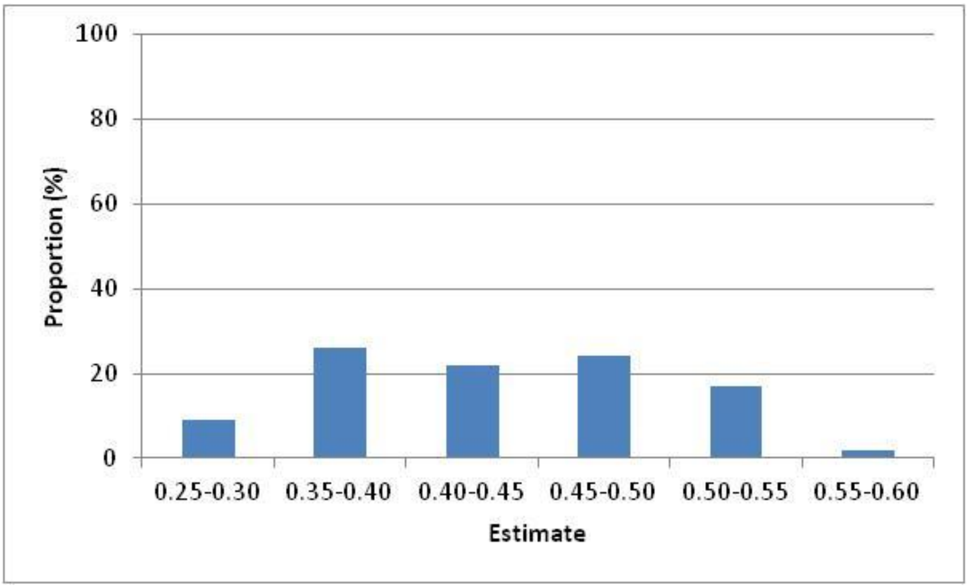


As will be discussed in section 4.3, many of the distributions of corporate risk measures used in the thesis have similar issues of skewness and kurtosis (although some of the measures are highly negatively skewed): some important implications of skewness and kurtosis for the conduct of empirical risk research are discussed in the next section.

3.3.3 The Impact of Skewness and Kurtosis

Such extreme skewness and kurtosis makes it difficult to characterise the distributions of individual variables with parameters. Location, or central tendency, is the most basic parameter of a distribution, and the sample mean is the most common measure of this: in order to illustrate the problem of using the sample mean to describe a distribution such as that of the standard deviation of ROE described above, a simulation was conducted. 500 data points were randomly drawn from the distribution shown in table 3.3 and the sample mean was calculated; this was repeated 100 times and the distribution of the sample means is shown in the fig. 3.3.

Fig. 3.3 – Distribution of Sample Mean of Standard Deviation of ROE

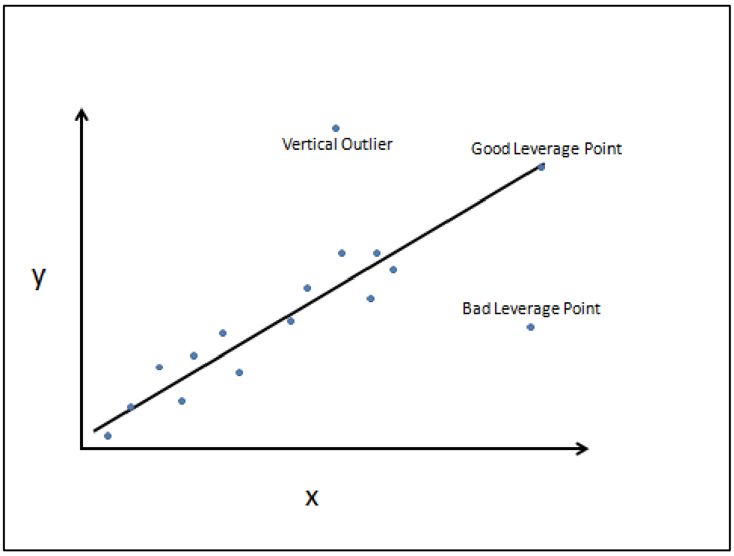


The sample mean is clearly very dependent on the precise values present in each sample used to calculate it, and it gives very little useful information about the overall population from which the sample is drawn: it is thus not possible to generalise from sample parameters to the population. Similar problems arise with the use of standard deviation to characterise the dispersion of such a distribution.

The issue of outliers becomes even more problematic when one wishes to analyse the relationships between variables. OLS regression and related techniques (eg ANOVA and principal components analysis) are based on calculations involving the squares of residuals, making these techniques very sensitive to large residuals; they may therefore give highly misleading results in the presence of outliers. The effect of outliers on regression results depends on both the distance of regressors from their mean values ("leverage"); and the "discrepancy" between the actual and predicted values of the dependent variable. Various measures have been proposed which combine leverage and discrepancy in order to give an overall measure of the "influence" of an individual observation on the regression results; these include $DFITS_i$ and Cook's D_i (Cook (1977)). However these techniques suffer from the drawback that they are all based on non-robust estimates of location and dispersion, so may not effectively detect outliers. The search for more robust methods of identifying influential outliers led to the development of the minimum covariance determinant (MCD) method (Rousseuw (1984)); which will be explained in more detail in section 3.6, where it is introduced in the context of its application in a robust technique for principal component analysis.

Building on the ideas of leverage and discrepancy, Rousseeuw and Leroy (1987) defined three classes of outliers, depending on how they impact on the regression results: “good leverage points”, “bad leverage points” and “vertical outliers”. The definitions of these are illustrated in the simple two-variable regression example shown in fig. 3.4.

Fig. 3.4 – Definition of Vertical Outliers, Good and Bad Leverage Points



Vertical outliers directly influence the parameter estimates, particularly the estimated intercept; and bad leverage points affect both the estimated slope and intercept. Good leverage points do not directly affect the estimated parameters but are still a concern because they deflate the estimated standard errors.

3.3.4 Treatment of Outliers in Previous Research

Despite growing awareness that outliers can unduly influence results, previous risk research has relied extensively on the estimation of standard parameters of distributions, such as sample means and standard deviations; Pearson correlations; and OLS regression. In the few cases where any acknowledgement has been made of the potential for outliers to distort the results; the problem has generally been addressed by simply removing the firms with the most extreme values from the sample (eg Miller and Bromiley (1990), Miller and Leiblein (1996)) which, as previously discussed, results in the loss of the most useful risk data. The other established technique, of transforming individual variables (typically taking the log or the square root) to reduce skewness and kurtosis, does not appear to have been widely used in risk research.

There is an alternative approach, using techniques that are specifically designed to be robust to outliers; but within the risk literature Bhagat et al's (2015) study of risk-taking in banks appears to be the only example of this approach, and the authors give no details of which of the many available technique(s) they used. Indeed, the application of such techniques throughout the whole of business and management research has been surprisingly limited: in a review of papers on the ECONLIT database, Zaman et al (2001) found only 14 examples containing the term "robust regression". The authors attribute the lack of use of these techniques to the following five factors: "The belief that large sample sizes make robust techniques unnecessary..."; "The belief that outliers can be detected simply..."; "Existence of several 'robust regression' techniques with little guidance available as to which is appropriate"; "Unfamiliarity with interpretation of results from a robust analysis"; and "Unawareness of gains available from robust analysis in real data sets" (p.1). The next three sections of this chapter aim to address some of these persistent barriers by describing and comparing a range of different robust techniques.

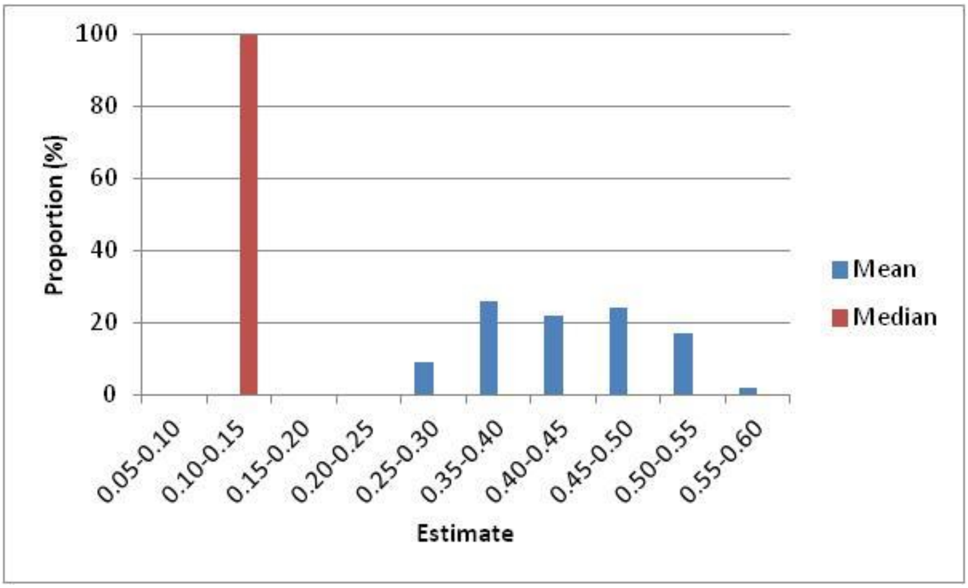
3.4 Robust Estimators of Location, Dispersion and Correlation

3.4.1 Estimators of Location

The sample median is a widely-accepted robust estimator of location. Whereas the estimated mean can be very significantly influenced by a single outlier; the median is bounded even if 50% of the data are replaced by arbitrarily high or low numbers. Formally, 50% is known as the "breakdown point" of the median[28], that is "the smallest proportion of the sample that may be arbitrarily replaced or added, which may result in the estimate becoming unbounded" (Berk (1990, p.301)). The other key consideration in choosing a suitable technique is efficiency, which is usually expressed as the efficiency relative to the corresponding non-robust technique on a Gaussian sample; which, for the median, is 64%. Typically, a trade-off is required between a high breakdown point and high efficiency; so the final choice for a given application will depend upon a good understanding of the nature of the data. This trade-off is illustrated below, once again using the data for the standard deviation of ROE in the period 2008-12 (see table 3.3). The simulation in section 3.3.3, based on drawing random samples of 500 data points from the distribution of the standard deviation of ROE, was repeated; and this time both the sample mean and median were calculated: the distributions of the estimated values are shown in fig. 3.5.

[28] The breakdown point of the mean is 0.

Fig. 3.5 – Distribution of Sample Mean and Median of Standard Deviation of ROE



As can be seen from the figure, despite its lower theoretical efficiency; the dispersion of the sample median is actually much less than the dispersion of the sample mean with this data because of the median's higher breakdown point. The sample median thus conveys information not only about the sample from which it was estimated, but also about the populations as a whole.

3.4.2 Estimators of Dispersion

A similar problem exists with measures of dispersion: once again the most common estimator of dispersion, standard deviation, is influenced by even a single outlier. The inter-quartile range is sometimes used as a more robust alternative but it has a breakdown point of only 25%. However, the median absolute deviation, defined as follows, is much more robust with a breakdown point of 50%.

$$MAD = b\ med_i(x_i - med_j(x_j)) \qquad (3.1)$$

Where b is a constant; for instance setting b equal to 1.4826 makes the estimates of the mean and median consistent for a Gaussian distribution. Rousseuw and Croux (1993) point out that the median absolute deviation has low relative efficiency

(37%); but, as measures of dispersion are not used directly for hypothesis testing in the empirical chapters of the thesis, this is not problematic.

3.4.3 Correlation Tests

The standard (Pearson) test of correlation between variables may also be severely influenced by a single outlier, as it depends on the squared deviations from estimated means. Spearman's (1910) correlation test provides a more robust approach, by ranking the data and then performing a Pearson correlation test on the ranks. An alternative robust correlation test was proposed by Kendall (1938), as follows:

$$r_K = \frac{2}{n(n-1)} \sum_{i<j} sign\left((x_i - x_j)(y_i - y_j)\right) \qquad (3.2)$$

Clearly both of these tests provide some robustness to outliers, but there is no generally agreed definition of "breakdown point" in the context of correlation tests. The relative efficiencies of both the Spearman and Kendall tests are greater than 70% for all possible correlation coefficients (Croux and Dehon (2010)).

3.5 Robust Regression Techniques

The effect of different types of outliers on regression results was discussed in section 3.3.3 above; and, as discussed by Zaman et al (2001), various different approaches have been developed to mitigate the impact of some, or all, of these different types of outliers. Three such approaches are discussed in this section: median regression, M-estimators, and high-breakdown-point estimators.

3.5.1 Median Regression

Median regression is a simple alternative to OLS regression that provides some robustness to outliers because it is based on minimising absolute values rather than squared residuals. The θth sample quantile in the location model is defined as any solution to the following minimization problem:

$$\min[\sum_{i:yi\geq b} \theta \left| y_i\text{-}b \right| + \sum_{i:yi<b}(1-\theta)\left| yi-b \right|] \qquad (3.3)$$

Where b is the value to be estimated. When θ = ½ this is, of course, equivalent to calculating the median. Koenker and Bassett (1978, p.38) extended this idea by defining the θth regression quantile as any solution to the following minimization problem:

$$\min[\sum_{i:yi\geq \boldsymbol{x}'\boldsymbol{i\beta}} \theta \left| y_i\text{-}\boldsymbol{x}'_i\boldsymbol{\beta} \right| + \sum_{i:yi<\boldsymbol{x}'\boldsymbol{i\beta}}(1-\theta)\left| yi-\boldsymbol{x}'\boldsymbol{i\beta} \right|] \qquad (3.4)$$

Where **x** is a column of regressors and **β** is a column of coefficients to be estimated.

The minimization problem (2) has to be solved by linear programming methods but the estimated regression quantiles are still consistent and asymptotically normal. Koenker and Bassett (1978) made the assumption that the conditional quantiles ($Q_\theta(y|\mathbf{x})$) were linear in x; but it turns out that the concept of the regression quantile is still useful even if this is not the case (see, for example, Angrist and Pischke (2009, p. 277)). The regression quantiles so defined have many useful applications, as they provide a much richer view of the relationship between the regressors and the dependent variable; including the ability to study the effect of regressors on both location and dispersion. As Angrist and Pischke (2009, p. 269) put it "Applied economists increasingly want to know what is happening to an entire distribution, to the relative winners and losers, as well as to averages." However, in this thesis, only the median regression (or "least absolute-deviations regression") is used as a robust alternative to OLS[29]. Whilst the median regression is robust to vertical outliers and good leverage points, it does not protect against bad leverage points so has a low breakdown point if these are present in the data; as regards efficiency, median regression has a relative efficiency of 64% (Verardi and Croux (2009)).

3.5.2 M-Estimators

The median regression is actually part of a broader class of "M-estimators" (Huber (1964)) which are based on solving the following minimization problem:

$$\min \left[\Sigma\, \rho(y_i - \mathbf{x}'_i\boldsymbol{\beta}) \right] \qquad (3.5)$$

Where **x** is a column of regressors; **β** is a column of coefficients to be estimated; and the objective function, ρ, is left unspecified; for example if $\rho(t) = t^2$ then the minimization problem is equivalent to OLS regression. In order to achieve greater robustness than median regression, various different sub-linear objective functions can be used such as least absolute residual (LAR), Huber, bi-weight/bi-square and Bell. The LAR and Huber estimators are both consistent and asymptotically normal; however, care needs to be taken with the use of bi-square and Bell objective functions if the distribution is not strongly unimodal (Berk (1990)). As with the median regression, all four of these estimators are robust to vertical outliers and

[29] The technique is also attractive as it avoids making assumptions about the parametric distribution of regression errors.

good leverage points but cannot protect against bad leverage points; so have a low breakdown point.

M-estimators are calculated by an iterative process; wherein an initial regression is performed to estimate the coefficients and calculate the residuals, which are then used to calculate the weights for the first stage of an iteratively-reweighted least squares regression. The Stata rreg function, used in the empirical chapters of this thesis, is based on an M-estimator which uses the Huber objective function to calculate an initial estimate, and the Tukey bi-weight function iteratively thereafter. However, the rreg function also provides some protection against bad leverage points by deleting (weighting zero) observations associated with a Cook's D_i greater than 1. With the objective functions given above, and the specific tuning constants used, rreg has a relative efficiency of approximately 95% (Hamilton (1991)).

3.5.3 High-Breakdown-Point Estimators

More recently, regression techniques have been developed that are also robust to bad leverage points; these are generically known as high-breakdown-point estimators. Rousseeuw and Yohai (1984) proposed a new type of estimator, the "S-estimator", based on computing a robust measure of dispersion, s. The S-estimator is conducted by choosing the regression coefficients that minimise s, subject to the following constraint:

$$1/n \sum \rho\, (r_i/s) = K \qquad (3.6)$$

Where: r_i are the residuals; ρ is a loss function which awards lower weight to large residuals; and $K = E[\rho(Z)]$. Setting K to this value ensures that s is a consistent estimator for σ, so long as the residuals are normally distributed. Once again, numerical methods must be employed to conduct the minimization. Using the Tukey bi-weight function as the loss function, a breakdown point of up to 50%, is achievable but at the expense of only 28.7% relative efficiency: this rose to 75.9% for a 25% breakdown point and 96.6% for a 10% breakdown point (Rousseeuw and Yohai (1984, p.268)). In order to address this shortcoming, Yohai (1987) subsequently proposed the "MM-estimator"; which consists of an initial S-estimate to give a high breakdown point, followed by iterated M-estimates providing high efficiency. A user-defined MM-estimator, mmregress, is available in Stata; it uses the Tukey bi-weight function as the loss function (for both the S-estimator and the M-estimator) to achieve a breakdown point of 50% with relative efficiency of 95% (Verardi and Croux (2009)).

3.6 Principal Component Analysis

Although not used extensively in the economics literature, principal component analysis (PCA) is a widely-used technique, within various branches of both the natural sciences and social sciences, for transforming a set of correlated variables into a smaller set of (usually uncorrelated) variables. PCA works by transforming the variables into a set of linear components: this is distinct from factor analysis which uses a mathematical model to estimate factors. The components are usually constructed using the eigenvectors of the variance-covariance matrix for the variables; with the components associated with the greatest eigenvalues explaining the highest proportion of variance. Whilst this sort of PCA has successfully been applied in many areas, the use of the variance-covariance matrix (based on squared residuals) makes the standard technique very prone to being skewed by outliers. This section begins by introducing a robust alternative to the standard variance-covariance matrix; this is followed by a brief explanation of how to choose which components to retain; and the section concludes with some remarks about interpreting the results of a PCA.

3.6.1 The Minimum Covariance Determinant Method

Rousseeuw (1984) developed the minimum covariance determinant (MCD) method as a way of constructing a robust variance-covariance matrix[30]. The method involves constructing a variance-covariance matrix for each subset containing h[31] observations and then using the matrix which has the lowest determinant; thus the MCD method has a breakdown point of h/n. Clearly though, this approach becomes impractical for large datasets as the number of subsets to be handled becomes

[30] In addition to their use in PCA, robust variance-covariance matrices have a range of other applications, including the detection of outliers and calculating robust correlation coefficients.

[31] For example Rousseeuw and Van Driessen (1999) used h = 0.75n.

impossibly large. Rousseeuw and Van Driessen (1999) therefore developed the FAST-MCD algorithm to approximate the MCD. Rather than randomly calculating covariance matrices for all possible subsets containing h observations; the FAST-MCD method starts with a number (typically 500) of subsets containing only p+1 observations (where p is the number of variables). Based on the parameters estimated from each p+1 subset, Mahalanobis distances (Mahalanobis (1936)) are calculated for all observations and subsets containing the h observations with the lowest Mahalanobis distances constructed. Variance-covariance matrices are computed from each h subset, and a small number (typically ten) of matrices with the lowest determinants are then iteratively "concentrated", a process that is guaranteed to yield a matrix with an equal or lower determinant, until convergence is achieved. The matrix with the overall lowest determinant is selected as the best approximation to the true MCD. Having constructed the MCD matrix in this way; the eigenvalues and eigenvectors are then used to generate the principal components in exactly the same way as for a conventional PCA.

3.6.2 Criteria for Deciding on how many Components to Retain

The output from the PCA contains as many components as there were original variables but, typically, only a small proportion of these components need to be retained to explain most of the variation. The PCAs conducted in this thesis are all exploratory PCAs: that is to say it is not known a priori how many components there should be or what they represent[32]; but a number of methods are available to decide how many of the components to retain. The choice of the most appropriate method depends on both the nature of the data and the purpose of the PCA. The Kaiser (1960) criterion simply consists of retaining all components with eigenvalues greater

[32] The related technique of confirmatory PCA is used where there is a solid theoretical and/or empirical basis for predicting the components.

than 1: this approach has been shown to be generally quite accurate unless there are a large number of variables and low communality (Stevens (2002, p.389)). For communalities less than 0.6 (Stevens (2002, p.390)), it is better to use the "scree test" (Cattell (1966)); which consists of plotting each eigenvalue against its ordinal number and retaining all components up to (but not including) the point of inflection. Alternatively one may simply choose to retain as many components are required to explain a certain amount of the total variance (usually at least 70%).

3.6.3 Interpretation of Components

The goal of exploratory PCA is to identify and interpret a small number of components that explain the majority of the total variation. However, typically, the retained components have many different variables loading onto them, making interpretation difficult: the components are therefore often rotated, using either an "orthogonal" or "oblique" rotation. For example varimax rotation (Kaiser (1960)), an orthogonal technique, aims to load small numbers of variables highly onto each component to aid interpretation. The choice of an orthogonal or oblique method in a particular setting depends on whether there is a theoretical basis for believing the components to be correlated or not. Stevens (2002, p.394) recommends "only using loadings which are about .40 or greater for interpretation purposes"; but he also tabulates critical values for statistical significance of loadings on components.

3.7 Summary

This chapter has introduced the data sources that are used throughout this study and highlighted some issues with the distributions of performance measures, and the risk measures derived from them, particularly with regard to the presence of outliers. Some of the problems that outliers present for conventional statistical techniques were then explained. As discussed in Chapter One, the treatment of outliers is a particularly important issue in risk research, as firms that experience extreme performance convey very important risk information; however previous risk research, in so much as it has addressed the issue of outliers at all, has tended to simply discard (firms with) outlying observations. A number of techniques that are robust to the effects of outliers were then discussed; these progressed from simple estimators of location and dispersion to multiple regression and, finally, principal component analysis. It is important to note that the different robust techniques (particularly the robust regression techniques) mitigate the influence of outliers in fundamentally different ways, and have different theoretical efficiencies; so wherever possible in the empirical chapters which follow, a range of techniques (including non-robust techniques) are used and the results compared.

Chapter Four - Measuring Corporate Risk

4.1 Introduction

As discussed in detail in Chapter One, risk is a highly contested construct; different stakeholder groups experience different risks; and there are numerous definitions in use, both in the academic and practitioner literature. In addition, risks are not directly observable so empirical work is necessarily based on the use of observable risk measures. The combination of these factors has resulted in the use of a bewildering array of different variables being used as corporate risk measures in previous research, often with little or no explanation of what they purport to measure; "Indeed, the empirical literature in finance often makes little distinction between variables which are measures of risk and those which constitute determinants of risk" (Ben-Zion and Shalit (1975, p.1017)). The objective of this chapter is to investigate the measurement properties of some of the most commonly used corporate risk measures; bearing in mind that these properties may vary as the environment changes. The risk measures are explored by way of a principal component analysis (PCA) of nineteen risk measures, most of which have been used in previous empirical work; in order to identify the underlying, unobservable, dimensions of risk. The analysis is repeated for six overlapping five-year time periods from 2003-07 to 2008-12: it is important to highlight that this timeframe includes the global financial crisis, beginning in 2007.

As well as a need for better corporate risk measures for use in academic research, this investigation is also motivated by the needs of risk management practitioners. Driven by a number of high-profile corporate failures, there has been a significant move towards formalised, auditable processes for managing risk in recent years, as Power et al (2009, p. 304) put it "The period since 1995 has seen an explosion of efforts to codify and formalize principles of risk management…organizations must apply rational standards of knowledge and frame what they do in these terms in order to maintain legitimacy". The validity of this assertion is demonstrated by the proliferation of guidance on corporate governance and internal control in recent years such as COSO (1992) and Turnbull (1999); and, more recently, formal standards for risk management such as ISO (2009). Effective measures of corporate risk are a fundamental requirement of all of these approaches.

The PCA results in a small number of components (three or four) being retained in each five-year period however, crucially, the component structure is not the same in each period. This finding is at variance with a previous similar study (Miller and Bromiley (1990)), and suggests that the relationships between different risk measures are not fixed but are mediated by the environmental uncertainty at the time. The outputs from the PCA represent another contribution, as they can be usefully applied as corporate risk measures; as indeed they are in subsequent chapters. The chapter also contributes to the wider debate on the desirable properties of risk measures, proposing a number of additional considerations for choosing a corporate risk measure.

The layout of the rest of this chapter is as follows. Building on the discussions in Chapter Two concerning the risks to different stakeholder groups and the origins of corporate risk; this chapter begins with a detailed review of the literature of direct relevance, including: risk measures as mental models; desirable characteristics of risk measures; and previous empirical work in related areas. The next section describes the data used in the PCA; this is followed by a section describing the methods of analysis and results. The chapter concludes by looking in detail at the results of the

PCA, including a discussion of the way in which different risk measures are affected by environmental uncertainty.

4.2 Risk Measures

This section picks up directly from the discussions in Chapter Two covering the risks to different stakeholder groups and the origins of corporate risk. The section begins by looking at how different mental models may be applied to convert observable risk measures into beliefs about future uncertainty; this is followed by a review of the desirable properties of corporate risk measures. The second half of the section focuses on a review of previous empirical work, looking at the risk measures that have been used in a wide range of studies; and then focusing on two previous analyses of the relationships between risk measures. This last sub-section concludes by making a number of observations about how these analyses of the relationships between risk measures can be improved upon, in order to develop more useful risk measures for both academic researchers and practitioners: this provides the motivation for the empirical work of this chapter.

4.2.1 Risk Measures as Mental Models

Risks are not directly observable so, necessarily, empirical work is based on the analysis of various observable risk measures. Rather than being simple proxies, these measures are only meaningful in the context of specific mental models of risk; as Slovic (2000, p.xxxvi) puts it: "There is no such thing as real or objective risk. Even the simplest, most straightforward risk assessments are based on theoretical models, whose structure is subjective and assumption-laden." Similarly, Beck (1992, p.58) argues that "Even in their highly mathematical or technical garb, statements on risk contain statements of the type *that is how we want to live*..." For instance, many of the corporate risk measures used in previous empirical work are based on the variability in some key aspect of firm performance, either accounting or market-based, such as the standard deviation of ROA or the idiosyncratic volatility of the share price. Indeed this approach had already become so standard that Bowman (1980, p.18) simply stated that "variance of profit is used here as a measure of risk. Research and professional practice accept this measure of risk." However, the use of such risk measures without any discussion of the mental model underlying them is meaningless, as these measures are ex-post estimates of the parameters of the firm's performance distribution; whereas "risk is inherently an ex-ante concept" (Henkel (2009 p.288)). Some sort of mental model is therefore required to convert these measures of historic variability into a (subjective) view of future states of the world. Such models could be based solely on the structure of the historic variability (for example this could be formalised in a GARCH model); or be based on a combination of the historical firm-level data and explicit predictions of how various environmental factors will evolve in the future.

Another category of corporate risk measures, or mental models, are based on observable firm characteristics, primarily financial ratios such as debt-to-equity or capital intensity: these are what Ben-Zion and Shalit (1975, p.1017) referred to as "determinants of risk." These measures can be interpreted in a number of different ways. At one extreme there is a straightforward, mathematical relationship between measures such as debt-to-equity and the (frequentist) probability of financial distress from which one can model this particular risk[33]; but measures such as capital intensity and R&D intensity have a much less straightforward interpretation. One can argue, for instance, that investment in capital equipment results in less flexibility to respond to fluctuations in demand, and that investment in R&D activity increases

[33] Note that this is not in conflict with the previous discussion of risk as subjective: even if the probability of an event is essentially objectively known, individual stakeholders will still have different perspectives on the impact if the event occurs.

the uncertainty of outcomes; R&D intensity is also widely used as a proxy for the costs incurred by financial distress, which is another important component of the risk to both shareholders and lenders. However, an alternative argument supports a relationship in the opposite direction "a company investing heavily in R&D may exhibit greater dynamic efficiency, or more flexibility than its competitors…" (Miller and Bromiley (1990, p.764)); recall also the discussion in Chapter Two about R&D activity creating real options. In addition, the observed aggregate R&D intensity does not differentiate between higher-risk "explorative" activities and lower-risk "exploitative" activities (March (1991)). All of the examples in this paragraph of firm characteristics (and many others) can also be interpreted as indicators of managerial propensity for risk taking from which stakeholders may draw conclusions about the future prospects of the firm.

4.2.2 Desirable Properties of Corporate Risk Measures

It was stressed in Chapter One that in any given situation there will always be a diversity of risk descriptions; however it was also emphasised that, if one is to proceed beyond a completely relativist approach, some means of arguing which particular risk descriptions (or risk measures) are of most use in any particular circumstances is required. What properties should one look for in a risk measure? This question is of both theoretical and practical importance and has previously been investigated from the point of view of regulators (eg Artzner et al (1999)); investors (eg Szëgo (2002)); and insurers (eg Wang (1998)). This section begins by summarising this prior work; before discussing the importance of one of the properties identified, subadditivity, in the context of this study. The section concludes by proposing some additional desirable properties of corporate risk measures.

4.2.2.1 Desirable Properties of Risk Measures

Taking the perspective of regulators, who are interested in the downside risks to the value of portfolios of securities; Artzner et al (1999) defined a risk measure ρ(X) as "the minimum extra cash the agent has to add to the risky position X, and invest 'prudently,' that is in the reference instrument". The authors then proceeded to define "coherent" risk measures as those which satisfy the four axioms of translation invariance, subadditivity, positive homogeneity and monotonicity; these axioms are defined respectively as follows:

$$\rho\,(X + \alpha r) = \rho(X) - \alpha$$

$$\rho\,(X + Y) \leq \rho(X) + \rho(Y)$$

$$\rho\,(\lambda X) \leq \lambda\rho(X)$$

$$X \leq Y \Rightarrow \rho(X) \leq \rho(Y)$$

Where r is the reference instrument; and α and λ are real numbers (λ ≥ 0). Applying these axioms, it is interesting to note that the widely-used measure value-at-risk is not coherent as it violates subadditivity. The concept of the "coherence" of risk measures has subsequently been applied by other authors, including Szëgo (2002); who thereby aligns the perspectives of investors and regulators.

As mentioned previously, the question of the desirable properties of risk measures has also been investigated from the point of view of insurers. The perspective of insurers is quite different to that of regulators and investors as it is principally concerned with the division of risks into different layers of cover. In particular, Wang (1998) highlights the importance of preserving first and second stochastic dominance (standard deviation and variance do not preserve first stochastic dominance); he also stresses the importance of additivity (as opposed to subadditivity) when risks are comonotonic.

4.2.2.2 Subadditivity of Corporate Risk Measures

Of all the criteria that are listed above the one that is most relevant in this study, indeed the only criterion that is directly relevant, is subadditivity. Subadditivity of risks is central to both Markowitz's (1952) work on "efficient combinations" of investments and Sharpe's (1964) CAPM, which were introduced in section 2.4.1.1 to explain investors' attitudes to risk. At the same time, subadditivity of risks provides the justification for pooling risks across the firm (Merton (2005), Nocco and Stultz (2006)), which is the core tenet of enterprise risk management (ERM); this is discussed in more detail in section 6.2.1.1. Subadditivity of risks is also relevant in the context of the merger of firms; as violation of subadditivity would imply that mergers, in themselves, create risks. Importantly, this creates potential agency issues as managers may seek to reduce the risk (eg of loss of employment) to themselves by acquiring other companies even if this is not in the interests of shareholders (who can achieve diversification simply by buying shares in other companies). Given the theoretical importance of the subadditivity of risks, from the perspectives of multiple stakeholder groups, satisfying this axiom must be a significant consideration in assessing the usefulness of any corporate risk measure.

4.2.2.3 Other Desirable Properties of Corporate Risk Measures

The desirable properties of risk measures discussed above are all binary: a risk measure either meets or does not meet each of them. It may also be useful to consider some criteria that capture the relative usefulness of different corporate risk measures on a continuous scale. For example, the risks to different stakeholder groups were discussed in some detail in Chapter Two; it is argued that the extent to which a corporate risk measure captures the risk to the particular stakeholder group of interest is another desirable property. This has, of course, already been captured implicitly in the articles mentioned in section 4.2.2.1 because these have only been looking at risk from the perspective of one particular stakeholder group (ie regulators, investors or insurers). In addition, it is proposed to introduce two further desirable properties: the degree to which a risk measure is forward-looking, and the resolution of a risk measure; these concepts are described in more detail below.

Section 4.2.1 discussed the difficulty of measuring the ex-ante concept of risk with ex-post data: each observable risk measure occupies a point somewhere on a continuum between backward-looking and forward-looking, with forward-looking measures being more useful. Variables derived from historical profitability figures represent the most backward-looking (and therefore least useful) risk measures; whereas those derived from market data are inherently more forward-looking because the future expectations of market participants are embedded in prices. As Vassalou and Xing (2004, p.3) argue, in the specific context of default risk models, "There are several concerns about the use of accounting models in estimating the default risk of equities. Accounting models use information derived from financial statements. Such information is inherently backward-looking, since financial statements aim to report a firm's past performance, rather than its future prospects."

The second proposed property is of a more practical nature. Measures that are derived from accounting data can only be updated annually, indeed many of these (eg standard deviation of ROE/ROA) require several years of accounting data, so they can only be calculated over a period of years; they are therefore unable to capture changes in risks occurring on timescales shorter than this (by contrast, market data is available almost continuously). A risk measure with greater resolution will generally be more useful than one with less resolution.

4.2.3 Corporate Risk Measures Use in Previous Research

As discussed above, an extremely diverse range of corporate risk measures has been used in previous empirical work. A selection of these, mainly drawn from studies of the relationship between firm-level risk and performance, are listed in table 4.1.

Table 4.1 - Risk Measures Used in Previous Studies

Risk Measure	References
Standard deviation of ROA	Bettis (1982), Miller & Bromiley (1990), Miller & Leiblein (1996), Miller & Chen (2004), Alessandri & Khan (2006), Andersen et al (2007)
Trend standard deviation of ROA	Miller & Leiblein (1996)
Variance of ROA	Ruefli (1990)
First-order root-lower-partial-moment of ROA	Miller & Leiblein (1996)
Second-order root-lower-partial-moment of ROA	Miller & Leiblein (1996)
Standard deviation of ROE	Fiegenbaum & Thomas (1988), Miller & Bromiley (1990), Alessandri & Khan (2006)
Variance of ROE	Bowman (1980)
‘True variance’ of ROE	Marsh and Swanson (1984)
'Corrected variance’ of ROE	Henkel (2009)
Debt-to-equity	Miller & Bromiley (1990)
Capital intensity	Miller & Bromiley (1990), Alessandri & Khan (2006)
R&D intensity	Miller & Bromiley (1990), Alessandri & Khan (2006)
'Altman's Z'	Alessandri & Khan (2006)
Beta	Miller & Bromiley (1990), Alessandri & Khan (2006), Ang, Chen and Xing (2006)
‘Downside beta’	Ang, Chen and Xing (2006)
Unsystematic risk	Miller & Bromiley (1990), Alessandri & Khan (2006)
Value at Risk	Bali et al (2009)
Standard deviation of analysts' forecasts	Miller & Bromiley (1990), Bromiley (1991)
Coefficient of variation of analysts’ forecasts	Miller & Bromiley (1990)

It should be noted that probability of default estimates (McNamara & Bromiley (1999)) are not included above as, following the discussion in section 4.2.1 above, they are not risk measures at all; rather they are the output from lending officers' mental models, formalised or not, which are presumably based to some extent on a number of the risk measures in the table.

The concept of subadditivity is not meaningful in the context of risk measures based on the dispersion of analysts' forecasts (Miller & Bromiley (1990), Bromiley (1991)); but of the remaining risk measures listed above, none violates the axiom[34]. Turning to look at the other desirable properties proposed above, the majority of the corporate risk measures used in previous empirical work can be plausibly associated with the risks to particular stakeholder groups. Variability of profitability, as captured by the standard deviation of ROE and/or ROA, has previously been argued to be the risk measure of most relevance to firm managers: "Reductions in profits result in numerous, usually unpleasant, managerial actions, such as layoffs, reductions in capital investment, and increases in cost control. In addition, stable, adequate profits facilitate implementation of corporate strategies. Alternatively, if managers are likely to be fired when profits fall rapidly, income stream stability should increase the stability of employment for a company's managers and other employees" (Miller and Bromiley (1990, p.763)). Building on these arguments, Miller and Leiblein (1996) subsequently proposed the first and second-order partial moments of ROA as downside measures of risk in an attempt to better capture the risk to managers. Financial ratios such as debt-to-equity and capital intensity are predictors of financial distress and thus more associated with the risk to lenders;

[34] Artzner et al (1999, p.215-217) provide various examples of portfolios of derivatives where value at risk violates subadditivity; but the measure used by Bali et al (2009), based on the lowest monthly market return for a firm in a 60-month period is indeed subadditive if one combines two firms.

indeed Altman's Z is specifically designed to predict the likelihood of financial distress. Meanwhile, measures based on market data would appear to capture the risk to investors; and the sample listed above includes both symmetrical and asymmetrical versions of these, as well as measures based on analysts' forecasts (Miller & Bromiley (1990), Bromiley (1991)).

Clearly relevance to the stakeholder group of interest will be a critical factor in choosing a risk measure. However, if we wish to choose between different risk measures relevant to a specific stakeholder group, the remaining desirable properties (the extent to which they are forward-looking and resolution) are of little use; as the measures relevant to each group tend to share many of the same characteristics (for instance, all the measures of risk to managers are derived from accounting data so share the same drawbacks of being backward-looking and having low resolution).

In view of the significant difficulty of choosing between these using arguments based on the desirable characteristics of corporate risk measures, some researchers have taken a completely different approach and attempted to synthesise new measures which correspond to some underlying, unobservable, dimensions of risk using the techniques of factor analysis and principal component analysis. Two of these previous analyses are discussed next.

4.2.4 Previous Studies of the Measurement Properties of Corporate Risk Measures

Two previous studies have investigated the measurement properties of corporate risk measures: Miller and Bromiley (1990) and Alessandri and Khan (2006). Miller and Bromiley (1990) investigated nine measures of firm-level risk that had been widely used in strategic management research up to that point: standard deviation of ROA, standard deviation of ROE, standard deviation of analysts' forecasts, coefficient of variation of analysts' forecasts, beta, unsystematic risk, debt-to-equity, capital intensity and R&D intensity. The study purported to be an exploratory factor analysis but, in fact, the three factors ("income stream risk, stock returns risk and strategic risk" (p. 756)) were introduced, without any theoretical discussion, prior to the analysis actually taking place. The study was based on a sample of "large", publicly-listed US firms across all industry sectors. Two five-year periods were studied (1978-82 and 1983-87), in order to test the stability of the relationships between risk measures, with data from 526 firms used in the first time period and data from 746 firms in the second (493 firms appeared in both time periods). The authors provide no summary statistics and simply state that "the firms studied were generally large", and that "these data included some extreme outlier values"; so it is impossible to say how significantly factors such as the skewness of distributions and presence of extreme values may have affected the results.

A number of different methods of analysis were applied but these all produced similar results; so the authors only reported figures for the PCA, in which three components were retained because they had eigenvalues greater than 1.0 (Kaiser's (1960) criteria). Unfortunately it is impossible to judge if the decision to retain three components was appropriate, and not influenced by the previous exposition of three "factors"; as no details are reported on the eigenvalues of the other components, or the amount of variance explained by those factors that were retained. The nine risk measures loaded onto the three components as predicted (all factor loadings were greater than 0.66 after varimax rotation); and tests of congruence (Harman (1976, p.344)) between the structures for 1978-82 and 1983-87 were greater than 0.98 for all three components, which led the authors to conclude that the component structure was indeed stable over the time period of the study.

Despite the emergence of a number of additional corporate risk measures in the intervening period, Alessandri and Khan (2006) used almost exactly the same set of risk measures as Miller and Bromiley (1990) and very similar terminology for their factors: “strategic risk”, “market risk” and “returns risk”. The study is based on a factor analysis of data from 373 large (average number of employees is 111 000), publicly-traded US firms over the period 1998-2003. Risk measures were also calculated at the industry level but, given that there were only 94 industries (at the 4-digit SIC level), it is not clear whether factor analysis was reliable (no formal test statistics of sampling adequacy are reported). There are also absolutely no descriptive statistics of the data so once again it is impossible to know if, for example, skewness may be affecting the results. The authors give very little detail about the conduct of the factor analysis, indeed it is not even clear if it was actually a PCA. Three factors were retained, which together explained 55.1% of the variance; but there is no explanation of how this decision was arrived at which, once again, raises the concern that the analysis was not truly exploratory. The eight risk measures loaded onto the three factors as predicted by theory, with all factor loadings greater than 0.57; it is not clear if factor rotation was applied and, if so, what kind (although it is explicitly stated that the factors are orthogonal).

Analysis of these two previous studies highlights a number of important ways in which improvements can be made, in order to identify more useful corporate risk measures for both academic researchers and practitioners; and this provides the motivation for the current study. Firstly, a much richer range of risk measures will be considered than in prior work, including measures of variability in cashflow; measures that are robust to outliers; and specific measures of downside risk (as per Miller and Leiblein (1996)). As regards the PCA, it will be conducted using a standard exploratory approach with absolutely no preconceptions about either the number, or interpretation, of components. In addition to a PCA based on the normal variance-covariance matrix; a PCA based on the minimum covariance determinant (MCD) matrix (Rousseeuw (1984, 1985)) will be used to improve robustness to outliers. Most importantly, following the analysis, it is intended to explore in much more detail: the relevance of these components to different stakeholder groups; their usefulness as risk measures; what they tell us about the underlying relationships between commonly-used risk measures; and how these relationships are affected by changes in environmental uncertainty.

4.3 Data

The analysis is based on a sample of listed UK firms over a ten-year period: accounting periods ending between 1st April 2003 and 31st March 2004 are denoted "2003"; through to accounting periods ending between 1st April 2012 and 31st March 2013, which are denoted "2012". All of the risk measures listed in table 1 are included in the analysis unless otherwise stated. Accounting data are taken from the FAME database (in certain instances where data were missing in FAME these were gathered from individual company annual reports) and market data from Datastream. As discussed in the previous chapter, a number of steps were taken in the construction of the sample to reduce the number of erroneous extreme values. However, as discussed below, where distributions still contained extreme outliers these were examined in more detail to identify any errors: in two cases it became apparent from examining the data for individual firms that the extreme values were misleading, and the variables were constructed in a different way as a result.

4.3.1 Construction of Corporate Risk Measures

The standard deviation of ROA was calculated as the sample standard deviation of ROA (FAME field 138 – "Return on Total Assets") over a five-year period. Note that as ROA is included as a measure of operational efficiency, of primary relevance to the managers of firms; profit before tax is used as the numerator rather than the more usual profit after tax. It is considered that there is no value in including variance of ROA in addition to the standard deviation; and there is no clear theoretical basis to justify the inclusion of a trend standard deviation of ROA. Given the important issues highlighted by a number of authors (Marsh and Swanson (1984), Henkel (2009)) with the use of standard deviations based on very small samples of data drawn from left-skewed populations; the median absolute deviation (MAD) of ROA is calculated as well to provide a measure of dispersion robust to outliers. The first-order root-lower-partial-moment (RLPM) of ROA is also calculated using the previous year's ROA as the target (the second-order root-lower-partial-moment (RLPM) is not included as the two measures were found to be highly correlated (Miller and Leibein (1996)). The RLPM of order α, measured over n[35] periods, is defined as follows:

$$RLPM = \{1/n.\ \Sigma\delta^{\alpha}\}^{1/\alpha} \qquad (4.1)$$

Where δ is the shortfall (if any) from the target each year.

A similar set of three measures (sample standard deviation, MAD and RLPM) is constructed for ROE; however there were a total of 380 firm-year observations in the sample (involving 143 firms) where book value of equity was negative, resulting in meaningless values of ROE. Not only would the exclusion of these observations have significantly reduced the overall sample size; but these firms with negative book value of equity are clearly at particularly high risk of financial distress, and thus of great interest in this particular study. This issue is simply not mentioned in any of the previous studies that have used the standard deviation of ROE (Fiegenbaum & Thomas (1988), Miller & Bromiley (1990), Alessandri & Khan (2006)) or variance of ROE (Bowman (1980)) as a risk measure; suggesting that a number of high risk firms may have been excluded from these analyses. The ROE values used to construct these measures were therefore calculated by dividing profit before tax (FAME field 14) by the market value of equity (Datastream field MV – "Market Value (Capital)"). The MAD of ROE is used as the robust measure of dispersion instead of 'true' (Marsh and Swanson (1984)) or 'corrected' (Henkel (2009)) variance of ROE (indeed 'corrected variance' cannot be calculated for such short time periods because of the need to estimate higher moments).

[35] $\alpha = 1$; n = 5 for all periods except for 2003-07 where n=4.

Beta is calculated as the slope coefficient from the regression of 60 monthly stock returns (Datastream field P – "Price (Adjusted – Default)") against the FTSE AIM All-Share index ("FTAI"); whereas "downside beta" is calculated as the slope coefficient from the regression of these monthly stock returns against the FTSE AIM All-Share index only during months when the index return is negative. Correlations between the returns of different assets could potentially vary with the state of the market so, in order to mitigate the influence of any extreme months, a "robust beta" is also calculated by conducting a median regression over the same period. Unsystematic risk is calculated as the residual standard error from the regression of monthly stock returns against the FTSE AIM All-Share index. Following Bali et al (2009) 'value at risk' is defined as the lowest monthly return during each five-year period[36]. It is not practical to use Miller & Bromiley's (1990) or Bromiley's (1991) definition of standard deviation of analysts' forecasts, as the I/B/E/S database that they used only covers a limited number of listed UK firms. An alternative measure of the dispersion in people's expectations: share turnover ratio (Ben-Zion and Shalit (1975)) is therefore used. This is calculated by dividing the annual sum of daily shares traded (Datastream field VO – "Volume") by the number of shares outstanding at the end of each year (Datastream field NOSH – "Number of Shares").

Two separate debt-to-equity measures were used: debt-to-book-value-of-equity and debt-to-market-value-of-equity. These were calculated as follows: short term loans and overdrafts (FAME field 52) plus long term liabilities (FAME field 85), divided by book value of equity (FAME field 93 – "Shareholders' Funds")[37]; and short term loans and overdrafts (FAME field 52) plus long term liabilities (FAME field 85), divided by the market capitalisation (Datastream field MV – "Market Value (Capital)"). Both

[36] This equates to the VAR for a holding period of one month at the 98.4 percentile.

[37] FAME field 113 - "Gearing" was not used as a debt-to-equity measure as there is an in-built cut-off.

ratios were calculated annually and then averaged over each five-year period. As mentioned previously, a number of firms have negative values for book value of equity in some years, resulting in negative values for debt-to-book-value-of-equity: these negative values were omitted from the calculation of five-year averages. Debt to book value of equity is, of course, a key component of Altman's Z (Altman (1968)); one further component of Altman's Z is also included as a risk measure: liquidity, calculated as current assets minus current liabilities[38] (FAME field 67 – "Net Current Assets"), divided by total assets (FAME field 70). Once again, this ratio was calculated annually and averaged over each five-year period.

Capital intensity was initially calculated by dividing tangible assets not including land and buildings (FAME field 34 - "Plant and Vehicles") by turnover (FAME field 1) for each year in the period. Initially this ratio was calculated annually but, even when the resulting ratio was averaged over a five-year period, this led to a distribution with a skewness of over 20. These extreme values of (average) capital intensity are driven by occasional huge changes in reported turnover (up to three orders of magnitude from year to year), principally in the oil and gas and mining industries; resulting in spuriously high values of capital intensity for individual years. Capital intensity was therefore recalculated by taking the mean value of tangible assets over each five-year period and dividing by the mean value of turnover. Many firms had missing data for tangible assets in individual years: these missing values were not included in the calculation of the averages. However, where a firm had no data for any year, the value for capital intensity is set to zero.

R&D intensity was initially calculated in the standard way by dividing R&D spending (FAME field 28 – "Research & Development") in each year by turnover (FAME field

[38] Negative values are included.

1); however, this also resulted in a distribution with a skewness of nearly 20. Further analysis revealed that a small number of extremely high values were due to companies that appeared to be in the start-up phase; within this group of firms, turnover is very low (typically tens or hundreds of thousands of pounds) and R&D expenditure may be orders of magnitude higher. Whilst these firms are inherently risky, and this should be captured in the risk measure; R&D as a proportion of turnover is an irrelevant measure in this context as the activity is actually funded by cash from equity investors. R&D spending as a proportion of book value of equity (FAME field 93 – "Shareholders' Funds") is therefore used as an alternative; and this ratio was calculated annually. As mentioned previously, a number of firms have negative values for book value of equity in some years, resulting in negative values of R&D intensity: these negative values were omitted from the calculation of five-year averages.

Finally, two additional risk measures, which had not been used in any of the studies listed in section 4.2.3, were included. Variability of cashflows is an important risk measure as it is both an indicator of the ability to service debt obligations and the ability to invest in value-creating opportunities when they become available (Minton and Schrand (1999)). It has also been found to be a significant driver of the adoption of enterprise risk management (Pagach and Warr (2011)). It was originally intended to use the coefficient of variation (standard deviation divided by mean) of cashflow as the measure of volatility (as per Minton and Schrand (1999)) but this led to very skewed distributions (skewness of greater than 50 in some cases). An alternative measure was therefore constructed by dividing the standard deviation of cash flow (FAME field 103 – "Net (De)Increase in Cash and Equiv.") for each five-year period by the average total assets (FAME field 70) over the five-year period. The MAD of cashflow divided by average total assets was also included to provide a robust measure of dispersion. The risk measures used are summarised in table 4.2.

Table 4.2 – Summary of Corporate Risk Measures

Risk Measure	Definition
SD of ROE	Sample SD of return on market value of equity over each five-year period.
SD of ROA	Sample SD of ROA over each five-year period.
MAD of ROE	Mean absolute deviation of return on market value of equity over each five-year period.
MAD of ROA	Mean absolute deviation of ROA over each five-year period.
RLPM of ROE	Root lower partial moment of order 1 of ROE/ROA, over each five-year period, using the previous year's value as the target.
RLPM of ROA	
Beta	Slope coefficient from OLS regression of 60 monthly stock returns on returns of FTSE AIM All-Share index.
Downside Beta	Slope coefficient from OLS regression of 60 monthly stock returns on returns of FTSE AIM All-Share index in months where index is negative.
Robust Beta	Slope coefficient from quantile regression of 60 monthly stock returns on returns of FTSE AIM All-Share index.
Unsystematic Risk	Residual standard error from the regression of 60 monthly stock returns on the FTSE AIM All-Share index.
Value at Risk	Lowest monthly return over 60 months
Share Turnover Ratio	Volume of shares traded over a year / number of shares outstanding at the end of each year. Ratio averaged over each five-year period.
Debt to BVE	(Short term loans and overdrafts + long term liabilities) / book value of equity at the end of each year. Ratio averaged over each five-year period.
Debt to MVE	(Short term loans and overdrafts + long term liabilities) / market capitalisation at the end of each year. Ratio averaged over each five-year period.
Liquidity	(Current assets - current liabilities) / total assets at the end of each year. Ratio averaged over each five-year period.
Capital Intensity	Tangible assets (averaged over each five-year period) / average turnover for five-year period.
R&D Intensity	R&D expenditure / book value of equity at the end of each year. Ratio averaged over each five-year period.
SD of Cashflow	Sample SD of cashflow over five-year period / average total assets for five-year period.
MAD of Cashflow	Mean absolute deviation of cashflow over five-year period / average total assets for five-year period.

4.3.2 Data Availability

In the period 2008-12, 282 firms were dropped from the overall sample of 1300 (see section 3.2) because they did not have accounting data going back as far as 2008, or because they had irregular accounting periods; and the necessary data on cash flow could not be found (either on the FAME database or through direct searches for company reports on the internet) for a further 12 firms. A further two firms were excluded because it was not possible to calculate a value for the robust beta[39]; and the requirement for book value of equity to be positive at least once in the period excluded another ten firms: the sample size for 2008-12 was therefore 994 firms. As shown in table 4.3, earlier periods had progressively smaller samples of firms: this is principally due to an increasing number of gaps in the FAME database.

Table 4.3 – Sample Sizes by Time Period

Period	Sample Size
2008-12	994
2007-11	981
2006-10	879
2005-09	702
2004-08	573
2003-07	519

Only about a quarter of the sample had any data on R&D spending over each five-year period but this could largely be explained by the fact that R&D is not carried out in many industries so this is not necessarily a data quality issue. Also, more than a quarter of firms had no data in any year for plant and equipment; once again this may well be an accurate reflection of reality and is not necessarily a data quality issue.

[39] The linear programming methods used to calculate quantile regressions do not work if there are a high proportion of zeros in the dependent variable.

4.3.3 Summary Statistics

Summary statistics for the nineteen risk measures in the period 2008-12 are shown in table 4.4.

Table 4.4 – Descriptive Statistics of Corporate Risk Measures (2008-12)

	N	Mean	Median	Min	Max	SD	MAD[40]	Skewness	Kurtosis
SD of ROE	994	0.389	0.123	0.00143	55.5	2.07	0.129	21.3	534
SD of ROA	994	0.128	0.063	0.000462	4.03	0.268	0.0640	9.73	127
MAD of ROE	994	0.0782	0.0278	0.000424	4.59	0.216	0.0304	12.9	233
MAD of ROA	994	0.0411	0.0177	0.000270	1.94	0.0898	0.0195	12.1	224
RLPM of ROE	994	0.194	0.0685	0	25.6	0.957	0.0723	21.1	530
RLPM of ROA	994	0.0661	0.0340	0	1.89	0.123	0.0351	8.08	96.5
Beta	994	0.682	0.605	-0.491	4.13	0.462	0.406	1.30	7.34
Downside Beta	994	0.652	0.611	-2.97	2.64	0.480	0.434	0.180	6.73
Robust Beta	994	0.561	0.526	-0.201	2.05	0.391	0.386	0.646	3.46
Unsystematic Risk	994	0.128	0.105	0.0179	1.86	0.108	0.0598	8.20	119
Value at Risk	994	0.319	0.296	0.0772	0.902	0.149	0.148	0.815	3.45
Stock Turnover Ratio	994	0.447	0.272	0.0000937	8.64	0.542	0.285	5.12	60.4
Debt to BVE	994	1.16	0.336	0	83.1	3.88	0.460	11.8	184
Debt to MVE	994	0.923	0.275	-0.130	51.3	2.93	0.382	9.62	126
Liquidity	994	0.130	0.100	-5.06	0.909	0.276	0.170	-6.54	129
Capital Intensity	994	0.111	0.00628	0	8.40	0.465	0.00931	12.3	194
R&D Intensity	994	0.0413	0	0	2.75	0.158	0	8.14	87.9
SD of Cashflow	994	0.0813	0.0523	0.000353	0.834	0.0975	0.0440	3.36	18.4
MAD of Cashflow	994	0.0421	0.0244	0.0000766	0.580	0.0578	0.0236	4.21	28.7

[40] The constant b in the calculation of median absolute deviation is set to 1.4826 to ensure consistency between estimators for standard deviation and median absolute deviation (see Chapter 3).

It is clear from table 4.4 that the distribution of many of the risk measures departs significantly from the normal; in particular, all of the measures of variability in profitability (ROE and ROA) are very positively skewed and contain a number of extreme outliers. The profit and loss data for a sample of firms with such extreme values were investigated in more detail and it was found that the variations in profit-before-tax arose directly from variations in the cost of sales and administrative expenses, and not from any sort of exceptional items. These extreme values would therefore appear to be capturing a real element of risk so it would be quite wrong to remove them. There is a single noticeable outlier on the right hand side of the distribution for unsystematic risk: more detailed analysis of the evolution of the firm's share price reveals nothing apart from the fact that it is extremely volatile. Despite the specific construction of the risk measure for capital intensity (described in section 4.3.1 above), the distribution still exhibits very high positive skewness. This is due to a number of very high values, mostly for firms in the extraction and energy sectors: once again these high values would appear to be a valid indicator of a certain type of risk inherent to those sectors. In order to illustrate these departures from normality further, quantile plots of the standard deviation of ROE, debt to book value of equity and capital intensity are shown in figs. 4.1 to 4.3.

Fig. 4.1 – Quantile Plot of Standard Deviation of ROE

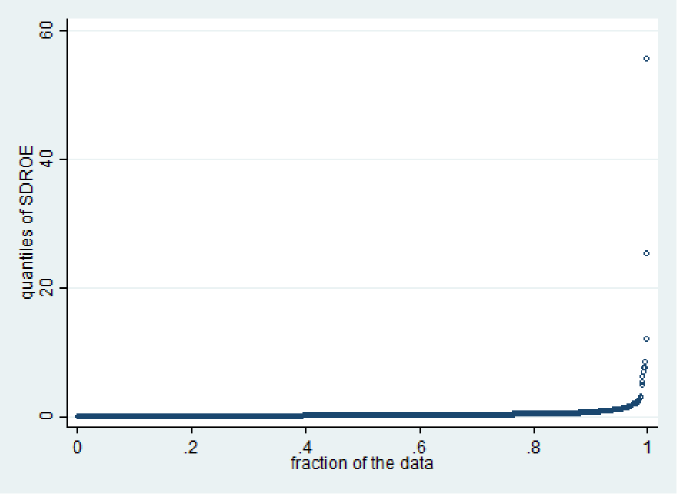


Fig. 4.2 – Quantile Plot of Debt to Book Value of Equity

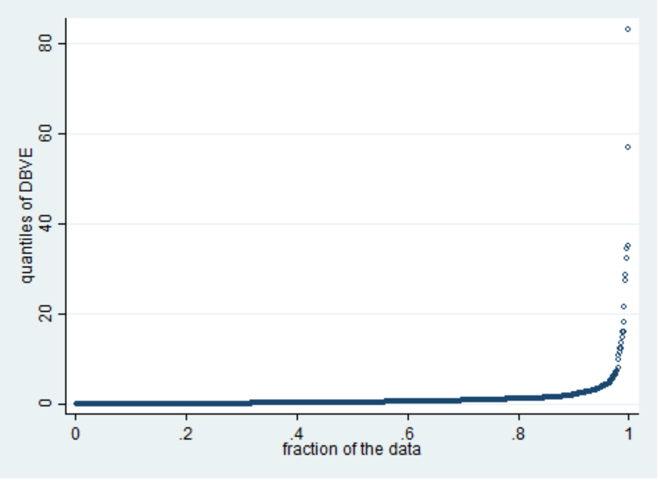
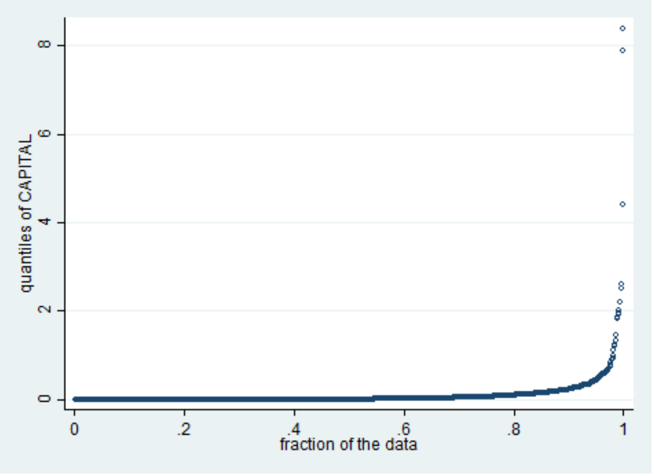


Fig. 4.3 – Quantile Plot of Capital Intensity



To further illustrate the issue of extreme outliers, various percentiles of the distributions of the standard deviation of ROE, debt to book value of equity and capital intensity are shown in table 4.5; expressed in terms of median absolute deviations from the median. The customary measure of standard deviations from the mean is not appropriate as neither of these estimators are themselves robust to outliers. As discussed in detail in Chapter Three, the extreme outliers in these distributions have the potential to significantly influence the estimations of variance and covariance that are central to the conduct of a standard PCA.

Table 4.5 – Quantiles of Standard Deviation of ROE, Debt to Book Value of Equity and Capital Intensity (Expressed in Median Absolute Deviations from the Median)

	1%	**2%**	**3%**	**4%**	**5%**	**95%**	**96%**	**97%**	**98%**	**99%**
SD of ROE	-0.889	-0.865	-0.847	-0.824	-0.816	7.65	8.97	11.2	15.0	36.6
Debt to BVE	-0.730	-0.730	-0.730	-0.730	-0.730	7.20	8.60	11.5	16.9	34.5
Capital Intensity	-0.675	-0.675	-0.675	-0.675	-0.675	47.2	59.4	70.6	99.0	208

Pair-wise correlation coefficients for the nineteen corporate risk measures in the period 2007-11 are shown in table 4.6.

Table 4.6 – Pearson Correlation of Corporate Risk Measures (2007-11)

	SD of ROE	SD of ROA	MAD of ROE	MAD of ROA	RLPM of ROE	RLPM of ROA	Beta	Downside Beta	Robust Beta	Unsystematic	Value at Risk	Turnover Ratio	Debt to BVE	Debt to MVE	Liquidity	Capital Intensity	R&D Intensity	CoV of Cashflow	MAD of Cashflow
SD of ROE	1																		
SD of ROA	0.24	1																	
MAD of ROE	0.31	0.25	1																
MAD of ROA	0.14	0.61	0.30	1															
RLPM of ROE	1	0.25	0.35	0.15	1														
RLPM of ROA	0.24	0.96	0.27	0.61	0.26	1													
Beta	0.21	0.05	0.19	0.02	0.22	0.03	1												
Downside Beta	0.21	0.05	0.15	0.04	0.21	0.03	0.66	1											
Robust Beta	0.17	0.06	0.07	0.02	0.17	0.06	0.79	0.62	1										
Unsystematic Risk	0.16	0.29	0.21	0.15	0.17	0.32	0.40	0.13	0.20	1									
Value at Risk	0.33	0.23	0.35	0.15	0.34	0.23	0.53	0.44	0.41	0.54	1								
Stock Turnover Ratio	0.07	0.14	0.04	0.40	0.09	0.20	0.09	0.05	0.11	0.04	0.07	1							
Debt to BVE	0.03	-0.04	0.00	-0.03	0.03	-0.04	0.02	0.02	0.04	-0.00	0.04	0.10	1						
Debt to MVE	0.36	-0.06	0.20	-0.07	0.37	-0.06	0.18	0.16	0.11	0.06	0.21	0.08	0.40	1					
Liquidity	-0.06	-0.31	-0.08	-0.38	-0.06	-0.27	0.01	-0.02	-0.03	0.03	0.02	-0.06	-0.13	-0.13	1				
Capital Intensity	-0.00	0.00	0.00	0.018	-0.00	0.00	0.09	0.04	0.07	0.06	0.05	0.01	0.00	-0.01	0.09	1			
R&D Intensity	0.01	0.09	0.01	0.17	0.01	0.08	0.02	0.02	-0.01	0.10	0.08	-0.02	0.15	-0.05	0.07	-0.00	1		
SD of Cashflow	0.04	0.35	0.09	0.38	0.04	0.36	0.08	0.05	-0.00	0.35	0.25	0.14	-0.08	-0.13	0.22	0.15	0.26	1	
MAD of Cashflow	0.03	0.26	0.06	0.27	0.03	0.27	0.08	0.02	0.01	0.28	0.22	0.01	-0.08	-0.12	0.24	0.09	0.29	0.74	1

1. Table 4.6 reports the Pearson correlation coefficients between each pair of variables over the period 2007-11.
2. For this sample size significance levels are as follows: $|r| > 0.063$, $p < .05$; $|r| > 0.082$, $p < 0.01$; $|r| > 0.10$, $p < 0.001$.

It is clear from table 4.6 that there are a number of clusters of corporate risk measures that are highly correlated with each other, for example different measures of variability in ROE; and different measures of volatility in share prices. These clusters may arise because the measures in each cluster relate to the same underlying dimension of risk; but it is also possible that these clusters simply arise from a shared relationship between the risk measures in a cluster and some other characteristic of the firm (eg size). In order to investigate the latter explanation, that there is a trivial explanation for the clusters observed amongst the Pearson correlation coefficients in table 4.6, a set of nineteen seemingly-unrelated regressions were estimated as follows:

$$\mathbf{y}_i = \mathbf{X}_i\boldsymbol{\beta} + \boldsymbol{\varepsilon}_i \qquad (4.2)$$

Where **y** is a column consisting of the nineteen corporate risk measures; **X** is a matrix of regressors with the same three variables in each row; and **ε** is a column of error terms that are assumed to have zero mean and to be independent across firms but, for a given firm, may be correlated across equations. If the error terms are not correlated, it would indicate that the correlations observed in table 4.6 can be explained by a common association with one or more of the three regressors. The three regressors used are as follows: the natural log of turnover (FAME Field 1) is used as a measure of firm size; market power of each firm is proxied by its market share, which is calculated as the proportion of turnover (FAME field 1) within the relevant industry sector[41]; and the Herfindahl Index is used as a measure of concentration within each industry sector[40]. The pair-wise correlation coefficients for the error terms for each risk measure are shown in table 4.7, using data from the period 2007-11.

[41] Based on the 21 sections in the 2007 SIC, and using the largest 12000 firms in the FAME database as at November 2013.

Table 4.7 – Correlation of Errors in Seemingly-Unrelated Regression (2007-11)

	SD of ROE	SD of ROA	MAD of ROE	MAD of ROA	RLPM of ROE	RLPM of ROA	Beta	Downside Beta	Robust Beta	Unsystem atic Risk	Value at Risk	Turnover Ratio	Debt to BVE	Debt to MVE	Liquidity	Capital Intensity	R&D Intensity	CoV of Cashflow	MAD of Cashflow
SD of ROE	1																		
SD of ROA	0.24	1																	
MAD of ROE	0.31	0.21	1																
MAD of ROA	0.14	0.57	0.26	1															
RLPM of ROE	1	0.25	0.35	0.15	1														
RLPM of ROA	0.24	0.96	0.23	0.58	0.26	1													
Beta	0.22	0.06	0.23	0.04	0.23	0.03	1												
Downside Beta	0.21	0.06	0.18	0.07	0.22	0.05	0.63	1											
Robust Beta	0.18	0.11	0.13	0.08	0.19	0.13	0.77	0.59	1										
Unsystematic Risk	0.16	0.24	0.19	0.10	0.17	0.27	0.40	0.12	0.23	1									
Value at Risk	0.33	0.20	0.36	0.14	0.35	0.21	0.51	0.42	0.40	0.52	1								
Stock Turnover Ratio	0.08	0.18	0.06	0.45	0.09	0.25	0.07	0.03	0.08	0.06	0.07	1							
Debt to BVE	0.04	0.03	0.04	0.04	0.04	0.03	0.01	0.01	-0.00	0.04	0.07	0.07	1						
Debt to MVE	0.38	0.02	0.25	-0.01	0.39	0.02	0.19	0.16	0.08	0.11	0.25	0.06	0.37	1					
Liquidity	-0.07	-0.36	-0.10	-0.43	-0.07	-0.32	0.01	-0.02	-0.02	0.01	0.01	-0.05	-0.11	-0.11	1				
Capital Intensity	-0.01	-0.04	-0.02	-0.01	-0.01	-0.04	0.10	0.05	0.09	0.04	0.03	0.02	0.02	0.01	0.08	1			
R&D Intensity	0.01	0.07	-0.00	0.16	0.01	0.06	0.04	0.04	0.02	0.10	0.09	-0.01	0.16	-0.04	0.08	-0.01	1		
SD of Cashflow	0.03	0.25	0.03	0.31	0.03	0.25	0.10	0.06	0.05	0.30	0.22	0.20	0.00	-0.05	0.21	0.11	0.26	1	
MAD of Cashflow	0.02	0.16	0.00	0.20	0.02	0.17	0.10	0.03	0.07	0.22	0.19	0.05	-0.01	-0.05	0.23	0.06	0.29	0.70	1

1. Table 4.7 reports the Pearson correlation of the error terms (ε) between each pair of dependent variables in the estimation of equation (2) using seemingly unrelated regression.
2. For this sample size significance levels are as follows: $|r| > 0.063$, $p < .05$; $|r| > 0.082$, $p < 0.01$; $|r| > 0.10$, $p < 0.001$.

Significant correlation between errors within the previously-observed clusters can still be seen, indicating that the clusters cannot be explained by a trivial association of these corporate risk measures with firm size, market power or industry concentration. This gives some confidence that the clusters arise because a number of different measures relate to the same underlying dimensions of risk.

Because of the very high (positive) skewness and kurtosis of a number of variables, a non-parametric (Spearman) correlation analysis was also performed. The pair-wise correlation results for the nineteen risk measures, using data from 2007-11, are presented in table 4.8; and can be seen to be very similar to the results of the Pearson correlation in table 4.6.

Table 4.8 – Spearman Correlation of Corporate Risk Measures (2007-11)

	SD of ROE	SD of ROA	MAD of ROE	MAD of ROA	RLPM of ROE	RLPM of ROA	Beta	Downside Beta	Robust Beta	Unsystem atic Risk	Value at Risk	Turnover Ratio	Debt to BVE	Debt to MVE	Liquidity	Capital Intensity	R&D Intensity	CoV of Cashflow	MAD of Cashflow
SD of ROE	1																		
SD of ROA	0.72	1																	
MAD of ROE	0.76	0.56	1																
MAD of ROA	0.52	0.76	0.62	1															
RLPM of ROE	0.96	0.70	0.73	0.51	1														
RLPM of ROA	0.69	0.90	0.53	0.67	0.75	1													
Beta	0.32	0.15	0.25	0.17	0.31	0.13	1.												
Downside Beta	0.21	0.10	0.15	0.10	0.21	0.10	0.71	1											
Robust Beta	0.20	0.08	0.15	0.11	0.21	0.08	0.84	0.63	1										
Unsystematic Risk	0.34	0.22	0.33	0.27	0.29	0.14	0.50	0.29	0.32	1									
Value at Risk	0.44	0.26	0.38	0.27	0.41	0.23	0.59	0.45	0.43	0.81	1								
Stock Turnover Ratio	-0.15	-0.16	-0.09	-0.05	-0.14	-0.14	0.27	0.19	0.39	0.05	0.09	1							
Debt to BVE	-0.06	-0.34	-0.00	-0.23	-0.08	-0.33	0.18	0.12	0.18	0.14	0.12	0.33	1						
Debt to MVE	0.16	-0.29	0.20	-0.21	0.13	-0.25	0.24	0.17	0.20	0.20	0.22	0.20	0.87	1					
Liquidity	-0.14	0.04	-0.11	0.09	-0.14	0.00	-0.03	-0.03	-0.06	0.19	0.08	-0.11	-0.34	-0.35	1				
Capital Intensity	-0.19	-0.28	-0.10	-0.17	-0.19	-0.28	0.18	0.13	0.15	0.25	0.18	0.21	0.37	0.34	0.10	1			
R&D Intensity	-0.18	-0.05	-0.11	0.01	-0.19	-0.11	0.00	0.00	0.01	0.18	0.09	0.08	0.05	-0.05	0.23	0.28	1		
SD of Cashflow	0.12	0.33	0.11	0.33	0.10	0.26	0.02	-0.01	-0.06	0.37	0.26	-0.17	-0.29	-0.33	0.44	0.01	0.17	1	
MAD of Cashflow	0.07	0.28	0.07	0.29	0.06	0.22	0.01	-0.02	-0.07	0.31	0.23	-0.16	-0.28	-0.32	0.38	0.00	0.17	0.82	1

1. Table 4.8 reports the Spearman correlation coefficients between each pair of variables over the period 2007-11.
2. For this sample size significance levels are as follows: $|r| > 0.063$, $p < .05$; $|r| > 0.082$, $p < 0.01$; $|r| > 0.10$, $p < 0.001$.

4.4 Principal Component Analysis – Method and Results

4.4.1 Determination of Component Structure

An exploratory principal component analysis (PCA) was conducted on the 19 corporate risk measures listed in table 4.2 for each five-year period in the dataset. As described in Chapter Three, PCA is based on calculating the eigenvectors of the variance-covariance matrix which can be strongly influenced by outliers; and it was previously noted (see section 4.3.3) that many of the risk measures had extreme outliers. The PCA was therefore conducted using Winsorized samples from the 2008-12 time period, where observations with the highest and lowest x% of values of standard deviation of ROE, debt to book value of equity and capital intensity were excluded. The loadings for the two components with the highest eigenvalues are shown in table 4.9 for the three different samples: it is clear from the table that, as suspected, the results are very strongly affected by extreme values.

Table 4.9 – Component Structures from PCA with Winsorized Samples (2008-12)

	Component 1			**Component 2**		
	Full Sample	**Winsorized (1%)**	**Winsorized (2.5%)**	**Full Sample**	**Winsorized (1%)**	**Winsorized (2.5%)**
SD of ROE	0.23	**0.33**	**0.32**	**0.40**	-0.04	-0.02
SD of ROA	0.28	**0.31**	0.28	-0.24	-0.29	**-0.31**
MAD of ROE	0.23	0.27	0.27	0.25	0.01	-0.01
MAD of ROA	0.27	0.27	0.26	-0.24	-0.26	-0.28
RLPM of ROE	0.23	**0.33**	**0.32**	**0.40**	-0.02	-0.01
RLPM of ROA	0.28	**0.32**	0.29	-0.24	**-0.30**	**-0.32**
Beta	**0.32**	0.27	0.29	0.03	**0.37**	**0.32**
Downside Beta	0.23	0.16	0.22	0.07	**0.34**	**0.32**
Robust Beta	0.24	0.19	0.22	0.06	**0.38**	**0.34**
Unsystematic Risk	0.31	0.27	0.27	-0.07	0.10	0.06
Value at Risk	**0.36**	**0.33**	**0.33**	0.01	0.19	0.16
Stock Turnover	0.11	0.08	0.07	0.15	0.28	0.23
Debt to BVE	0.01	0.03	0.07	0.11	0.23	0.25
Debt to MVE	0.17	0.09	0.12	**0.44**	0.28	**0.30**
Liquidity	-0.04	-0.05	-0.09	-0.06	0.04	0.07
Capital Intensity	0.09	0.05	0.05	-0.02	0.07	0.16
R&D Intensity	0.12	0.12	0.12	-0.15	-0.14	-0.16
SD of Cashflow	0.25	0.22	0.22	**-0.31**	-0.21	-0.24
MAD of Cashflow	0.22	0.19	0.17	**-0.30**	-0.20	-0.23
Communality	0.58	0.59	0.59			
KMO	0.66	0.69	0.70			

1. Table 4.9 reports the results of principal component analyses in Stata using the pca function.
2. The communality is calculated using the Stata estat smc post-estimation routine and averaging over the 19 variables.
3. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was calculated using the Stata estat kmo post-estimation routine. Low values indicate that the variables have too little in common to warrant a PCA; results can be interpreted as follows (Kaiser (1974)):

0 – 0.49	Unsatisfactory
0.50 – 0.59	Middling
0.60 – 0.69	Mediocre
0.70 – 0.79	Middling
0.80 – 0.89	Meritorious
0.90 – 1.00	Marvellous

4. Component loadings with an absolute value greater than or equal to 0.16 are significant at p=.01 (Stevens (2002, p.394)).
5. Component loadings with an absolute value greater than or equal to 0.30 are shown in bold.
6. All results are given to two decimal places.

Given the sensitivity of the PCA results to outliers, and the underlying desire not to simply discard extreme observations; an alternative method of PCA, based on the transformation of a robust covariance matrix was therefore employed (see Chapter Three for a detailed discussion of this technique). Hereinafter, any reference to "PCA" relates specifically to this robust technique. PCAs were conducted for each of the six time periods: the number of components with eigenvalues > 1 (Kaiser's (1960) criterion for retaining components) is shown in table 4.10. An alternative criterion for determining how many components to retain, the scree test (Cattell (1966)), was also applied and the results are also shown in the table.

Table 4.10 – Component Structures from Robust PCA

Period	Number of Components with Eigenvalues > 1	Percentage Variation Explained	Number of Components to be Retained (Scree Test)	Percentage Variation Explained
2008-12	6	75%	4	64%
2007-11	5	72%	3	59%
2006-10	5	73%	3	60%
2005-09	5	73%	3	60%
2004-08	5	73%	3	59%
2003-07	5	67%	4	61%

1. Table 4.10 reports the results of principal component analyses in Stata using the user-written function mcd (Verardi and Croux (2009))), followed by the standard function pcamat.
2. The size of the sub-samples is 0.75n and 1014 sub-samples were used.
3. All results are given to two decimal places.

By way of illustration of the different component structures, the scree plots for 2008-12 and 2007-11 time periods are shown in figs. 4.4 and 4.5 respectively for comparison. In 2008-12 a point of inflection can clearly be seen at the fifth point from the left, so four components are retained; in 2007-11 it occurs at the fourth point from the left so only three components are retained.

Fig. 4.4 – Scree Plot 2008-12

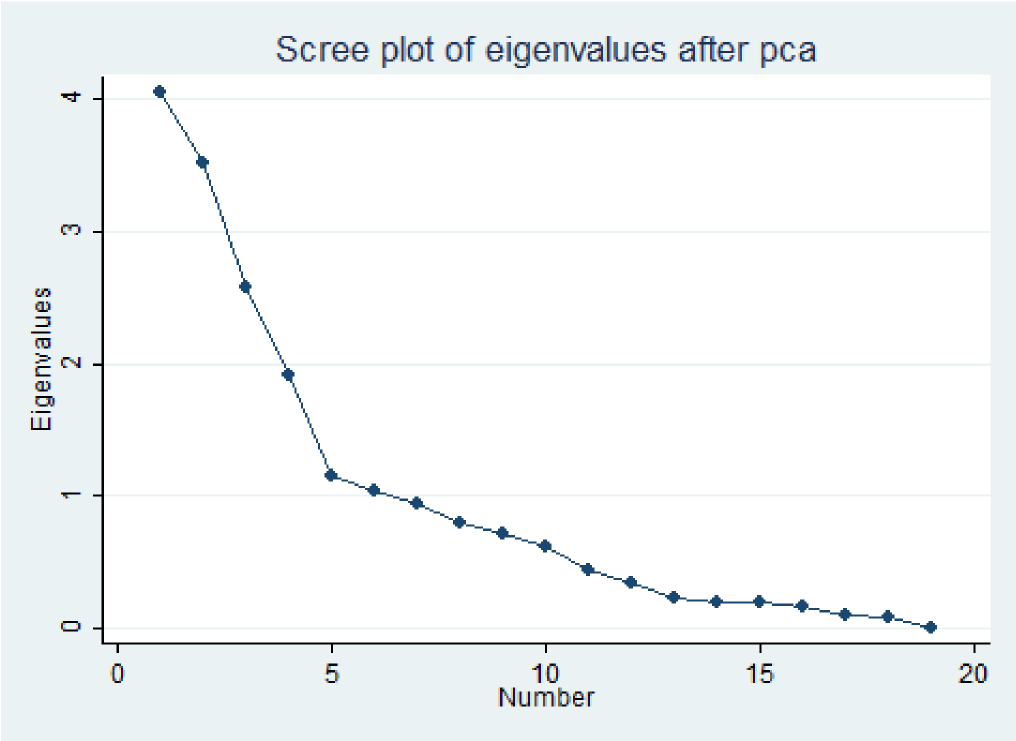
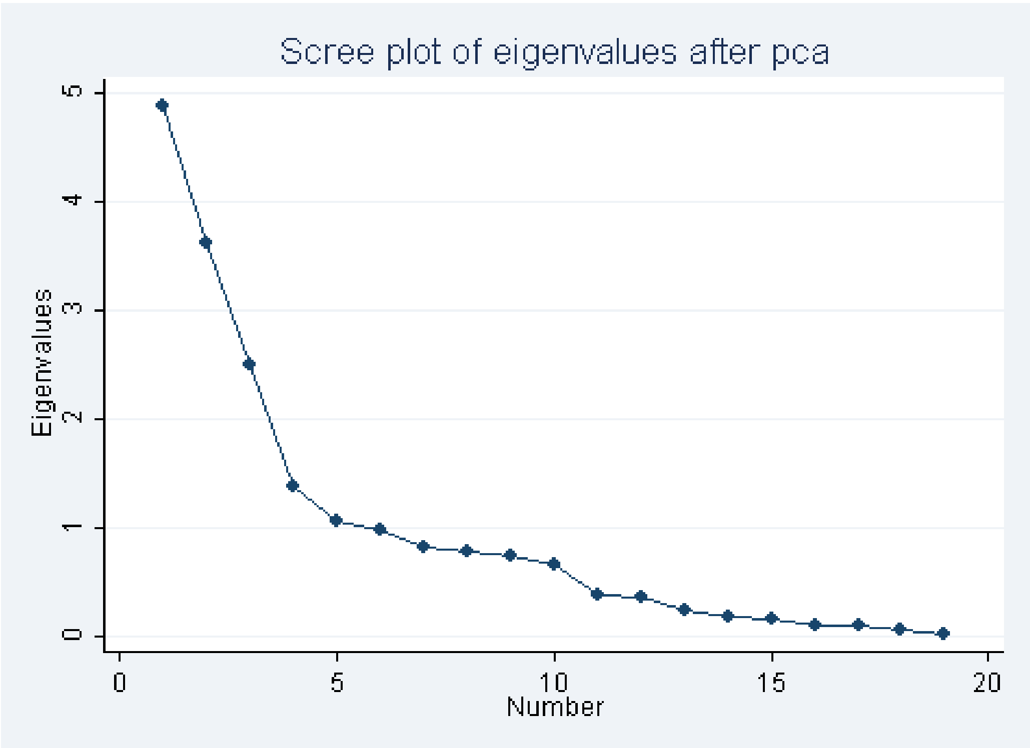


Fig. 4.5 – Scree Plot 2007-11



Given the relatively low communalities reported in table 4.9, the scree test is the preferred criterion for determining how many components to retain (Stevens (2002, p.390)); as can be seen from table 4.10, this always results in a smaller number of components being retained.

4.4.2 Rotation of Components

A varimax rotation was then performed with each set of retained components; the results are presented in tables 4.11 and 4.12. Contrary to the findings of Miller and Bromiley (1990), the component structures for periods 2003-07 and 2008-12 are very different to the intervening periods, and to each other.

Table 4.11 – Component Loadings after Varimax Rotation (2003-07 and 2008-12)

	Components (2003-07)				**Components (2008-12)**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
SD of ROE	**0.44**	0.11	0.04	-0.01	**0.47**	-0.01	0.15	-0.07
SD of ROA	**0.39**	-0.11	-0.02	0.05	**0.49**	0.02	-0.06	0.05
MAD of ROE	**0.40**	0.06	0.05	-0.04	0.10	-0.12	**0.55**	-0.04
MAD of ROA	**0.36**	-0.07	0.04	-0.00	0.07	-0.05	**0.43**	0.16
RLPM of ROE	**0.43**	0.10	-0.02	-0.03	**0.48**	0.00	0.14	-0.07
RLPM of ROA	**0.39**	-0.10	-0.07	0.03	**0.47**	0.04	-0.09	0.05
Beta	-0.01	-0.05	0.14	**0.58**	0.02	**0.53**	-0.00	0.01
Downside Beta	0.04	-0.02	-0.15	**0.38**	0.03	**0.49**	-0.04	-0.01
Robust Beta	-0.01	-0.07	0.00	**0.58**	0.02	**0.52**	-0.07	-0.02
Unsystematic Risk	-0.00	0.16	**0.52**	0.16	-0.10	0.20	**0.39**	0.11
Value at Risk	0.03	0.14	**0.52**	0.16	-0.01	0.29	**0.30**	0.08
Stock Turnover	-0.07	0.29	-0.05	0.14	-0.11	0.24	-0.01	-0.17
Debt to BVE	-0.02	**0.52**	0.04	-0.06	-0.15	-0.02	0.23	**-0.40**
Debt to MVE	0.07	**0.57**	0.06	-0.10	-0.09	-0.02	**0.32**	**-0.40**
Liquidity	-0.07	-0.11	0.23	0.02	-0.11	0.04	0.03	**0.37**
Capital Intensity	-0.08	0.28	0.04	-0.06	-0.11	0.04	0.14	-0.08
R&D Intensity	-0.03	0.14	0.01	0.02	-0.03	-0.00	-0.03	-0.03
SD of Cashflow	-0.01	-0.23	**0.41**	-0.22	-0.06	-0.02	0.15	**0.49**
MAD of Cashflow	-0.00	-0.23	**0.41**	-0.20	-0.06	-0.03	0.12	**0.46**

1. Table 4.11 reports the results of principal component analyses in Stata using the user-written function mcd (Verardi and Croux (2009))), followed by the standard function pcamat with varimax rotation of four components.
2. The size of the sub-samples is 0.75n and 1014 sub-samples were used.
3. Component loadings with an absolute value greater than or equal to 0.23 (2003-07) and 0.16 (2008-12) are significant at p=.01 (Stevens (2002, p.394)).
4. Component loadings with an absolute value greater than or equal to 0.3 are shown in bold.
5. All results are given to two decimal places.

Table 4.12 – Component Loadings after Varimax Rotation (2004-08, 2005-09, 2006-10 and 2007-11)

	Components (2004-08)			**Components (2005-09)**			**Components (2006-10)**			**Components (2007-11)**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
SD of ROE	**0.39**	0.08	-0.07	**0.39**	0.07	-0.04	**0.39**	0.09	-0.04	**0.39**	0.07	-0.06
SD of ROA	**0.42**	0.01	0.01	**0.40**	-0.01	0.00	**0.41**	-0.01	0.00	**0.42**	-0.02	0.02
MAD of ROE	**0.35**	0.01	-0.02	**0.35**	0.01	-0.02	**0.35**	0.03	-0.04	**0.35**	0.04	-0.02
MAD of ROA	**0.35**	0.02	0.09	**0.35**	-0.01	0.02	**0.37**	0.02	0.03	**0.36**	0.00	0.06
RLPM of ROE	**0.41**	0.02	-0.05	**0.39**	0.06	-0.04	**0.40**	0.05	-0.05	**0.40**	0.05	-0.06
RLPM of ROA	**0.41**	-0.01	0.01	**0.40**	-0.01	0.01	**0.41**	-0.04	-0.01	**0.42**	-0.03	0.00
Beta	0.03	**0.50**	-0.01	0.05	**0.49**	-0.03	0.05	**0.47**	-0.02	0.05	**0.48**	-0.03
Downside Beta	0.05	**0.47**	-0.07	0.06	**0.44**	-0.06	0.07	**0.41**	-0.03	0.06	**0.40**	-0.02
Robust Beta	0.02	**0.45**	-0.05	0.05	**0.44**	-0.11	0.05	**0.43**	-0.07	0.05	**0.43**	-0.06
Unsystematic Risk	-0.11	0.28	0.21	-0.12	**0.37**	0.19	-0.09	**0.37**	0.20	-0.10	**0.38**	0.19
Value at Risk	-0.04	**0.42**	0.15	-0.05	**0.43**	0.17	-0.02	**0.41**	0.16	-0.02	**0.43**	0.14
Stock Turnover	-0.06	0.17	-0.24	-0.10	0.11	-0.27	-0.10	0.19	-0.23	-0.07	0.15	-0.21
Debt to BVE	-0.16	0.03	**-0.33**	-0.17	0.04	**-0.34**	-0.17	0.10	**-0.32**	-0.14	0.12	**-0.34**
Debt to MVE	-0.09	0.13	**-0.35**	-0.12	0.14	**-0.32**	-0.12	0.18	-0.28	-0.08	0.19	**-0.32**
Liquidity	-0.09	0.06	**0.33**	-0.09	0.05	**0.35**	-0.08	0.05	**0.40**	-0.10	0.03	**0.38**
Capital Intensity	-0.16	0.08	-0.11	-0.14	0.08	-0.11	-0.13	0.13	-0.13	-0.14	0.13	-0.12
R&D Intensity	-0.09	0.07	0.02	-0.11	-0.00	0.02	-0.08	0.05	-0.08	-0.07	0.04	-0.03
SD of Cashflow	-0.04	0.03	**0.51**	-0.04	0.03	**0.50**	-0.02	0.05	**0.52**	-0.02	0.07	**0.51**
MAD of Cashflow	-0.03	0.01	**0.49**	-0.04	0.02	**0.49**	-0.04	0.03	**0.49**	-0.02	0.06	**0.50**

1. Table 4.12 reports the results of principal component analyses in Stata using the user-written function mcd (Verardi and Croux (2009))), followed by the standard function pcamat with varimax rotation of three components.
2. The size of the sub-samples is 0.75n and 1014 sub-samples were used.
3. Component loadings with an absolute value greater than or equal to 0.21 (2004-08), 0.19 (2005-09), 0.17 (2006-10) and 0.16 (2007-11) are significant at p=.01 (Stevens (2002, p.394)).
4. Component loadings with an absolute value greater than or equal to 0.3 are shown in bold.
5. All results are given to two decimal places.

An oblimax oblique rotation was also performed: the results were almost identical, as shown in table 4.13 for the period 2008-12. As oblique rotation introduces further issues concerning the validity and interpretation of the results of the PCA, it is not pursued further.

Table 4.13 – Comparison of Component Loadings after Varimax and Oblimax Rotation (2008-12)

	Varimax Components				**Oblimax Components**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
SD of ROE	**0.47**	-0.01	0.15	-0.07	**0.47**	-0.00	0.15	-0.07
SD of ROA	**0.49**	0.02	-0.06	0.05	**0.48**	0.02	-0.06	0.05
MAD of ROE	0.10	-0.12	**0.55**	-0.04	0.10	-0.11	**0.55**	-0.04
MAD of ROA	0.07	-0.05	**0.43**	0.16	0.07	-0.04	**0.43**	0.16
RLPM of ROE	**0.48**	0.00	0.14	-0.07	**0.48**	0.01	0.14	-0.07
RLPM of ROA	**0.47**	0.04	-0.09	0.05	**0.47**	0.04	-0.09	0.05
Beta	0.02	**0.53**	-0.00	0.01	0.02	**0.53**	0.02	-0.00
Downside Beta	0.03	**0.49**	-0.04	-0.01	0.03	**0.49**	-0.03	-0.02
Robust Beta	0.02	**0.52**	-0.07	-0.02	0.02	**0.52**	-0.05	-0.02
Unsystematic Risk	-0.10	0.20	**0.39**	0.11	-0.09	0.20	**0.40**	0.11
Value at Risk	-0.01	0.29	**0.30**	0.08	-0.01	**0.30**	**0.31**	0.08
Stock Turnover	-0.11	0.24	-0.01	-0.17	-0.11	0.24	-0.00	-0.17
Debt to BVE	-0.15	-0.02	0.23	**-0.40**	-0.14	-0.01	0.22	**-0.40**
Debt to MVE	-0.09	-0.02	**0.32**	**-0.40**	-0.08	-0.01	**0.31**	**-0.40**
Liquidity	-0.11	0.04	0.03	**0.37**	-0.11	0.03	0.04	**0.37**
Capital Intensity	-0.11	0.04	0.14	-0.08	-0.11	0.04	0.14	-0.08
R&D Intensity	-0.03	-0.00	-0.03	-0.03	-0.03	-0.00	-0.03	-0.03
SD of Cashflow	-0.06	-0.02	0.15	**0.49**	-0.06	-0.03	0.17	**0.49**
MAD of Cashflow	-0.06	-0.03	0.12	**0.46**	-0.06	-0.03	0.13	**0.46**

1. Table 4.13 reports the results of principal component analyses in Stata using the user-written function mcd (Verardi and Croux (2009))), followed by the standard function pcamat with varimax/oblimax rotation of four components.
2. The size of the sub-samples is 0.75n and 1014 sub-samples were used.
3. Component loadings with an absolute value greater than or equal to 0.16 (2008-12) are significant at p=.01 (Stevens (2002, p.394)).
4. Component loadings with an absolute value greater than or equal to 0.3 are shown in bold.
5. All results are given to two decimal places.

4.5 Discussion

Recalling the original motivation for this chapter, that better corporate risk measures are needed for both academic research and practical risk management; the robust principal component analysis identified a compact set of components in each time period which account for the majority of the variation (at least 59% in each case). Consistent with both Miller and Bromiley (1990) and Alessandri and Khan (2006), in the period 2003-07 there are components based upon variability in profitability and variability in share price. Consistent with Miller and Bromiley (1990) there is also a component that captures leverage/liquidity[42]. In addition, in this period, there is a fourth component based on variability in cashflow; which was simply not considered in the previous analyses. The analysis also made the striking finding that, contrary to Miller and Bromiley's (1990) results, the component structure changes markedly over time: from 2004-08 to 2007-11 only three components are retained and their composition is different to the components in 2003-07. It is argued that this change in component structure is a result of a step-change in the levels of environmental uncertainty which occurred with the onset of the financial crisis. In the period 2008-12 four components are retained once again, but their composition is different to the components in any previous period. This section begins by interpreting the individual components in each time period; this is followed by an assessment of the usefulness of these components as corporate risk measures; and the section concludes with a discussion of how changing levels of environmental uncertainty impacts on individual risk measures and on the overall component structure.

[42] Alessandri and Khan (2006) used only a single variable leverage/liquidity measure, "bankruptcy risk", which loads onto their "returns risk" component.

4.5.1 Component Structures

The component structures for the four time periods with three components (2004-08, 2005-09, 2006-10 and 2007-11) are all very similar to each other. Component 1 can be characterised as “profit risk”, as all the measures of variability in profitability (including the specific robust and downside measures) load onto this component; it is similar to Miller and Bromiley’s (1990, p.763) “income stream risk” construct and Alessandri and Khan’s (2006, p.1107) “returns risk” construct. All the measures of share-price variability load onto component 2, so it can be characterised as “market risk” (as per Miller and Bromiley (1990) and Alessandri and Khan (2006)); as with component 1, explicitly robust and downside risk measures load onto this factor. Component 3 can best be characterised as “cashflow risk” as it has high factor loadings for both measures of volatility in cashflows; but, surprisingly, this component also has significant negative loadings for both measures of debt to equity and positive loading for liquidity. It is argued that this is an example of reverse causality, in that firms with high volatility of cashflows choose not to, or are unable to, borrow heavily; and also have to maintain higher levels of liquidity.

The component structure for the two time periods with four components (2003-07 and 2008-12) are different to each other, so will be discussed individually. The component structure for the time period 2008-12 is broadly similar to those time periods with three components. Component 1 can still be characterised as “profit risk”, however the robust measures of variability in profit ratios do not load onto this component but appear instead in component 3, along with unsystematic risk and value at risk. Component 2 can best be characterised as “systematic market risk”; and component 4 is essentially the same as the “cashflow risk” defined previously, with significant negative loadings for both measures of debt to equity and a positive loading for liquidity. Component 3 is labelled “robust profit risk”, but its precise interpretation is somewhat unclear. The component structure for 2003-07 is quite different to that for all other time periods. Component 1 is the same as the "profit risk" construct observed in those time periods with three components; whilst component 4 is similar to the "systematic market risk" observed in the period 2008-12. Component 2 is unique to this time period and can be characterised as "distress risk" with high loadings for both measures of debt to equity (and a small negative loading for liquidity). This component corresponds very roughly to Miller and Bromiley's (1990) "strategic risk" construct, which had high loadings for debt-to-equity, capital intensity and R&D intensity (negative loading); although component 2 has a positive loading for R&D intensity. Component 3 can again be characterised as "cashflow risk"; but it is very different from the equivalent constructs observed in other time periods, with lower loadings for the cashflow variables and very high loadings for unsystematic market risk and value at risk. The interpretation of the different risk components in each time period is summarised in table 4.14.

Table 4.14 – Interpretation of Varimax Rotated Components

	2003-07	**2004-08**	**2005-09**	**2006-10**	**2007-11**	**2008-12**
Component 1	Profit Risk	Profit Risk	Profit Risk	Profit Risk	Profit Risk	Profit Risk
Component 2	Distress Risk	Market Risk	Market Risk	Market Risk	Market Risk	Systematic Market Risk
Component 3	Cashflow Risk	Cashflow Risk	Cashflow Risk	Cashflow Risk	Cashflow Risk	Robust Profit Risk
Component 4	Systematic Market Risk	N/A	N/A	N/A	N/A	Cashflow Risk

Whilst most of the nineteen corporate risk measures used in the PCA load onto one or other of the components discussed above, it is important to note that two of the proposed risk measures do not have a high loading onto any components in any time period: R&D intensity and stock turnover. Notwithstanding the possible issue of poor data quality for R&D intensity, the failure to load onto any component would suggest that it is fundamentally not a particularly useful risk measure: as highlighted previously, competing theories see R&D as either a source of risk (March (1991)) or as a means of mitigating risk (Miller and Bromiley (1990)). Stock turnover was specifically included as an ex-ante measure of risk, but it does not have a high loading onto any component in any time period either: this contrasts with the results of Miller and Bromiley's (1990) analysis, where the variation in analysts' forecasts loaded onto their "income stream risk" factor. As with R&D intensity, this would suggest that stock turnover is not a useful measure of risk. It is also interesting to note that the inclusion of specific robust and downside measures of risk added little to the analysis as (with the exception of the median absolute deviation of ROE and ROA in 2008-12) they always loaded onto the same component as the equivalent measure based on standard deviation.

4.5.2 Applying the Components as Corporate Risk Measures

As stated above, the PCA identified a small number of components in each time period which can account for the majority of the variation (at least 59%). In each time period there is a component relating to each of the following dimensions of risk: variability in profitability; variation in share price and variability of cashflows. In addition, in the time period 2003-07, there is a component capturing leverage and liquidity, which relates to the probability of financial distress. The principal component analysis has the added advantage of ensuring that these components are orthogonal to each other, so they are potentially very useful to both researchers and practitioners as a set of risk measures. It is important to reiterate though that the relationships between risk measures are not static (this is discussed in more detail in section 4.5.3), so a component is only of use as a risk measure during the specific time period over which it was constructed. In order to gauge their usefulness as corporate risk measures, the components are discussed below in the context of the desirable properties for risk measures introduced in section 4.2.2.

It follows from the mapping of the components to specific dimensions of risk that all the components relate quite naturally to specific stakeholder groups, which was previously argued to be a desirable property for a risk measure. Miller and Bromiley (1990, p.763) argued that variation in profitability is “generally believed to be the measure of risk most relevant to general managements”; market risk is clearly of interest to investors; cashflow risk is likely to be of interest to both managers (as cash is needed to exploit value-creating opportunities) and lenders (as cash is required to service debt); and distress risk captures the risk perspective of lenders. It was also argued that it is desirable for risk measures to be forward-looking. In essence, the components occupy the same position on the forward-looking/backward-looking continuum as the individual risk measures that load most heavily onto them; so profit risk and cashflow risk are more rearward-looking than market risk.

The principal drawback of the use of components, rather than individual risk measures, is the loss of resolution; as the resolution of every component is limited by the lowest resolution risk measure in the study. This presents a particular problem with the market risk component, as measures of market risk generally have very high resolution. However, if a higher resolution measure of risk from an investor perspective is required, the individual risk measure with the highest loading (in this case beta) can be used instead of the component. Finally, composed as they are of linear combinations of risk measures which are (with one exception) subadditive, these components will essentially satisfy the criteria of subadditivity.

4.5.3 The Effect of Environmental Uncertainty

Whilst the results for 2008-12 can potentially be seen as a perturbation to the general pattern, there was clearly a fundamental change in the component structure from 2003-07 to 2004-08; with the market risk component now having the second largest eigenvalue and the distress risk component becoming buried amongst the other components that are not retained. This is very different to the results of Miller and Bromiley (1990); who found near identical component structures for the periods 1978-82 and 1983-87[43] (the coefficients of congruence were greater than 0.98 for all three factors). It is argued that the explanation for this difference lies in a very sharp increase in environmental uncertainty that occurred with the onset of a worldwide recession in 2007: much previous work finds such increases in uncertainty, howsoever measured, during recessions (see Bloom (2014) for a detailed review).

Three explanations are suggested for the observed increase in uncertainty (Bloom (2014)): lower trading activity reduces the flow of information about firms and hence increases uncertainty; forecasting is harder during recessions because people have less experience of such conditions; and there is greater likelihood of political experimentation in the economy with uncertain outcomes. All three of these explanations are clearly pertinent to the financial crisis beginning in 2007, especially the issue of political experimentation. By way of comparison, the period 1978-87 studied by Miller and Bromiley (1990) contained four "stock-market volatility shocks" (Bloom (2009)): OPEC II; Afghanistan and the Iran hostages; the US monetary cycle turning point; and 'Black Monday'. However, none of these led to either the same level of political experimentation or such a reduction in trade activity as the financial crisis of 2007; this lack of a major discontinuity in environmental uncertainty could

[43] As well as being almost identical to each other, Miller and Bromiley's (1990) component structures were also similar to the structure observed in this study in the period 2003-07.

well explain why the authors found no changes in the relationships between risk measures from the first half to the second half of the period of their study.

Table 4.15 shows two standard measures of environmental uncertainty (Bloom (2014)) from 1983-2012: the standard deviation in UK quarterly GDP growth; and the standard deviation of the FTSE All-Share Index ("FTAS") [44]. The median standard deviations of ROE and ROA for the firms in the study for each time period are also included as alternative measures of environmental uncertainty.

Table 4.15 – Measures of Environmental Uncertainty

Period	SD of Quarterly GDP Growth	SD of FTSE Monthly Returns	Median SD of ROE	Median SD of ROA
2008-12	0.84%	4.9%	12.3%	6.3%
2007-11	0.95%	5.0%	12.4%	6.9%
2006-10	0.96%	4.8%	12.5%	7.2%
2005-09	1.01%	4.5%	12.3%	6.5%
2004-08	0.93%	3.8%	13.8%	6.4%
2003-07	0.42%	2.8%	7.9%	5.5%
1983-2002	**0.60%**	**4.8%**		

As predicted, the financial crisis beginning in late 2007 appears to have resulted in a marked increase in environmental uncertainty, regardless of the specific measure used. This step-change will have impacted differentially on each corporate risk measure; and the individual effects on some specific risk measures are discussed in detail in the next paragraph. Equally importantly though, the step-change also appears to have altered the relationships between the different risk measures. This can be illustrated by plotting beta against the standard deviation of cashflows in the periods 2003-07 and 2004-08 respectively in figs. 4.6 and 4.7.

[44] The FTSE AIM All-Share index could not be used here as data are only available from 2000 onwards.

Fig. 4.6 – Beta vs Standard Deviation of Cashflows (COVCASH) in the Period 2003-07

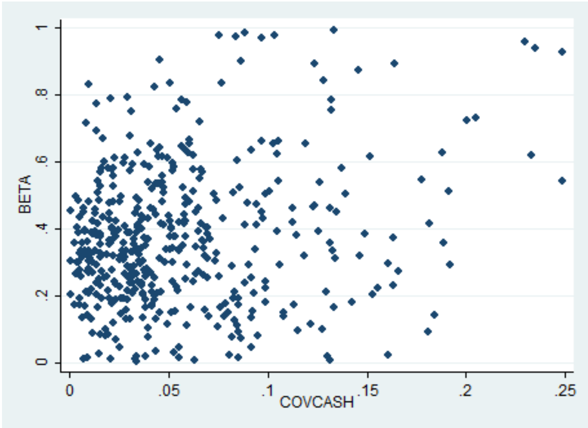
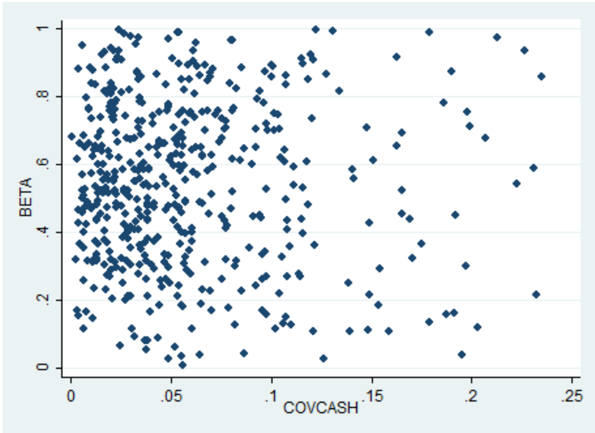


Fig. 4.7 – Beta vs Standard Deviation of Cashflows (COVCASH) in the Period 2004-08



A positive association between beta and the standard deviation of cashflows can be discerned in 2003-07 (fig. 4.6), but not in 2004-08 (fig. 4.7); this change in the relationship between the risk measures can also be seen from the Spearman correlation coefficient, which falls from 0.07 (p=0.10) to 0.04 (p=0.39). It is argued that this change arises because the rearward-looking measure of the standard deviation of cashflow is still based on pre-crisis data; but the forward-looking beta has already factored in the very changed environment. A similar argument would apply to all relationships between rearward-looking and forward-looking risk measures in the presence of such a major discontinuity. In these conditions, forward-looking risk measures become much more useful, as evidenced by the sudden increase in the proportion of variance explained by the market risk component from 11.8% in 2003-07 to 17.8% in 2004-08.

As regards the effect of environmental uncertainty on individual corporate risk measures, the analysis suggested that the measures of unsystematic market risk, leverage and liquidity all cease to be effective measures of risk in conditions of high environmental uncertainty; these measures are discussed in turn below. The various measures of systematic market risk are highly correlated with each other in all time periods; initially (2003-07) they are not correlated with measures of unsystematic market risk, but between 2004-08 and 2007-11 they are. This strongly suggests that the measures for systematic and unsystematic risk are differentially impacted by the increase in environmental uncertainty that occurs between 2003-07 and 2004-08. Judging by the positive correlation of unsystematic risk measures with standard deviation of cashflows in 2003-07, it would appear that in this period these measures are actually measuring something about the idiosyncratic risk to the firm's stakeholders. However, after the increase in environmental uncertainty from 2004-08, it appears that they are just capturing the heteroscedasticity in the regression of individual firms returns on the market return and really have no value as risk measures. As environmental uncertainty begins to fall in the period 2008-12, the link between systematic and unsystematic market risk measures breaks down again and the measures of unsystematic risk form a new component, together with the robust measures of variability in profitability: as in the period 2003-07, it would appear that these measures are providing some real information about the risk to the firm's stakeholders. Turning to consider the measures of leverage and liquidity, in 2003-07 these measures loaded onto a distress risk component; but, from 2004-08 onwards, the distress risk component disappears and these measures load onto the cashflow risk component. Moreover, the loading on cashflow risk was in the opposite direction than expected (ie leverage has a negative loading and liquidity is positive). As discussed previously it would appear that, in an environment of very high uncertainty, leverage and liquidity are not actually acting as corporate risk measures; rather firms with higher variability in cashflow are unwilling or unable to borrow heavily and have to maintain liquidity.

4.5.4 Limitations and Directions for Further Research

The main limitation of this analysis is that, because of the requirement for market data, the sample only includes publicly-listed firms: it is therefore not possible to generalise the findings to other firms. In particular, it is not possible to say anything about the risks to the stakeholders in smaller firms. It would be perfectly possible to conduct a PCA using only the twelve risk measures that are based on accounting data; which would allow for a much larger, and more diverse, sample comprising both listed and unlisted firms. However, as discussed in the next chapter, the components derived from this process would be incomplete in that they would not be capturing the risk to the owners of the firm, a key stakeholder group. This prompts another interesting research question: how does one construct risk measures relevant to owners of firms that are not quoted; particularly in closely-held firms, where the dividend policy may be determined by unobservable personal preferences of the owners?

The extent to which the results can be generalised is also limited by the unusual, and rapidly changing, environmental conditions during the course of the study. It would therefore be very useful to continue the study longitudinally and observe how the relationships between corporate risk measures continue to change as macroeconomic conditions evolve (potentially returning towards historic norms). In particular this might help in interpreting the, as yet unexplained, component structure for the period 2008-12.

Historically, the main motivation behind the measurement of risk at the firm level in academic research has been to study the relationship between risk and performance, and it would be very interesting to see how the corporate risk measures derived in this chapter can be applied to this question: this is the topic of the next chapter.

Chapter Five - The Relationship between Corporate Risk and Performance

5.1 Introduction

Ever since Bowman's (1980) finding that, contrary to the predictions of the Capital Assets Pricing Model (Sharpe (1964)), accounting-based measures of risk and performance at the firm level were negatively related; there has been significant interest in analysing such risk-return relationships and numerous empirical studies have been published. However these studies, using a number of different methods and data from different periods of time; have produced divergent and often contradictory results. Whilst many of the methodological flaws in earlier studies have now been addressed, progress has continued to be limited by "confusion over the meaning and measurement of risk" (Palmer and Wiseman (1999, p.1037)); misspecification of regression models; and the failure to deal appropriately with the presence of extreme outliers in the distributions of many risk measures. This study seeks to address the first of these limitations by using a novel set of risk measures at the firm level; critically these measures include a "cashflow risk" component that has not been used in previous studies. Misspecification in the regression analysis is eliminated by including a number of control variables and by the removal of firm fixed effects[45]; and the failure of previous studies to adequately consider how to deal with outliers is addressed by using a range of different robust techniques.

This chapter takes two complementary approaches to investigating the relationship between corporate risk and performance: simple, univariate tests to directly address Bowman's (1980) "paradox"; and regression analysis to gain a deeper understanding of the relationship between the multiple dimensions of corporate risk and firm

[45] However, as discussed in Chapter One, this has the effect of removing the firms' risk management capability; this issue will be discussed in more detail in Chapter Seven.

performance. The analysis uses risk measures constructed over five overlapping five-year time-periods from 2003-07 to 2007-11: it is important to highlight that this timeframe includes the global financial crisis, beginning in 2007/08. The main contribution of this chapter is the finding that the relationship between risk and return, measured with both accounting and market-based measures, is contingent on environmental conditions. In particular, in the environment of stability and growth that existed immediately prior to the onset of the financial crisis, there was a significant positive relationship between the standard deviation of ROA and subsequent ROA; contrary to the findings of Bowman (1980) and many subsequent studies.

The rest of the chapter is organised as follows. The next section reviews the existing literature on the relationship between risk and performance at the firm level, with a particular focus on previous empirical work; this is followed in section 5.3 by a brief explanation of the specific hypotheses to be tested. Section 5.4 describes, in detail, the data used in all the subsequent analysis. The method and results of both univariate tests and cross-sectional regression analyses are then presented sequentially in section 5.5, and the chapter concludes with a discussion of the findings.

5.2 Risk and Return

Chapter Two rehearsed various, sometimes contradictory, arguments about how risk and performance (both measured in a variety of ways) are related: this section begins by summarising the key points. The discussion is then extended to consider how the relationship between risk and future performance may be mediated by past performance; and the persistence of profits literature is briefly introduced. The section continues with a detailed review of the previous empirical studies that are most relevant to the approach adopted in this chapter; and concludes by summarising how it is intended to improve upon prior work in the current study.

5.2.1 The Relationship Between Corporate Risk and Performance

Arguments based on risk aversion have been applied to predict relationships between both market risk and return, and accounting risk and return. In the context of market risk and return, the CAPM model of Sharpe (1964) predicted a very simple positive relationship between systemic risk (beta) and expected return; however, subsequent empirical work (eg Fama and French (1992)) led to the model being modified to include additional idiosyncratic terms. More fundamentally, Pettengill et al (1995) noted that when realised (as opposed to expected) returns are used, the relationship becomes conditional on the overall performance of the market; with a positive relationship between beta and returns when market excess returns are positive and a negative relationship between beta and returns when market excess returns are negative. Similar risk aversion arguments predict that higher expected accounting returns are required to invest in projects where outcomes are uncertain, leading to a positive relationship between profit risk and profitability at the firm level; but this completely omits to consider the quality of managerial decision making (Andersen et al (2007)) and other firm-specific capabilities. It is also important to consider the direct costs of increased profit risk, such as increased tax charges, increased cost of debt and underinvestment (Smith and Stultz (1985), Shapiro and Titman (1986), Lessard (1990) and Froot, Scharfstein and Stein (1993)). Cashflow risk is not believed to be such a salient factor in decision making but is still accompanied by direct costs.

5.2.2 The Mediating Effect of Prior Performance on the Relationship Between Risk and Performance

There are a number of reasons to believe that the relationship between risk and future performance may be contingent upon current performance, arguments include: the behavioural theory of the firm (Cyert and March (1992)); agency theory (Jensen and Meckling (1976)); and prospect theory (Kahneman and Tversky (1979). These three theories are briefly discussed in turn below, followed by a summary of the empirical evidence.

Cyert and March (1992) argue that the managers of poorly performing firms may be driven to take on additional risk, without the appropriate compensating increase in expected return, as a result of "problemistic search" for solutions to their poor performance. Sustained poor performance may also influence risk-taking indirectly through the depletion of "slack resources": a lack of sufficient "slack resources" to absorb exogenous shocks to the firm tending to make managers more risk-seeking. These predictions receive some support from March and Shapira's (1987 p.1409) study of managerial perspectives on risk; which find that managers "…believe that fewer risks should, and would, be taken when things are going well. They expect riskier choices to be made when an organization is failing." However, the surveys analysed by March and Shapira (1987 p.1410) also found that "Over 90% of the executives interviewed by Shapira said they would not take risks where a failure could jeopardize the survival of the firm"; so as managers in firms close to bankruptcy will tend to be very risk averse. Conversely to this survival hypothesis, agency theory (Jensen and Meckling (1976)) makes the specific prediction that the managers of firms in danger of bankruptcy will tend to be risk-seeking as the shareholders, whose interests they should represent, have little left to lose (and potentially much to gain).

Theories of behavioural decision making at the individual level have fundamentally challenged the use of expected utility theory. In particular Kahneman and Tversky (1979, p.263) developed "an alternative theory of choice…in which value is assigned to gains and losses rather than final assets…the value function is normally concave for gains, commonly convex for losses, and is generally steeper for losses than for gains." In the context of this discussion, the crucial point in their alternative "Prospect Theory" of choice is that, in the domain of losses, people are generally risk-seeking; hence people's decisions are very much dependent on whether they frame a given outcome as a gain or a loss. Building on this, Thaler and Johnson (1990, p.657) proceeded to look in detail at how past gains or losses affected subsequent decisions and identified a "break-even effect" in which people who had suffered a loss found a gamble that offered the chance of recovering to their previous state particularly attractive. However, they also cautioned that "Perhaps the most important conclusion to be reached from this research is that making generalizations about risk-taking preferences is difficult" (p. 660). Directly applying such theories to the managers of firms, suggests once again that the relationship between risk and performance is contingent on whether the firm is a high or low performer relevant to a reference point; as managers of low performing firms would tend to be more risk-seeking, particularly if they are presented with an opportunity to break even. However, such an extension of a theory of individual decision making to the firm level has not been rigorously justified; and there are particular problems with defining appropriate performance reference points in order to test these theories empirically.

Cyert and March's (1992) argument received some early empirical support from Fiegenbaum and Thomas (1988), who found a negative association between risk and performance for firms whose performance fell below the median, and a positive relationship for high-performers[46]; and Bromiley (1991), who found that poor performance tends to drive increased risk-taking. However, more recent and specific tests have produced varying results. Miller and Chen (2004) conducted a direct test of March and Shapira's (1987) predictions by studying firms in three groups: firms close to bankruptcy; firms that were not at high risk of bankruptcy but were performing below aspirations; and firms performing above aspirations. Contrary to March and Shapira's (1987) prediction of a focus on survival for firms close to bankruptcy, and consistent with agency theory, it was found that risk (measured as the standard deviation of ROA) decreased as performance improved within this group. It was also found that risk decreased as performance improved for firms performing above aspirations, contrary to their predictions. In summary, the empirical evidence appears to support a generally negative relationship between the performance of firms and risk-seeking behaviour by managers, which mediates the relationship between risk and performance; but this general trend may not apply to the highest and lowest-performing firms.

Before proceeding to review some previous empirical tests of the relationship between risk and performance at the firm-level; it is necessary to briefly consider the theoretical predictions and empirical evidence for persistence of profits, and this is the topic of the next paragraph.

[46] However, see section 5.2.4 for a critique of Fiegenbaum and Thomas's (1988) methodology.

5.2.3 Persistence of Profits

The majority of studies of the relationship between risk and performance at the firm level use some measure of profitability, usually ROE and ROA, as the dependent variable (see table 1 below). In view of this, it is important to briefly review the literature on the persistence of profits; starting with the two quite distinct explanations for why a firm may enjoy sustained high or low profitability. At the industry level, structural issues such as exit and entry barriers may enable the firms within that sector to maintain persistently high or low profitability (Porter (1980)). However, inter-firm heterogeneity in resources and capabilities may also result in individual firms within an industry consistently out-performing or under-performing their peer group: this is the focus of the RBV, which was discussed in detail in Chapter Two. Furthermore, "market power" (Porter (1981)), chance events and "cumulative advantage" (Denrell et al (2013)) may all lead to sustained superior performance, even in the absence of any competitive advantage.

A number of early studies focused on the performance differences between different sectors and, in particular, found a significant correlation between industry concentration and average performance over subsequent years: Brozen (1970) provides a detailed review of these studies. Mueller (1977) departed from this approach, being possibly the first study to explore persistence at the firm-level[47]. His method was quite similar to the earlier studies though, in that he grouped firms based on their profitability in the first year of the study and then followed their performance over the next 23 years. The results lent support to the persistence of profits within sectors: he found that the estimated long-term profitability of firms that started in the group with highest profitability was 46% above the mean;

[47] Although there had been specific studies of the relationship between firm size and performance such as Hall and Weiss (1967).

whereas that of firms which started in the lowest group was 24% below the mean. Hawawini et al (2003), using a random-effects ANOVA method, explicitly examined whether performance is driven more by industry or firm-specific effects and concluded that, whilst the performance of a small number of outliers within each sector is driven by firm-specific effects; when these firms are removed, the principal variation is between industry sectors. More recent work has generally been based on the use of auto-regressive models for profitability as a function of time, typically an AR(1) model of the form:

$$\pi_{it} = \alpha_i + \lambda_i \pi_{it-1} + \varepsilon_{it} \qquad (5.1)$$

Where: π_{it} is the profit rate of firm i at time t; α_i and λ_i are firm-specific parameters to be estimated and μ_{it} is an error term with constant variance and mean zero. This body of work has lent further support to the existence of the phenomenon, and provided more detailed insights into the drivers of persistence. For instance McMillan and Wohar (2011) found that 89% of their sample of UK firms had positive estimates for λ_i in equation (5.1); and that 26% had estimates between 0.5 and 1. They also found that the estimates for λ_i were greater for high-performing firms than low-performing firms. Similarly, Gschwandtner and Cuaresma (2013) found a highly significant average λ_i of 0.667 for their sample of 151 US firms; they also found that industry concentration had a significant positive effect on persistence, but that firms' market share had a negative impact. It is important to note that both of these studies used ROA as the measure of profitability; but it is possible that similar effects may be observed if ROE is used[48]. The way in which some different empirical studies of the relationship between risk and performance have attempted to compensate for the persistence of profits is discussed in the next section.

[48] McMillan and Wohar (2011, p.517) state that "(return on equity was also consider[ed] with similar results)"; but they do not specify if the denominator was book value of equity or market value of equity.

5.2.4 Empirical Work on the Relationship Between Risk and Return at the Firm Level

Bowman's (1980) original study took an entirely non-parametric, contingency-table, approach, based on dividing firms into high (above median) and low groups based on their average ROE and variance in ROE over the same five-year period. The analysis was initially conducted at the firm-level for each of nine industry sectors: eight industries showed a negative association (although not necessarily significant) between performance and risk. The analysis was then repeated with 85 industry sectors using data over a nine-year period: a negative relationship was found in 56 industries. The analysis was repeated again using firm-level data from all industry sectors, and using averaged firm-level data for each of the 85 industry sectors; but no relationships were observed. Bowman's (1980) method was severely criticised by Marsh and Swanson (1984, p.37); beginning with "even If his contingency table tests were correctly specified, we could, at most, conclude that if firm A's mean ROE is above the median for companies in its industry, then it is slightly more likely that its ROE variance will be below the industry median. Hence...his results are not 'parametric' enough to lend much support to decision makers." The authors then proceeded to explain why the tests are not correctly specified, most importantly they highlight that the negative skewness of the distribution of profitability[49] leads to an inherent negative correlation between the **estimated** mean and variance; Shanmugam (2007, p.409) derives the following formula:

$$\mathrm{Corr}\,[\overline{X}, S^2] = (|S_k/(K_u - 1 + 2/(n-1))|)^{½},\ n \geq 2 \qquad (5.2)$$

where S_k is the sample skewness and K_u the kurtosis. More recently, Henkel (2009) quantified this spurious negative correlation between the estimated mean and

[49] There is a realistic upper bound on the profit that a firm can generate but no corresponding lower bound.

variance, finding that it accounts for much of the observed correlation in these early studies.

Fiegenbaum and Thomas (1988), once again using variance of ROE as their measure of risk, used a very similar approach to Bowman (1980) with two improvements: Spearman correlation tests were conducted as well as contingency-table tests in order to provide more 'parametric' results; and tests were conducted separately on high and low-performing firms. The authors found a negative association between risk and performance at both firm and industry-level for poor performers; but a positive relationship for high performers. Whilst this result is very interesting, the authors failed to address the critical methodological problems identified by Marsh and Swanson (1984) so their results cannot be considered reliable. Shortly afterwards their whole approach, and that of Bowman (1980), was undermined when Ruefli (1990) pointed out that, because mean and variance are both functions of the same variable (eg ROE), the method suffers from a particularly severe form of the identification problem. In many instances of the identification problem (eg trying to calculate both demand and supply curves from data on quantity and price), the problem can be solved if additional variables can be found that enter only one of the equations, but this is simply not possible in this instance; as a result "the computed mean-variance relationship cannot be identified in distinction to the effects of shifts in the relationship over time – without additional information or assumptions" (Ruefli (1990, p.372). Ruefli (1990) goes on to demonstrate, by construction, that a series of positive mean-variance relationships in each sub-period could give rise to an overall negative relationship (and vice versa); so as a relationship calculated in one time period cannot be generalised to any other time period.

Miller and Bromiley (1990) not only addressed the identification problem highlighted by Ruefli (1990), but also made the important advances of considering multiple risk measures and allowing for persistence of profits. The authors conducted a principal component analysis on nine measures of firm-level risk that had been widely used in strategic management research up to that point, this yielded three components which they named: “income stream risk”, “stock returns risk” and “strategic risk” (see previous chapter for further discussion of the method and results of the principal component analysis). They then conducted an OLS regression with these three risk components and performance, calculated over a five-year period, as explanatory variables; and performance over the subsequent five-year period as the dependent variable. Their key findings were that both income stream risk and strategic risk were negatively associated with subsequent performance. Whilst this study represents a significant advance on previous work, there are still two methodological concerns. Firstly, the regression model is mis-specified as performance is modelled to be based solely on the three risk components and prior performance, without controlling for firm size, industry sector or any other possible drivers of performance. Secondly, the authors acknowledge the potential impact of outliers on the regression results stating that “We eliminated outliers in the annual data by deleting the observations with values in the bottom or top 2 percent of each variable’s distribution” (p.760); but do not discuss the nature of these outliers, or consider any alternative techniques that are robust to outliers. As discussed in detail in Chapter Three, in the context of risk research, simply deleting outliers may destroy the most valuable data.

Most subsequent empirical work has followed the same general methodology of regressing performance on lagged measures of risk and performance, but a number of different measures of risk have been used. Bromiley (1991) used variance of analysts' forecasts as a measure of risk and, applying a panel approach with GLS regression, found that increased risk resulted in lower performance (ROA). This study is particularly interesting as an example of the use of an ex-ante measure of risk, which more naturally fits with the strategic management literature's interest in decision-making. Applying the behavioural theory of the firm (Cyert and March (1992)), Miller and Leiblein (1996) constructed a measure of "downside risk" (p. 101), based on failure to meet annual ROA targets. In common with Miller and Bromiley (1990), the risk measure was constructed over one five year period and performance was measured over the next five years. This study also investigated the effect of prior performance on risk, although the regressions for risk and return were estimated separately (unlike Bettis's (1982) simultaneous equation model). The regression with performance as the dependent variable found that their downside risk construct "demonstrated more consistent significant relations with return [ROA] than did returns standard deviation", and that contrary to previous studies, "consistent with the behavioural theory of the firm, the results support a positive effect of downside risk on performance" (p. 117)[50]. Meanwhile, the regressions with downside risk as the dependent variable found a negative association with prior performance, also in support of the behavioural theory of the firm. As with Miller and Bromiley (1990), Miller and Leiblein (1996, p.104) acknowledge the presence of outliers in their sample "Firms with returns...beyond three standard deviations from the annual mean across all firms were considered outliers and eliminated from that

[50] It is also interesting to note the recent interest in downside risk measures in the financial economics literature with the use of constructs such as: 'downside beta' (Ang, Chen and Xing (2006)); value at risk (Bali et al (2009)); and 'idiosyncratic bond value-at-risk' (Gemmill and Keswani (2011)) used to explain variation in performance.

year's data set". Subsequently, further observations (up to 8.9% in one regression) were deleted because of their high influence (based on DFFITS values (Belsley, Kuh and Welsch (1980))); however, "A comparison of the regression results before and after elimination of outliers indicated no substantive differences in the signs or magnitudes of the estimated coefficients" (p.105). There is no consideration of any robust techniques.

Some key features in the design of the studies discussed are summarised in table 5.1

Table 5.1 – Previous Studies of Risk and Performance

Study	Timeframe	Dependent Variable	Method	Results
Bowman (1980)	Five years (1972-76) Nine years (1968-76)	ROE	Contingency tables at firm and industry-level, conducted by industry sector and aggregated.	Negative risk-return relationship in most industry sectors; no relationship for aggregated data.
Bettis (1982)	Five years (1973-77)	ROA	Regression analysis using simultaneous equation model.	Parameter estimate for risk is positive in single-equation model but becomes negative (ns) in simultaneous equation model.
Marsh and Swanson (1984)	24 years (1958-1981)	ROE	Bespoke measure of association to correct for autocorrelation and cross-sectional interdependence, applied by industry sector and aggregated.	No significant relationship between risk and return.
Fiegenbaum and Thomas (1988)	20 Years (1960-79); analysis also conducted over 5 and 10-year sub-periods	ROE	Contingency tables and Spearman correlation at firm and industry-level, conducted by industry sector and aggregated.	Negative risk-return relationship for firms performing below median; positive relationship for those above.
Miller and Bromiley (1990)	Two five-year periods (1978-82 and 1983-87)	ROE and ROA	OLS regression analysis using five-year lag structure. Also investigated effect of performance on risk.	Both income stream risk and strategic risk are negatively associated with performance.
Bromiley (1991)	12 years (1976-87)	ROA	Panel data (GLS) approach using one-year lag structure (only nine data points because of need for IVs).	Increased risk leads to lower performance.
Miller and Leiblein (1996)	Four five-year periods (1972-76, 1977-81, 1982-86 and 1987-91)	ROA	OLS regression analysis using five-year lag structure.	Downside risk is positively associated with performance.

5.2.5 Summary

Building on the discussions in Chapter Two, concerning the relationship between risk and performance; this section went on to consider how the relationship between risk and future performance may be mediated by past performance, and the persistence of profits literature was briefly introduced. This was followed by a discussion of some of the challenges in conducting empirical tests of these theoretical predictions; and the section concluded by summarising how it is intended to improve upon prior empirical work in this chapter. The starting point for the design of the regression models used in the current study is Miller and Bromiley (1990), as their approach simultaneously: addresses the identification problem; acknowledges the existence of alternative measures of risk with relevance to different stakeholder groups; and allows for the persistence of profits. However their model is mis-specified: there are no control variables (eg for firms size), and the model takes no account of the mediating effect of prior performance on the relationship between risk and return. Furthermore, their model cannot distinguish between true persistence of profits and firm fixed effects.

The current study is motivated by a desire to directly address these methodological shortcomings, in order to make a contribution to our understanding of the relationship between risk and performance. A number of additional variables, including an interaction term between profit risk and a dummy variable indicating whether prior profitability has been high or low (above or below the median), are therefore added to the regression model; first-differencing is used to remove firm fixed effects; and, as previously mentioned, a novel cashflow risk measure is used. In addition, cross-sectional analyses are conducted over multiple time-periods to examine if the relationships between risk and performance are stable over time. The regression model is discussed in more detail in the next section, after the specific hypotheses to be tested are outlined.

5.3 Hypothesis Development

Drawing on the various theoretical strands outlined in the previous section, four specific hypotheses will be tested in the regression analyses. As summarised in section 5.2.1, Sharpe (1964), predicts a very simple positive relationship between the systematic risk (beta) and returns to shareholders; however Pettengill et al (1995) argued, and demonstrated empirically, that the relationship is actually contingent on the performance of the market.

> *Hypothesis 1a: Increased market risk is associated with higher future returns to shareholders when returns on the market portfolio are above the risk-free rate.*

> *Hypothesis 1b: Increased market risk is associated with lower future returns to shareholders when returns on the market portfolio are below the risk-free rate.*

Section 5.2.1 also summarised numerous arguments for both positive and negative relationships between profit risk and future profitability (ROE and ROA); and, as discussed in section 5.2.4, empirical tests have yielded very mixed results. By contrast, cashflow risk has not been considered in previous studies of the risk-return relationship; and, in so much as it has previously been considered as a risk measure, it has been in the context of the risk of financial distress and thus primarily of interest to lenders. There is therefore no reason to believe that it is a salient factor in managerial decision-making about projects, and hence no reason to expect a positive relationship between cashflow risk and return. However, variability in cashflows may reduce future income as the firm is unable to exploit value-creating opportunities as and when they arise[51]; and uncertainty in future cashflows may increase the cost of debt as lenders perceive a greater probability of default. One of the advantages of the PCA approach adopted in the last chapter is that the varimax rotation attempts to load a small number of variables highly onto each component. The fact that the cashflow risk construct captures elements of risk that have a purely negative association with return, therefore makes it likely that those elements of risk loading onto profit risk will be more positively associated with return.

Hypothesis 2: Increased profit risk is associated with higher future profitability.

Hypothesis 3: Increased cashflow risk is associated with lower future profitability.

Section 5.2.2 outlined a number of reasons to suspect that the relationship between risk and performance is contingent on whether the firm has been a high or low performer; as risk-seeking behaviour by managers would tend to increase profit risk without a commensurate increase in expected profits. The theoretical predictions are not all consistent with each other, but the empirical evidence appears to support the argument that low performance tends to lead to risk-seeking behaviour by managers, resulting in the final hypothesis.

Hypothesis 4: The effect of profit risk on profitability is less positive (or indeed negative) for lower-performing firms.

Following the approach of Miller and Bromiley (1990) to allow for persistence of profits, a dynamic model of the following form will be used to test hypotheses 2 to 4:

$$\text{Performance}_i = \alpha \, \text{L.Performance}_i + \mathbf{x}^{\mathbf{T}}_i\boldsymbol{\beta} + \mu_i + \varepsilon_i \qquad (5.3)$$

[51] Minton and Schrand (1999) found that cash flow volatility was negatively associated with both average capital expenditures and spending on R&D and advertising.

Where performance is based on measures of profitability; α is a constant to be estimated; **x** is a column of regressors (including both explanatory and control variables); **β** is a column of coefficients to be estimated; μ is a firm-specific effect that does not vary over time[52]; and ε_{it} is a random error term. Hypothesis 1 can be tested using a simpler, static version of the model, as follows:

$$Performance_i = \mathbf{x}^T{}_i\boldsymbol{\beta} + \mu_i + \varepsilon_i \qquad (5.4)$$

Where performance is measured by returns to shareholders.

[52] Amongst other things, this addresses the concern that the tests are just separating well-run and poorly-run firms (Bowman (1980), Andersen et al (2007)). However, as noted in Chapter One, the removal of firm-fixed effects in this way also precludes any examination of the impact of risk management on the relationship between risk and performance in this model; this is discussed in more detail in Chapter Seven.

5.4 Data

The regression analysis is based on the same sample of firms that was used for the principal component analyses in the previous chapter. Definitions of the dependent and explanatory variables for the study are given in section 5.4.1, with a summary in table 5.2; this is followed by summary statistics in section 5.4.2.

5.4.1 Variable Definitions

5.4.1.1 Dependent Variables

Bowman (1980, p.19) chose ROE[53] as his measure of profitability, stating "Not only does ROE tend to normalize for trends, but it is the variable of interest here. Return on equity is not only the profit measure of primary interest to most managers and strategic planners, it is one of the more common measures of profits used in economic research." However, Marsh and Swanson (1984) caution that ROE is very susceptible to noise, and more recent studies (eg Miller and Bromiley (1990), Miller and Chen (2004)) have usually included ROA as a profitability measure instead of, or as well as, ROE. Both the return on the book value of equity, hereinafter abbreviated to RBVE, and ROA are used as profitability measures in this chapter; the return on market value of equity, hereinafter abbreviated to RMVE, is also used[54]. In addition, annual returns to shareholders is included as a more forward-looking measure of performance, and in order to test hypotheses 1a and 1b. RBVE is calculated by dividing profit before tax (FAME field 14) by book value of equity (FAME field 93 – "Shareholders' Funds"): firm-year observations where book value of equity is negative are omitted. ROA is taken directly from FAME field 138 – "Return on Total Assets"; and RMVE is calculated by dividing profit before tax (FAME field 14) by

[53] The precise definition used for ROE is not clear from the article; but it is presumed that the denominator was book value of equity.
[54] The reason for this is explained in section 5.5.2.3.

market value of equity (Datastream field MV – “Market Value (Capital)”. Annual returns to shareholders are calculated from Datastream field RI – “Total Return Index”, which includes both capital appreciation and dividends paid during the year and is calculated as follows:

$$RI_t = RI_{t-1} . (P_t + DD_t) / P_{t-1} \quad (5.5)$$

Where: P is the (adjusted) share price; DD are the (adjusted) dividends paid during the year (based on ex-dividend dates); and $RI_0 = 100$. Annual returns to shareholders (RTS) are then calculated as follows:

$$RTS_t = (RI_t - RI_{t-1}) / RI_{t-1} \quad (5.6)$$

The dependent variables are generally values for a single year (the year following the five-year period over which the explanatory variables are calculated) but, for one particular univariate analysis (see section 5.5.1), ROA is averaged over a five-year period: this is denoted by MROA.

There is clearly the potential for a sample selection bias in this approach in that, if a firm performs very badly and goes out of business, no data will be available. However, there were no firms in the sample for which the explanatory variables were available but for which there were no performance data[55].

5.4.1.2 Explanatory Variables

The key explanatory variables in this study are the three risk components that were observed in each time period in the previous chapter: profit risk, market risk and cashflow risk. However, because of the need to first-difference variables (in order to remove firm fixed effects), the risk measure with the highest loading on each

[55] As can be seen from table 5.3, the ROA value is missing for one firm-year and returns to shareholders data are missing for ten firm-years; as discussed in section 4.3 there are a large number of missing values for RBVE.

component is used as a proxy for the actual components, these are respectively: standard deviation of ROA, beta and standard deviation of cashflow. All variable definitions are identical to the ones used in Chapter Four.

A number of other explanatory variables are included in this study in addition to those defined in Chapter Four, and these are described below. As originally hypothesised by Baumol (1957), and subsequently shown empirically by Hall and Weiss (1967); large firms have all the options of small firms plus additional options not available to smaller firms so should be more profitable. Therefore firm size is included as an explanatory variable; defined as the natural log of the average turnover (FAME field 1) over each five-year period[56]. Market power is also included, and is proxied by market share; which is calculated as the proportion of turnover (FAME field 1) within the relevant industry section in the 2007 SIC, using the largest 12000 firms in the FAME database as at November 2013[57]. Industry dummies were not included as these would be removed in the first-differencing process (see section 5.5.2 below). In order to test hypothesis 4, a dummy variable for "high ROE" is interacted with the standard deviation of ROA. The high ROE dummy is "1" if RMVE averaged over the five-year estimation period was above the median and "0" otherwise. As discussed in section 2.4.1.1 above, Fama and French (1992) found that the cross-sectional variation in returns to shareholders was explained by size and the book-to-market ratio: the (natural log of the) book-to-market ratio is therefore included in the regressions with returns to shareholders as the dependent variable. This was calculated by dividing book value of equity (FAME field 93 – "Shareholders'

[56] The natural log of total assets was used as an alternative measure of firm size in some regressions as a robustness test but the results were almost identical so these are not reported. Both measures of size were deflated to 2013 values using ONS GDP deflators (June 2014).

[57] In each time period a very small number of firms (less than five in all cases) had to be removed from the sample because of the absence of a SIC code.

Funds")[58] by the market capitalisation (Datastream field MV – "Market Value (Capital)") annually, averaging over each five-year period (negative and zero values of the ratio are not included in the average) and taking the natural log.

Definitions of all variables are summarised in table 5.2.

Table 5.2 – Variable Definitions

Variable	Definition
Dependent Variables	
RBVE	Profit before tax / book value of equity for a single year.
ROA	Return on total assets for a single year.
RMVE	Profit before tax / market value of equity for a single year.
RTS	(Capital appreciation + dividends paid in a single year) / share price at start of the year.
MROA	Return on total assets averaged over a five-year period.
Explanatory Variables	
Size	Ln (turnover averaged over five-year period).
Power	Turnover averaged over five-year period / total turnover for relevant sector in 2013.
High RMVE	Dummy variable = "1" if RMVE averaged over a five-year period is above the median.
Ln[Book-to-Market Value]	Ln[Book value of equity / market value of equity]. Ratio calculated annually, averaged over five-year period and natural log taken.
SD of ROA	Sample SD of ROA over five-year period.
Beta	OLS regression of 60 monthly stock returns on returns of FTSE AIM All-Share index.
SD of Cashflow	Sample SD of cashflow over five-year period / average total assets over five-year period.

Summary statistics for the dependent variables in the pooled sample and each five-year period are shown in table 5.3.

[58] FAME field 113 - "Gearing" was not used as a debt-to-equity measure as there is an in-built cut-off.

5.4.2 Summary Statistics

Table 5.3 – Summary Statistics (Dependent Variables)

	N	Mean	Median	Min	Max	SD	MAD	Skewness
Panel A – Pooled Sample								
RBVE	3859	-0.0245	0.0707	-119	29.1	2.33	0.114	-37.5
ROA	3952	-0.0122	0.0323	-7.58	2.92	0.332	0.0759	-9.39
RMVE	3953	-0.0915	0.0568	-125	11.7	2.18	0.0977	-48.0
RTS	3943	0.135	0.0758	-0.965	27.1	0.770	0.415	13.5
Panel B – 2012								
RBVE	982	0.0273	0.0563	-6.91	7.36	0.666	0.0984	-3.43
ROA	1006	-0.000459	0.0307	-2.54	1.16	0.246	0.0659	-4.40
RMVE	1007	-0.141	0.0472	-125	11.7	4.01	0.0791	-29.7
RTS	1004	0.201	0.168	-0.941	5.62	0.444	0.307	2.52
Panel C – 2011								
RBVE	875	0.0728	0.0675	-8.84	29.1	1.18	0.0966	16.3
ROA	892	-0.00167	0.0331	-5.31	2.92	0.354	0.0644	-9.10
RMVE	892	-0.0543	0.0557	-22.6	3.51	0.983	0.0908	-16.3
RTS	890	-0.0644	-0.0921	-0.965	4.56	0.397	0.285	2.80
Panel D – 2010								
RBVE	764	0.0466	0.0813	-27.0	9.91	1.23	0.0948	-13.6
ROA	779	0.00344	0.0354	-4.88	0.381	0.320	0.0601	-10.5
RMVE	779	-0.00109	0.0593	-7.97	0.884	0.458	0.0742	-10.7
RTS	777	0.321	0.206	-0.806	27.1	1.13	0.338	17.5
Panel E – 2009								
RBVE	649	-0.0899	0.0860	-50.8	15.3	2.34	0.130	-16.2
ROA	671	-0.00871	0.0392	-7.58	0.446	0.426	0.0919	-11.5
RMVE	671	0.00227	0.0698	-3.56	1.21	0.347	0.115	-4.42
RTS	669	0.559	0.367	-0.902	12.9	0.944	0.421	5.67
Panel F -2008								
RBVE	589	-0.276	0.0601	-119	5.43	4.97	0.194	-23.4
ROA	604	-0.0711	0.0229	-2.96	0.357	0.317	0.125	-3.90
RMVE	604	-0.285	0.0654	-18.5	1.39	1.55	0.262	-8.12
RTS	603	-0.392	-0.417	-0.955	1.46	0.301	0.283	1.23

It is clear that the dependent variables have some extreme outliers and are all very skewed; in order to illustrate this further, quantile plots of the four dependent variables from the pooled sample are shown in figs. 5.1 to 5.4.

Fig. 5.1 – Quantile Plot of RBVE

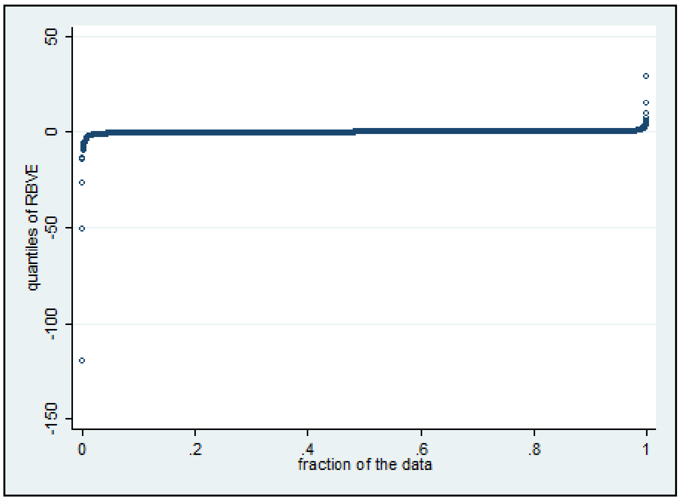


Fig. 5.2 – Quantile Plot of ROA

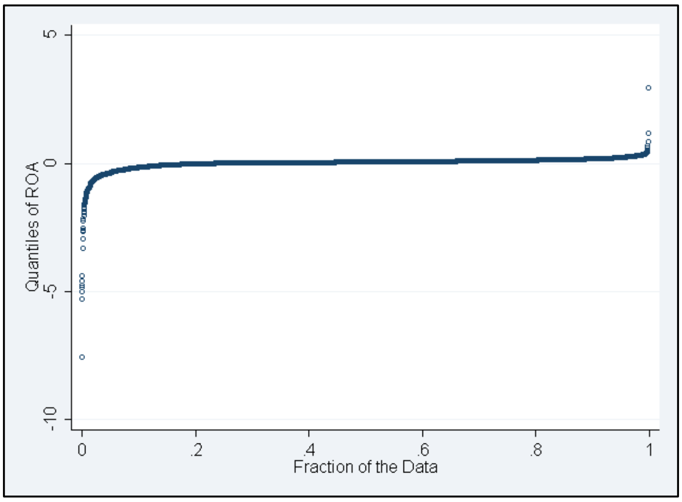


Fig. 5.3 – Quantile Plot of RMVE

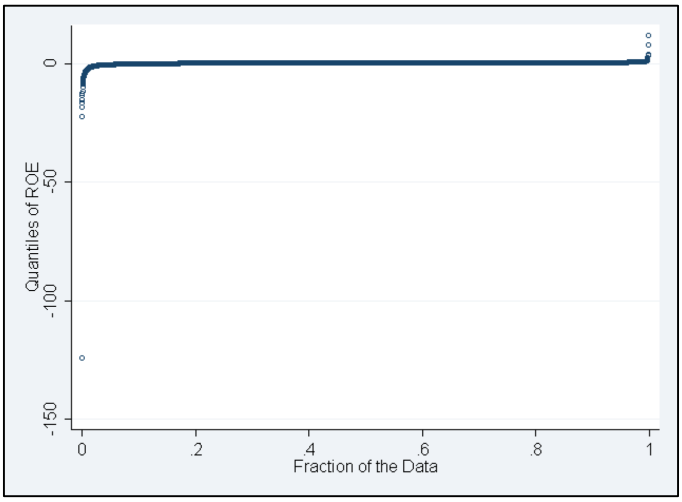
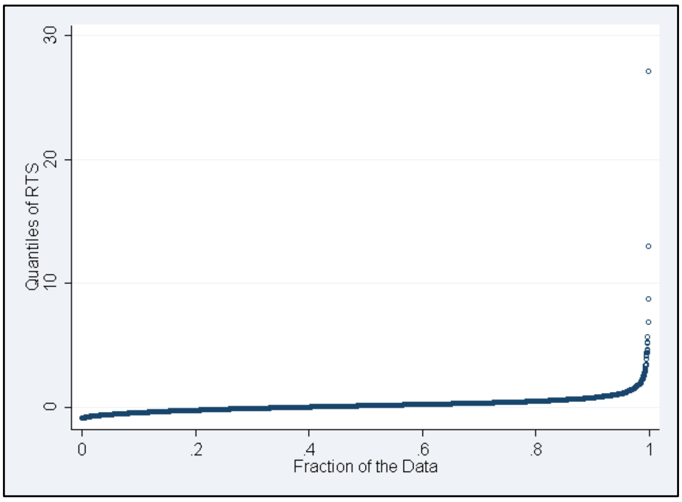


Fig. 5.4 – Quantile Plot of Returns to Shareholders



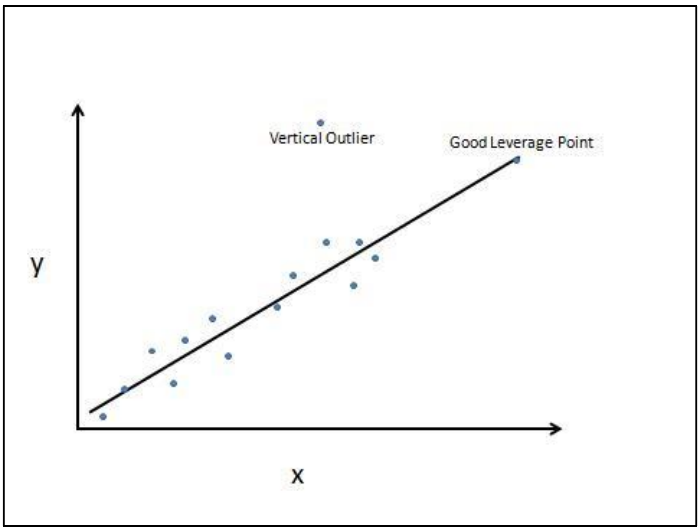
To further illustrate the issue of extreme outliers, various percentiles of the distributions are tabulated below, expressed in terms of median absolute deviations from the median. The customary measure of standard deviations from the mean is not appropriate as neither of these estimators are themselves robust to outliers.

Table 5.4 – Quantiles of RBVE, ROA, RMVE and Returns to Shareholders (Expressed as Median Absolute Deviations from the Median)

	1%	2%	3%	4%	5%	95%	96%	97%	98%	99%
RBVE	-21.2	-13.3	-9.87	-7.56	-6.43	3.56	4.03	4.50	6.06	11.1
ROA	-15.2	-9.67	-7.47	-6.22	-5.62	2.30	2.57	2.91	3.26	3.88
RMVE	-28.1	-15.2	-10.4	-8.75	-7.03	2.39	2.73	3.30	3.85	5.54
RTS	-2.19	-2.04	-1.90	-1.83	-1.73	2.30	2.59	3.14	3.91	5.46

As discussed In Chapter Three, outlying values of the dependent variable such as these can cause problems for regression estimates in one of two ways, depending on whether they are “good leverage points” or “vertical outliers” (Rousseeuw and Leroy (1987)), as illustrated in the simple two-variable regression example shown in fig. 5.5.

Fig. 5.5 – Definition of Vertical Outliers and Good Leverage Points



Good leverage points do not directly affect the estimated parameters but are a concern because they deflate the estimated standard errors. Vertical outliers are even more problematic as they do directly influence the parameter estimates: it is therefore very important to take steps to limit the impact of these outliers.

Summary statistics for the explanatory and control variables in the pooled sample and each five-year period are shown in table 5.5.

Table 5.5 – Summary Statistics (Explanatory and Control Variables)

	N	Mean	Median	Min	Max	SD	MAD	Skewness
Panel A – Pooled Sample								
Size	3953	10.8	10.6	1.39	19.3	2.86	2.90	0.0110
Power	3938	0.00338	0.0000898	4.24×10^{-9}	0.240	0.0145	1.31×10^{-4}	8.60
Ln[Book-to-Market]	3942	-0.300	-0.184	-5.73	7.10	0.953	0.749	0.903
SD of ROA	3953	0.134	0.0667	0.000453	3.91	0.252	0.0661	7.89
Beta	3953	0.625	0.569	-2.45	4.87	0.434	0.366	1.33
SD of Cashflow	3953	0.0860	0.0519	.0000205	1.27	0.111	0.0460	3.85
Panel B - 2007-11								
Size	1007	10.7	10.5	1.41	19.4	2.87	2.90	0.0438
Power	1004	0.00331	0.0000707	4.24×10^{-9}	0.240	0.0157	1.03×10^{-4}	9.60
Ln[Book-to-Market]	1002	-0.230	-0.0720	-5.73	4.90	0.897	0.741	-0.546
SD of ROA	1007	0.143	0.0687	0.000482	3.91	0.302	0.0683	7.92
Beta	1007	0.693	0.620	-2.20	4.50	0.468	0.389	1.16
SD of Cashflow	1007	0.0910	0.0517	0.000205	1.20	0.121	0.0470	3.74

Table 5.5 (Cont.)

	N	Mean	Median	Min	Max	SD	MAD	Skew
Panel C – 2006-10								
Size	892	10.8	10.6	1.44	19.3	2.86	2.96	0.0323
Power	889	0.00324	0.0000845	4.24×10^{-9}	0.211	0.0145	1.23×10^{-4}	9.14
Ln[Book-to-Market]	889	-0.331	-0.190	-4.51	3.31	0.866	0.751	-0.904
SD of ROA	892	0.145	0.0737	0.000453	3.65	0.269	0.0755	7.46
Beta	892	0.689	0.630	-2.45	4.45	0.467	0.393	1.12
SD of Cashflow	892	0.0899	0.0535	0.000808	0.853	0.109	0.0477	3.19
Panel D - 2005-09								
Size	779	11.0	10.9	1.44	19.3	2.83	2.87	0.00408
Power	776	0.00352	0.000100	4.24×10^{-9}	0.199	0.0145	1.46×10^{-4}	8.23
Ln[Book-to-Market]	778	-0.381	-0.232	-4.74	3.16	0.858	0.745	-0.927
SD of ROA	779	0.140	0.0693	0.000551	3.21	0.241	0.0694	7.08
Beta	779	0.680	0.621	-0.201	4.87	0.442	0.364	1.90
SD of Cashflow	779	0.0861	0.0530	0.000593	1.16	0.109	0.0471	3.98

Table 5.5 (Cont.)

	N	Mean	Median	Min	Max	SD	MAD	Skew
Panel E – 2004-08								
Size	671	11.0	10.9	1.44	19.1	2.87	2.94	-0.0513
Power	668	0.00346	0.000102	4.24×10^{-9}	0.165	0.0134	1.50×10^{-4}	7.19
Ln[Book-to-Market]	670	-0.254	-0.130	-4.75	6.88	1.02	0.731	0.771
SD of ROA	671	0.132	0.0645	0.00157	3.15	0.228	0.0640	6.97
Beta	671	0.598	0.584	-0.269	2.28	0.330	0.316	0.594
SD of Cashflow	671	0.0805	0.0528	0.000673	0.977	0.100	0.0456	3.68
Panel F - 2003-07								
Size	604	11.0	11.0	1.44	19.0	2.86	2.89	-0.0570
Power	601	0.00342	0.000101	4.24×10^{-9}	0.141	0.0134	1.48×10^{-4}	6.71
Ln[Book-to-Market]	603	-0.321	-0.360	-4.75	7.10	1.17	0.824	1.15
SD of ROA	604	0.0943	0.0543	0.00131	2.06	0.150	0.0509	6.77
Beta	604	0.374	0.343	-0.712	1.76	0.107	0.0399	0.747
SD of Cashflow	604	0.0779	0.0463	0.000462	1.27	0.299	0.221	4.91

5.5 Empirical Tests

This section describes both the methods and results of a series of empirical tests. The analysis begins with various univariate tests in order to make a direct comparison with earlier work that was based on such methods (eg Bowman (1980), Fiegenbaum and Thomas (1988)); this is followed by cross-sectional regression analyses to explore the effect of multiple risk components on performance.

5.5.1 Univariate Tests

Early studies of the relationship between risk and performance used simple non-parametric tests, such as Bowman's (1980) 2x2 contingency tables and Fiegenbaum and Thomas's (1988) correlation tests; based on mean ROE and standard deviation of ROE values calculated over the same five-year period. However, given both the comments referred to in section 5.4.1.1 about ROE being susceptible to noise and the issues discussed in section 4.3 about the large number of firm-year observations with negative book value of equity; ROA and the standard deviation of ROA are used in this study instead. The overall approach of both Bowman (1980) and Fiegenbaum and Thomas (1988) is replicated below using both Pearson (table 5.6) and Spearman (table 5.7) correlation tests to calculate corr [$MROA_{(t-5,\ t-1)}$, SD of $ROA_{(t-5,\ t-1)}$]. Note that, in order to allow for comparison, the same samples of firms are used in all tests in this section.

Table 5.6 – Pearson Correlation Coefficients (corr [$MROA_{(t-5,\ t-1)}$, SD of $ROA_{(t-5,\ t-1)}$])

t	N	ρ
Pooled	2941	-0.788***
2012	887	-0.786***
2011	779	-0.810***
2010	671	-0.817***
2009	604	-0.732***
2008	604	-0.769***

1. Table 5.6 reports the Pearson correlation coefficients between MROA and the standard deviation of ROA.
2. MROA and the standard deviation of ROA are calculated over five-year periods from 2003-07 to 2007-11.
3. Significance levels are indicated as follows: * p < .05, ** p<.01, ***p<.001.

Table 5.7 – Spearman Correlation Coefficients (corr [$MROA_{(t-5, t-1)}$, SD of $ROA_{(t-5, t-1)}$])

t	N	ρ
Pooled	2941	-0.528***
2012	887	-0.632***
2011	779	-0.557***
2010	671	-0.442***
2009	604	-0.455***
2008	604	-0.251***

1. Table 5.7 reports the Spearman correlation coefficients between MROA and the standard deviation of ROA.
2. MROA and the standard deviation of ROA are calculated over five-year periods from 2003-07 to 2007-11.
3. Significance levels are indicated as follows: * p < .05, ** p<.01, ***p<.001.

The Pearson correlation coefficients may be unreliable, due to the extreme skewness of the data; but the Spearman coefficients are also universally negative and highly significant, in keeping with Bowman's (1980) observed "paradox". However, as discussed in section 5.2.4: Marsh and Swanson (1984) pointed out that there is an inherent negative correlation between mean and variance for a skewed distribution such as this; and Ruefli (1990) demonstrated that results obtained from this mean-variance approach could not be generalised because of an identification problem. In order to address both these issues, Pearson and Spearman correlation coefficients were calculated using ROA values for the year following the end of the five-year period over which the standard deviation of ROA was calculated; ie corr [ROA_t, SD of $ROA_{(t-5, t-1)}$]; the results are shown in tables 5.8 and 5.9.

Table 5.8 – Pearson Correlation Coefficients (corr [ROA_t, SD of $ROA_{(t-5, t-1)}$])

t	N	ρ
Pooled	2941	-0.207***
2012	887	-0.0608
2011	779	-0.155***
2010	671	-0.293***
2009	604	-0.431***
2008	604	-0.297***

1. Table 5.8 reports the Pearson correlation coefficients between ROA and the standard deviation of ROA.
2. ROA values are for individual years from 2008 to 2012, the standard deviation of ROA is calculated over the preceding five-year period.
3. Significance levels are indicated as follows: * $p < .05$, ** $p<.01$, ***$p<.001$.

Table 5.9 – Spearman Correlation Coefficients (corr [ROA_t, SD of $ROA_{(t-5, t-1)}$])

t	N	ρ
Pooled	2941	-0.302***
2012	887	-0.379***
2011	779	-0.410***
2010	671	-0.337***
2009	604	-0.0378
2008	604	-0.288***

1. Table 5.9 reports the Spearman correlation coefficients between ROA and the standard deviation of ROA.
2. ROA values are for individual years from 2008 to 2012, the standard deviation of ROA is calculated over the preceding five-year period.
3. Significance levels are indicated as follows: * $p < .05$, ** $p<.01$, ***$p<.001$.

Once again, the use of Pearson correlation coefficients may be problematic because of outliers. However, the Spearman correlation coefficients are still universally negative (and significant in all but one case). Following the discussion in section 5.2.5 about the need to remove firm fixed effects; correlation coefficients were then calculated using first-differenced values of the variables, as follows:

$$\Delta(ROA_t) = ROA_t - ROA_{t-1} \quad (5.7)$$

$$\Delta(\text{SD of } ROA_{(t-5, t-1)}) = \text{SD of } ROA_{(t-5, t-1)} - \text{SD of } ROA_{(t-6, t-2)} \quad (5.8)$$

Table 5.10 – Pearson Correlation Coefficients (corr [Δ(ROA_t), Δ(SD of $ROA_{(t-5, t-1)}$)])

t	N	ρ
Pooled	2941	0.534***
2012	887	0.465***
2011	779	0.456***
2010	671	0.643***
2009	604	0.556***

1. Table 5.10 reports the Pearson correlation coefficients between (first-differenced) ROA and the (first-differenced) standard deviation of ROA.
2. The (first-differenced) ROA values are for individual years from 2009 to 2012, the (first-differenced) standard deviation of ROA is calculated over the preceding five-year period.
3. Significance levels are indicated as follows: * p < .05, ** p<.01, ***p<.001.

Table 5.11 – Spearman Correlation Coefficients (corr [Δ(ROA_t), Δ(SD of $ROA_{(t-5, t-1)}$)])

t	N	ρ
Pooled	2941	0.148***
2012	887	-0.0214
2011	779	0.0253
2010	671	0.101**
2009	604	0.476***

1. Table 5.11 reports the Spearman correlation coefficients between (first-differenced) ROA and the standard deviation of ROA.
2. The (first-differenced) ROA values are for individual years from 2009 to 2012, the (first-differenced) standard deviation of ROA is calculated over the preceding five-year period.
3. Significance levels are indicated as follows: * p < .05, ** p<.01, ***p<.001.

A completely different pattern is observed when first-differenced variables are used, with all correlation coefficients either significantly positive or insignificant. Focusing on the results of the Spearman correlation, as the more robust technique, there are now positive and highly significant correlation coefficients for the pooled sample and in the first two time periods; but insignificant correlation coefficients in later time periods. This result is important not only in explaining Bowman's (1980) paradox, and highlighting the need to remove firm fixed effects; but it also suggests that risk-return relationships may be contingent upon environmental conditions, and hence cross-sectional regressions should be used in the next section rather than a panel regression.

5.5.2 Cross-Sectional Regression

5.5.2.1 Outline

The two regression models to be estimated were introduced in section 5.3. Because of possible persistence of profits, a dynamic model is required where accounting measures of performance are used; as per equation 5.3, which is reproduced below:

$$\text{Performance}_i = \alpha \text{ L.Performance}_i + \mathbf{x}^T{}_i\boldsymbol{\beta} + \mu_i + \varepsilon_i$$

Where, following previous studies, performance is measured in two different ways (RBVE and ROA); α is a constant to be estimated; **x** is a column of regressors including both risk measures and control variables (estimated over a five-year period); **β** is a column of coefficients to be estimated; μ is a firm-specific effect that does not vary over time; and ε is a random error term which, it is assumed, is uncorrelated across firms but may be correlated over time.

However, a static model can be used when market measures of performance (returns to shareholders) are used; as per equation 5.4, which is reproduced below:

$$\text{Performance}_i = \mathbf{x}^T{}_i\boldsymbol{\beta} + \mu_i + \varepsilon_i$$

Section 5.5.2.2 describes the estimation of the dynamic regression model (equation 5.3) with RBVE and ROA as dependent variables. However, estimation of this model is complicated by an endogeneity issue, so instrumental variable techniques are required: no valid instruments can be identified so it is not possible to pursue this approach further. The dynamic regression model is therefore estimated with RMVE as the dependent variable in section 5.5.2.3: valid instruments are available and, critically, it turns out that the lagged dependent variable is not required. Section 5.5.2.4 then presents the results of estimating the static model (equation 5.4) with both RMVE and returns to shareholders as the dependent variable; using OLS, median, M-estimator and MM-estimator regressions. The results of all the regressions are summarised in section 5.5.2.5

5.5.2.2 Dynamic Regression Model (Dependent Variables RBVE and ROA)

The inclusion of a firm-specific effect in equation 5.3, which was missing in previous models (eg Miller and Bromiley (1990)), is necessary in order to capture any unobservable characteristics of individual firms which could affect performance. However, in order to estimate the regression, these firm-specific effects need to be removed[59]. One method of achieving this is first differencing as follows:

$$\Delta \text{Performance}_i = \alpha\, \Delta(\text{L.Performance}_i) + \Delta \mathbf{x}^T_i \boldsymbol{\beta} + \Delta\varepsilon_i \qquad (5.9)$$

But:

$$\Delta(\text{L.Performance}_i) = (\text{L.Performance}_i - \text{L}^2.\text{Performance}_i) = \alpha\, (\text{L}^2.\text{Performance}_i - \text{L}^3.\text{Performance}_i) + (\text{L}.\mathbf{x}^T_i - \text{L}^2.\mathbf{x}^T_i)\boldsymbol{\beta} + (\text{L}.\varepsilon_i - \text{L}^2.\varepsilon_i) \qquad (5.10)$$

Hence there is an issue of endogeneity: corr [Δ(L.Performance$_i$), $\Delta\varepsilon_i$] $\neq 0$, as both Δ(L.Performance$_i$) and $\Delta\varepsilon_i$ contain the term L.ε_i. However, it may be possible to use further lags of performance as instruments for L.Performance, so long as the errors are not serially correlated. There are alternative methods of removing firm-specific effects of which de-meaning, ie subtracting the estimated mean over all observations for the firm from each observation, is the most common (eg in the estimation of fixed-effects static panel models). However, the endogeneity issue here is less tractable as each lagged value of the dependent variable will now contain the term $\bar{\varepsilon}_i$ so there are no available instruments. The same argument applies to Bramati and Croux's (2007) robust method of removing fixed effects by subtracting the median

[59] Asymptotic theory for short panels relies on N $\rightarrow\infty$, but as N $\rightarrow\infty$ so does the number of μ_i to be estimated; this is called the incidental-parameters problem.

(again estimated over all observations for that firm) from each value: all lagged values of the dependent variable will contain median(ε_i).

Serial correlation in the error term was tested for using Woolridge's (2002) test for serial correlation in panel data; the results are shown in table 5.12.

Table 5.12 – Results of Wooldridge's (2002) Test for Serial Correlation in Panel Data

Dependent Variable	RBVE	ROA
Woolridge Test	F(1, 663) = 9.41	F(1, 666) = 13.3
p>F	0.002	0.000

1. Table 5.12 reports the results of Woolridge's (2002) test for serial correlation in panel data.
2. The test was conducted using the Stata xtserial function which, by default, adjusts for clustering and is robust to heteroskedacity.
3. The null hypothesis of the test is that there is no first-order correlation.

The null hypothesis of no first-order serial correlation can clearly be rejected in the case of both RBVE and ROA as the dependent variable, so L^2.RBVE (L^2.ROA) cannot be used as an instrument for L.RBVE (L.ROA) but further lags of RBVE (ROA) may be valid instruments. In order to test if valid instruments for L.RBVE (L.ROA) are available, equation 5.9 was estimated with (first-differenced) RBVE (ROA) in 2012 as the dependent variable; and (first-differenced) values of RBVE (ROA) in 2009 and 2008 as instruments for (first-differenced) RBVE (ROA) in 2011. Estimating the model is complicated by the skewed distributions of data, with some extreme outliers (see Figs. 5.1-5.3). Because of the requirement to use instrumental variables, it is not possible to use more advanced robust techniques (eg median regression, M-estimator, or MM-estimator regression) so Winsorization is used; specifically, the observations below the 1^{st} (2.5^{th}) percentile and above the 99^{th} (97.5^{th}) percentile for RBVE (ROA) will be removed. The results of the specification tests are shown in table 5.13 and 5.14.

Table 5.13 – Results of Specification Tests for IV Regressions (Dependent Variable First-Differenced RBVE in 2012)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
K-P Statistic	1.04	1.58	1.59
Hansen-J	0.614	0.741	0.646
Chi-square p-val	0.43	0.39	0.42
C-Test	1.52	0.291	0.392
Chi-square p-val	0.22	0.59	0.53

1. Table 5.13 reports the results of specification tests for the estimation of equation 5.9 using instrumental variables regression (GMM).
2. The sample period for (first-differenced) RBVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2007-11.
3. IV regression was estimated using the user-written Stata function ivreg2 (Baum et al (2007)).
4. The Kleibergen-Paap rk statistic is the appropriate test for weak instruments where heteroskedastic errors are suspected; critical values for size are as follows (Stock and Yogo (2005)):
   0.1 19.93
   0.15 11.59
   0.2 8.75
   0.25 7.25
5. The Hansen J-test is used because of possible heteroskedacity; the null hypothesis is that all instruments are valid.
6. The null hypothesis of the C-test (Eichenbaum (1988)) is that the instrumented variable is actually exogenous.

Table 5.14 – Results of Specification Tests for IV Regressions (Dependent Variable First-Differenced ROA in 2012)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
K-P Statistic	2.53	0.068	0.064
Hansen-J	0.000	0.809	0.129
Chi-square p-val	0.99	0.37	0.72
C-Test	1.32	0.009	0.405
Chi-square p-val	0.25	0.93	0.52

1. Table 5.14 reports the results of specification tests for the estimation of equation 5.9 using instrumental variables regression (GMM).
2. The sample period for (first-differenced) ROA is described above; the sample period for all other (first-differenced) explanatory and control variables is 2007-11.
3. See also notes to table 5.13

The results of these specification tests strongly suggest that any results from these regressions will not be reliable. In all cases the instruments are very weak; and the null hypothesis of the C-test (instrumented variable is exogenous) cannot be rejected, even though it is known that the lagged dependent variable is correlated with the error term in this model. Equation 5.9 was re-estimated with (first-differenced) RBVE (ROA) in 2011 as the dependent variable; and (first-differenced) values of RBVE (ROA) in 2008 and 2007 as instruments for (first-differenced) RBVE (ROA) in 2010. The results are shown in table 5.15 and 5.16: once again there are very significant concerns about weak instruments.

Table 5.15 – Results of Specification Tests for IV Regressions (Dependent Variable First-Differenced ROA in 2011)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
K-P Statistic	0.792	1.16	1.13
Hansen-J	1.17	0.981	1.02
Chi-square p-val	0.28	0.32	0.31
C-Test	0.006	0.016	0.000
Chi-square p-val	0.94	0.90	0.99

1. Table 5.15 reports the results of specification tests for the estimation of equation 5.9 using instrumental variables regression (GMM).
2. The sample period for (first-differenced) RBVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2006-10.
3. See also notes to table 5.13.

Table 5.16 – Results of Specification Tests for IV Regressions (Dependent Variable First-Differenced ROA in 2011)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
K-P Statistic	2.10	2.61	2.79
Hansen-J	0.151	0.221	0.251
Chi-square p-val	0.70	0.64	0.62
C-Test	0.756	0.019	0.057
Chi-square p-val	0.38	0.89	0.81

1. Table 5.16 reports the results of specification tests for the estimation of equation 5.9 using instrumental variables regression (GMM).
2. The sample period for (first-differenced) ROA is described above; the sample period for all other (first-differenced) explanatory and control variables is 2006-10.
3. See also notes to table 5.13.

As it is not possible to pursue any further analysis with RBVE or ROA as the dependent variable, a dynamic model with an alternative dependent variable, RMVE, is estimated in the next sub-section.

5.5.2.3 Regression Results with a Dynamic Model (Dependent Variable RMVE)

It may make the estimation of equation 5.9 more tractable if a hybrid accounting/market profitability measure, RMVE, is used as the dependent variable: the market value of equity will evolve in response to shocks and may therefore reduce serial correlation. However, the use of such a hybrid measure introduces complications in the interpretation of the results of the regression, as (unlike RBVE, ROA and returns to shareholders) it cannot be attributed to a single stakeholder group. This point will be explored in more detail when the results are discussed in section 5.6.1.4.

The same empirical approach was followed as in the previous section, beginning with Wooldridge's (2002) test for serial correlation in panel data; the results are shown in table 5.17.

Table 5.17 – Results of Wooldridge's (2002) Test for Serial Correlation in Panel Data

Dependent Variable	RMVE
Woolridge Test	F(1, 666) = 0.594
p>F	0.44

1. Table 5.17 reports the results of Woolridge's (2002) test for serial correlation in panel data.
2. The test was conducted using the Stata xtserial function which, by default, adjusts for clustering and is robust to heteroskedacity.
3. The null hypothesis of the test is that there is no first-order correlation.

The null hypothesis of no first-order correlation cannot be rejected, so equation 5.9 was estimated with (first-differenced) RMVE in 2012 as the dependent variable; and (first-differenced) values of RMVE in 2010 and 2009 as instruments for (first-differenced) RMVE in 2011. GMM is used throughout, as this is more efficient in the presence of heteroscedasticity[60]. As in section 5.5.2.2, the equation was estimated with three different samples; the results are shown in table 5.18.

[60] Results using 2SLS were very similar and are reproduced at Appendix 1.

Table 5.18 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2012)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Δ(L.RMVE)	14.637	0.001	-0.182
	(0.54)	(0.00)	(-0.64)
Δ(Size)	-2.300	-0.085*	-0.074*
	(-0.62)	(-2.17)	(-2.10)
Δ(Power)	-266.819	-7.304+	-6.010+
	(-0.48)	(-1.71)	(-1.65)
Δ(SD of ROA)	29.384	2.090*	1.748*
	(0.57)	(2.39)	(2.08)
Δ(Beta)	26.391	0.449	0.210
	(0.78)	(1.22)	(0.79)
Δ(SD of Cashflow)	2.484	0.167	0.100
	(0.56)	(1.03)	(0.71)
High RMVE * Δ(SD of ROA)	-28.052	-1.590+	-1.255
	(-0.58)	(-1.82)	(-1.52)
Constant	0.247	0.035**	0.031**
	(0.24)	(2.68)	(2.69)
N	665	656	637
Wald Test of Joint Significance	F(7,657)=0.12	F(7,648)=3.51	F(7,629)=5.68
p>F	0.997	0.001	0.0000
K-P Statistic	0.189	9.91	3.26
Hansen-J	0.072	0.010	0.055
Chi-square p-val	0.79	0.92	0.82
C-Test	0.998	9.51	8.27
Chi-square p-val	0.32	0.002	0.004

1. Table 5.18 reports the results of the estimation of equation 5.9 using instrumental variables regression (GMM).
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample period for (first-differenced) RMVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2007-11.
4. IV regression was estimated using the user-written Stata function ivreg2 (Baum et al (2007)).
5. R^2 values are omitted as they have no meaningful interpretation in IV regression.
6. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places)
7. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.
8. The Kleibergen-Paap rk statistic is the appropriate test for weak instruments where Heteroscedastic errors are suspected; critical values for size are as follows (Stock and Yogo (2005)):

   0.1 19.93
   0.15 11.59
   0.2 8.75
   0.25 7.25
9. The Hansen J-test is used because of possible heteroscedasticity; the null hypothesis is that all instruments are valid.
10. The null hypothesis of the C-test (Eichenbaum (1988)) is that the instrumented variable is actually exogenous.

Equation 5.9 was then estimated with (first-differenced) RMVE in 2011 as the dependent variable; and (first-differenced) values of RMVE in 2009 and 2008 as instruments for (first-differenced) RMVE in 2010. As before, three different samples were used; the results are shown in table 5.19.

Table 5.19 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2011)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Δ(L.RMVE)	-0.246	0.030	0.035
	(-1.56)	(0.50)	(0.71)
Δ(Size)	0.017	0.010	0.015
	(0.48)	(0.32)	(0.52)
Δ(Power)	-3.040	0.582	0.246
	(-0.94)	(0.46)	(0.21)
Δ(SD of ROA)	1.233*	2.139***	2.078***
	(2.31)	(5.75)	(8.78)
Δ(Beta)	0.425	-0.184	-0.086
	(0.92)	(-1.24)	(-0.80)
Δ(SD of Cashflow)	-0.815+	-0.126	-0.067
	(-1.66)	(-0.40)	(-0.24)
High RMVE * Δ(SD of ROA)	-1.363*	-1.934***	-1.910***
	(-2.19)	(-3.74)	(-3.98)
Constant	-0.043+	0.005	0.007
	(-1.75)	(0.42)	(0.82)
N	601	591	575
Wald Test of Joint Significance	F(7,593)=4.62	F(7,583)=5.83	F(7,567)=15.7
p>F	0.0000	0.0000	0.0000
K-P Statistic	15.9	13.5	12.4
Hansen-J	1.03	1.72	0.332
Chi-square p-val	0.31	0.19	0.56
C-Test	0.580	8.28	10.3
Chi-square p-val	0.45	0.004	0.001

1. Table 5.19 reports the results of the estimation of equation 5.9 using instrumental variables regression (GMM).
2. The sample period for (first-differenced) RMVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2006-10.
3. See also notes to table 5.18.

Equation 5.9 was also estimated with (first-differenced) RMVE in 2010 as the dependent variable; and (first-differenced) values of RMVE in 2008 and 2007 as instruments for (first-differenced) RMVE in 2009; the results are shown in table 5.20.

Table 5.20 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2010)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Δ(L.RMVE)	0.030	0.030	0.016
	(1.42)	(1.42)	(0.77)
Δ(Size)	-0.305	-0.020	-0.008
	(-1.47)	(-0.29)	(-0.12)
Δ(Power)	7.009	0.340	-0.059
	(1.39)	(0.18)	(-0.03)
Δ(SD of ROA)	0.746*	0.633*	0.604*
	(2.35)	(2.56)	(2.56)
Δ(Beta)	0.063	0.101	0.127
	(0.31)	(0.76)	(0.94)
Δ(SD of Cashflow)	0.633	0.292	0.365
	(1.20)	(1.09)	(1.37)
High RMVE * Δ(SD of ROA)	0.464	0.054	0.366
	(0.38)	(0.05)	(0.37)
Constant	-0.011	0.001	0.009
	(-0.43)	(0.08)	(0.80)
N	601	592	576
Wald Test of Joint Significance	F(7,593)=2.08	F(7,584)=1.99	F(7,568)=1.97
p>F	0.04	0.05	0.06
K-P Statistic	1190	1150	888
Hansen-J	1.39	1.25	1.21
Chi-square p-val	0.24	0.26	0.27
C-Test	12.8	11.8	10.6
Chi-square p-val	0.0004	0.001	0.001

1. Table 5.20 reports the results of the estimation of equation 5.9 using instrumental variables regression (GMM).
2. The sample period for (first-differenced) ROE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2005-09.
3. See also notes to table 5.18.

Finally, equation 5.9 was estimated with (first-differenced) RMVE in 2009 as the dependent variable; and (first-differenced) values of RMVE in 2007 and 2006 as instruments for (first-differenced) RMVE in 2008; the results are shown in table 5.21.

Table 5.21 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2009)

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Δ(L.RMVE)	0.361	0.307	0.356+
	(0.47)	(0.40)	(1.66)
Δ(Size)	-0.474	-0.506	-0.505
	(-0.81)	(-0.88)	(-1.39)
Δ(Power)	-2.650	-1.957	-1.479
	(-0.20)	(-0.16)	(-0.17)
Δ(SD of ROA)	9.005	8.893	9.545***
	(1.39)	(1.31)	(3.57)
Δ(Beta)	0.969	0.871	0.880*
	(1.21)	(1.15)	(2.09)
Δ(SD of Cashflow)	-0.748	-0.650	-0.533
	(-0.53)	(-0.48)	(-0.61)
High RMVE * Δ(SD of ROA)	-1.018	-2.016	-2.652
	(-0.18)	(-0.33)	(-0.66)
Constant	-0.071	-0.054	-0.055
	(-0.45)	(-0.37)	(-0.52)
N	555	545	526
Wald Test of Joint Significance	F(7,547)=2.02	F(7,537)=2.03	F(7,518)=5.22
p>F	0.05	0.05	0.0000
K-P Statistic	1.58	1.99	16.3
Hansen-J	0.847	0.961	1.81
Chi-square p-val	0.36	0.33	0.18
C-Test	2.98	1.17	1.65
Chi-square p-val	0.08	0.28	0.20

1. Table 5.21 reports the results of the estimation of equation 5.9 using instrumental variables regression (GMM).
2. The sample period for (first-differenced) RMVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2004-08.
3. See also notes to table 5.18.

With the exception of 2009, there is at least one regression in each time period where: the parameter estimates are jointly significant; the instruments are not unduly weak; the instruments are valid; and the null hypothesis of the C-test (that the instrumented variable, lagged RMVE, is actually exogenous) can be rejected, as expected. In each of these cases, the parameter estimates for lagged RMVE are insignificant; indeed the parameter estimates for lagged RMVE are insignificant in all of the regressions. It is therefore argued that it is possible to conduct regressions with RMVE as the dependent variable using a static model. This might appear to be at variance with the persistence of profits literature but, to reiterate, RMVE is a hybrid measure of profitability: arguments based on market efficiency would suggest that the market value of equity would evolve to remove any persistence.

5.5.2.4 Regression Results with a Static Model (Dependent Variables RMVE and Returns to Shareholders)

Given that the lagged RMVE term is consistently insignificant in the dynamic models above, and it has already been argued that there is no need for a lagged returns to shareholders term; it is possible to estimate instead the simpler, static model shown below:

$$\text{Performance}_i = \mathbf{x}^T_i\boldsymbol{\beta} + \mu_i + \varepsilon_i \qquad (5.11)$$

Where performance is measured in two different ways (RMVE and returns to shareholders). Equation 5.9 can be written in first-differenced form as follows:

$$\Delta\text{Performance}_i = \Delta\mathbf{x}^T_i\boldsymbol{\beta} + \Delta\varepsilon_i \qquad (5.12)$$

As instrumental variables are no longer required, it is possible to use more sophisticated methods of dealing with outliers: equation 5.12 was estimated in each of the four time periods using OLS, median regression; regression using M-estimators; and regression using MM-estimators[61]. Regression results with (first-differenced) RMVE as the dependent variable are shown in tables 5.22 to 5.25; and results with (first-differenced) returns to shareholders as the dependent variable are shown in tables 5.26 to 5.29.

[61] All of these, with the exception of OLS, are robust to vertical outliers and good leverage points but, in addition, the latter two techniques are robust to bad leverage points (see Chapter Three for a more detailed discussion).

Table 5.22 – Results of OLS Regression (Dependent Variables First-Differenced RMVE in 2012, 2011, 2010 and 2009)

	Δ(RMVE in 2012)	**Δ(RMVE in 2011)**	**Δ(RMVE in 2010)**	**Δ(RMVE in 2009)**
Δ(Size)	-0.342	0.058	-0.231*	-0.159
	(-0.68)	(0.53)	(-2.09)	(-0.42)
Δ(Power)	-5.490	-1.895	5.191	-3.359
	(-0.06)	(-0.13)	(0.47)	(-0.14)
Δ(SD of ROA)	2.782+	1.202***	0.682***	7.574***
	(1.90)	(3.81)	(3.51)	(16.27)
Δ(Beta)	12.224***	0.477	0.124	0.699***
	(6.30)	(1.63)	(1.18)	(4.28)
Δ(SD of Cashflow)	1.296	-0.623	0.641	-0.538
	(0.54)	(-0.89)	(1.49)	(-0.63)
High RMVE * Δ(SD of ROA)	-3.323	-1.634	0.739	-1.089
	(-0.77)	(-0.86)	(0.71)	(-0.85)
Constant	-0.188	-0.062+	-0.004	-0.083
	(-1.25)	(-1.87)	(-0.17)	(-1.29)
R^2	0.05	0.02	0.04	0.40
N	885	776	668	555
Wald Test of Joint Significance	F(6,878)=7.69	F(6,769)=2.83	F(6,661)=4.15	F(6,548)=60.1
p>F	0.000	0.010	0.000	0.0000

1. Table 5.22 reports the results of the estimation of equation 5.12 using OLS regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) RMVE are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
5. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 5.23 – Results of Median Regression (Dependent Variables First-Differenced RMVE in 2012, 2011, 2010 and 2009)

	Δ(RMVE in 2012)	**Δ(RMVE in 2011)**	**Δ(RMVE in 2010)**	**Δ(RMVE in 2009)**
Δ(Size)	-0.016	-0.005	-0.009	-0.188
	(-0.93)	(-0.90)	(-0.29)	(-1.47)
Δ(Power)	-3.424	0.269	-0.701	2.819
	(-1.08)	(0.22)	(-0.28)	(0.87)
Δ(SD of ROA)	0.158	0.161	0.235	5.552***
	(0.38)	(0.27)	(0.54)	(6.79)
Δ(Beta)	-0.086+	0.084*	0.037	-0.052
	(-1.66)	(2.52)	(1.12)	(-1.03)
Δ(SD of Cashflow)	0.014	-0.143	0.050	0.003
	(0.23)	(-1.07)	(0.44)	(0.01)
High RMVE * Δ(SD of ROA)	0.093	-0.014	0.246	-1.970*
	(0.23)	(-0.03)	(0.50)	(-2.16)
Constant	-0.003	0.007*	-0.000	-0.003
	(-1.28)	(2.17)	(-0.04)	(-0.21)
Pseudo-R^2	0.002	0.005	0.01	0.21
N	885	776	668	555
Wald Test of Joint Significance	F(6,878)=1.28	F(6,769)=1.55	F(6,661)=0.91	F(6,548)=30.9
p>F	0.27	0.16	0.49	0.0000

1. Table 5.23 reports the results of the estimation of equation 5.12 using median regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) RMVE are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. Median regression was performed using the Stata qreg function.
5. t-statistics are shown in parentheses (2 decimal places) based on boot-strapped standard errors (100 replications).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 5.24 – Results of M-Estimator Regression (Dependent Variables First-Differenced RMVE in 2012, 2011, 2010 and 2009)

	Δ(RMVE in 2012)	**Δ(RMVE in 2011)**	**Δ(RMVE in 2010)**	**Δ(RMVE in 2009)**
Δ(Size)	-0.016**	-0.006	0.020	-0.238**
	(-2.58)	(-0.84)	(0.92)	(-2.77)
Δ(Power)	-1.097	0.677	-0.915	2.461
	(-1.06)	(0.74)	(-0.42)	(0.45)
Δ(SD of ROA)	-0.121***	0.068*	0.438***	4.755***
	(-6.81)	(2.36)	(11.61)	(41.71)
Δ(Beta)	-0.067**	0.047*	0.029	-0.126***
	(-2.79)	(2.57)	(1.43)	(-3.33)
Δ(SD of Cashflow)	-0.056+	-0.090*	0.091	-0.007
	(-1.93)	(-2.07)	(1.09)	(-0.04)
High RMVE * Δ(SD of ROA)	0.314***	0.118	0.387+	-1.877***
	(5.98)	(0.99)	(1.91)	(-6.37)
Constant	-0.011***	0.009***	0.001	0.022
	(-5.85)	(4.48)	(0.18)	(1.47)
R^2	0.08	0.02	0.19	0.78
N	884	775	668	554
Wald Test of Joint Significance	F(6,877)=13.3	F(6,768)=3.07	F(6,661)=26.0	F(6,547)=327
p>F	0.0000	0.006	0.0000	0.0000

1. Table 5.24 reports the results of the estimation of equation 5.12 using M-estimator regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) RMVE are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. M-estimator regression was performed using the Stata rreg function.
5. t-statistics are shown in parentheses (2 decimal places) based on pseudo-values.
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 5.25 – Results of MM-Estimator Regression (Dependent Variables First-Differenced RMVE in 2012, 2011, 2010 and 2009)

	Δ(RMVE in 2012)	**Δ(RMVE in 2011)**	**Δ(RMVE in 2010)**	**Δ(RMVE in 2009)**
Δ(Size)	-0.009	-0.006	0.007	-0.174
	(-0.79)	(-1.36)	(0.13)	(-0.82)
Δ(Power)	-5.812***	0.533	-0.710	2.153
	(-7.67)	(1.45)	(-0.58)	(0.76)
Δ(SD of ROA)	-0.194***	0.121**	0.055	4.432***
	(-5.50)	(3.00)	(1.58)	(7.64)
Δ(Beta)	-0.092*	0.088**	0.047	-0.118*
	(-2.42)	(3.05)	(1.43)	(-2.56)
Δ(SD of Cashflow)	-0.060	-0.094	0.053*	-0.009
	(-0.82)	(-1.55)	(2.13)	(-0.09)
High RMVE * Δ(SD of ROA)	0.254***	0.064	0.467	-1.321+
	(3.50)	(0.68)	(1.55)	(-1.68)
Constant	-0.010***	0.010***	0.000	0.007
	(-6.50)	(5.29)	(0.01)	(0.42)
N	885	776	668	555
Wald Test of Joint Significance	F(6,878)=22.46	F(6,769)=6.57	F(6,661)=3.27	F(6,548)=25.41
p>F	0.0000	0.0000	0.004	0.0000

1. Table 5.25 reports the results of the estimation of equation 5.12 using MM-estimator regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) RMVE are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. MM-estimator regression was performed using the user-defined mmregress function (Verardi and Croux (2009)).
5. t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 5.26 – Results of OLS Regression (Dependent Variables First-Differenced Returns to Shareholders in 2012, 2011, 2010 and 2009)

	Δ(RTS in 2012)	**Δ(RTS in 2011)**	**Δ(RTS in 2010)**	**Δ(RTS in 2009)**
Δ(Size)	-0.325	-0.138	-0.132	0.325
	(-1.62)	(-1.40)	(-0.47)	(1.31)
Δ(Power)	-16.311**	-1.643	4.359	-7.744
	(-3.16)	(-0.12)	(0.52)	(-0.82)
Δ(SD of ROA)	0.381+	0.029	1.526	0.526*
	(1.78)	(0.08)	(1.25)	(2.36)
Δ(Beta)	1.436**	-4.368+	-2.014***	0.869***
	(2.64)	(-1.73)	(-4.60)	(4.68)
Δ(SD of Cashflow)	-1.097	1.002	0.687	-0.469
	(-1.63)	(0.97)	(1.49)	(-0.89)
Δ(Ln[Book to Market])	0.980***	1.484***	0.054	0.270*
	(5.79)	(4.06)	(1.20)	(2.19)
Constant	0.179***	-0.423***	-0.081	0.660***
	(7.22)	(-10.38)	(-1.26)	(13.66)
R^2	0.15	0.21	0.09	0.13
N	880	771	665	599
Wald Test of Joint Significance	F(6,873)=9.87	F(6,764)=3.94	F(6,658)=3.84	F(6,592)=6.26
p>F	0.0000	0.001	0.001	0.0000
Δ(FTSE Returns)[62]	**12.5%**	**-18.1%**	**-13.6%**	**58.7%**

1. Table 5.26 reports the results of the estimation of equation 5.12 using OLS regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) returns to shareholders are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
5. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

[62] Based on the FTSE All-Share Index ("FTAS").

Table 5.27 – Results of Median Regression (Dependent Variables First-Differenced Returns to Shareholders in 2012, 2011, 2010 and 2009)

	Δ(RTS in 2012)	**Δ(RTS in 2011)**	**Δ(RTS in 2010)**	**Δ(RTS in 2009)**
Δ(Size)	-0.084	-0.130	-0.067	0.481+
	(-1.60)	(-1.51)	(-0.37)	(1.77)
Δ(Power)	-20.370*	-3.183	4.151	-18.733
	(-2.23)	(-0.22)	(0.34)	(-1.56)
Δ(SD of ROA)	0.191	-0.000	0.184	0.706**
	(0.88)	(-0.00)	(0.41)	(2.94)
Δ(Beta)	1.807***	-1.309***	-1.294***	0.775***
	(5.56)	(-4.52)	(-8.56)	(6.10)
Δ(SD of Cashflow)	-0.333	0.411	0.653	-0.677
	(-0.84)	(1.23)	(1.06)	(-0.86)
Δ(Ln[Book to Market])	0.827***	0.821***	0.023	0.266+
	(5.97)	(3.44)	(0.87)	(1.88)
Constant	0.187***	-0.332***	-0.107***	0.536***
	(12.68)	(-12.75)	(-4.87)	(12.83)
Pseudo-R^2	0.08	0.06	0.07	0.09
N	880	771	665	599
Wald Test of Joint Significance	F(6,873)=14.7	F(6,764)=7.06	F(6,658)=12.7	F(6,592)=12.5
p>F	0.0000	0.0000	0.0000	0.0000
Δ(FTSE Returns)	**12.5%**	**-18.1%**	**-13.6%**	**58.7%**

1. Table 5.27 reports the results of the estimation of equation 5.12 using median regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) returns to shareholders are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. Median regression was performed using the Stata qreg function.
5. t-statistics are shown in parentheses (2 decimal places) based on boot-strapped standard errors (100 replications).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 5.28 - Results of M-Estimator Regression (Dependent Variables First-Differenced Returns to Shareholders in 2012, 2011, 2010 and 2009)

	Δ(RTS in 2012)	Δ(RTS in 2011)	Δ(RTS in 2010)	Δ(RTS in 2009)
Δ(Size)	-0.080	-0.123*	-0.110	0.387*
	(-1.61)	(-2.39)	(-1.05)	(2.18)
Δ(Power)	-15.663*	1.773	4.081	-10.900
	(-1.98)	(0.26)	(0.39)	(-0.93)
Δ(SD of ROA)	0.186	0.100	0.278	0.743***
	(1.44)	(0.69)	(1.53)	(3.60)
Δ(Beta)	1.535***	-1.224***	-1.242***	0.726***
	(8.48)	(-8.34)	(-12.45)	(9.54)
Δ(SD of Cashflow)	-0.367	0.416	0.809*	-0.889*
	(-1.62)	(1.27)	(1.98)	(-2.26)
Δ(Ln[Book to Market])	0.807***	0.791***	0.003	0.255***
	(10.19)	(7.32)	(0.09)	(6.03)
Constant	0.177***	-0.334***	-0.130***	0.544***
	(11.24)	(-20.58)	(-5.83)	(18.04)
R^2	0.18	0.15	0.20	0.24
N	879	770	665	599
Wald Test of Joint Significance	32.1	22.4	27.0	30.5
p>F	0.0000	0.0000	0.0000	0.0000
Δ(FTSE Returns)	**12.5%**	**-18.1%**	**-13.6%**	**58.7%**

1. Table 5.28 reports the results of the estimation of equation 5.12 using M-estimator regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) returns to shareholders are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. M-estimator regression was performed using the Stata rreg function.
5. t-statistics are shown in parentheses (2 decimal places) based on pseudo-values.
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 5.29 - Results of MM-Estimator Regression (Dependent Variables First-Differenced Returns to Shareholders in 2012, 2011, 2010 and 2009)

	Δ(RTS in 2012)	**Δ(RTS in 2011)**	**Δ(RTS in 2010)**	**Δ(RTS in 2009)**
Δ(Size)	-0.076*	-0.100	-0.091	0.249
	(-2.01)	(-1.40)	(-0.66)	(1.25)
Δ(Power)	-15.043**	9.206	2.502	-12.327*
	(-2.90)	(0.85)	(0.53)	(-2.44)
Δ(SD of ROA)	0.180*	0.058	0.075	1.021***
	(2.11)	(0.79)	(0.51)	(6.23)
Δ(Beta)	1.563***	-1.099***	-1.186***	0.659***
	(3.68)	(-5.16)	(-8.67)	(5.46)
Δ(SD of Cashflow)	-0.405+	0.410*	0.798***	-1.352***
	(-1.68)	(1.97)	(4.08)	(-3.84)
Δ(Ln[Book to Market])	0.776***	0.814***	-0.001	0.428***
	(7.59)	(3.69)	(-0.06)	(3.75)
Constant	0.181***	-0.320***	-0.110***	0.498***
	(10.78)	(-14.10)	(-5.50)	(16.13)
N	880	771	665	599
Wald Test of Joint Significance	F(6,873)=13.9	F(6,764)=5.77	F(6,658)=17.0	F(6,592)=30.7
p>F	0.0000	0.0000	0.0000	0.0000
Δ(FTSE Returns)	**12.5%**	**-18.1%**	**-13.6%**	**58.7%**

1. Table 5.29 reports the results of the estimation of equation 5.12 using MM-estimator regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for (first-differenced) returns to shareholders are 2012, 2011, 2010 and 2009; and the corresponding sample periods for (first-differenced) explanatory and control variables are 2007-11, 2006-10, 2005-09 and 2004-08.
4. MM-estimator regression was performed using the user-defined mmregress function (Verardi and Croux (2009)).
5. t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

5.5.2.5 Summary

The possibility of persistence of profits led to the use of a dynamic mode for regressions with accounting performance measures as the dependent variable, which required the use of instrumental variable techniques; however it turned out to be impossible to find instruments for lagged RBVE and ROA in order to estimate the model. RMVE was therefore used as an alternative dependent variable, noting that the use of such a hybrid measure of profitability introduces complications in the interpretation of any results from these regressions. Not only was it possible to instrument lagged RMVE, but the regression results indicated that the lagged RMVE term could be dropped and a simpler static model used (the results of which are discussed in the next paragraph). The results from the IV regression need to be treated with caution as there is a finite-sample bias and the only way to reduce the influence of outliers is by Winsorization; but the parameter estimates for the standard deviation of ROA were universally positive, and significant for at least one sample in each time period.

Results from the different static models are broadly consistent, but: the median regression lacks power (as would be expected from its lower theoretical efficiency – see Chapter Three); and there are a number of differences in the signs and significance of parameter estimates between the OLS regression and the robust (M-estimator and MM-estimator) regressions, suggesting that outliers can unduly influence the results. The following discussion will therefore focus on the results of the M-estimator and MM-estimator regressions using the static model (tables 5.24, 5.25, 5.28 and 5.29). The first observation is that the model with RMVE as the dependent variable appears to work very well in the first time-period (first-differenced RMVE in 2009), with high values of (pseudo) R^2 and highly-significant F-values from the Wald test, but the fit is much poorer in subsequent time periods;

indeed the F-values from the median regression are insignificant in all other time periods. This finding is consistent with the discussions in previous chapters about a step-change in environmental uncertainty following the onset of the financial crisis in 2007/08: the model appears to have good explanatory power in stable conditions but loses much of this when the system is subjected to major shocks. The model with returns to shareholders as the dependent variable works somewhat better in the first two time-periods; but there is no sudden breakdown as noted above.

Looking first at the results from the model with RMVE as the dependent variable (tables 5.24 and 5.25), it appears from both the M-estimator and MM-estimator regressions that the parameter estimates for the risk variables change over time. In the first period the parameter estimates for standard deviation of ROA are positive and highly significant; in the middle two periods they are still positive but reduced in significance; and in the final period they are negative and highly significant. Meanwhile the parameter estimates for the interaction term of standard deviation of ROA with prior performance are negative and at least moderately significant in the first period; insignificant in the middle two periods and positive and highly significant in the final period. The parameter estimates for standard deviation of cashflow vary between positive and negative, and are almost all non-significant. No specific predictions were made about the relationship between beta and subsequent RMVE but the results from both the M-estimator and MM-estimator regressions show the same pattern: significant negative parameter estimates in the first and last time periods, and a significant positive parameter estimate in 2011. As stated previously, considerable care must be taken in the interpretation of these results because of the hybrid nature of the dependent variable and these will be discussed in detail in section 5.6.1.4.

Turning to look at the results with returns to shareholders as the dependent variable both the M-estimator and MM-estimators regression techniques produce the same pattern of results for the parameter estimates of beta (see tables 5.28 and 5.29), with significant positive values in the first and last time period and significant negative values in the middle two periods. No predictions were made about the relationship between standard deviation of ROA and subsequent returns to shareholders, but all four regression techniques give a positive and significant parameter estimate for standard deviation of ROA in the first period. No predictions were made about the relationship between standard deviation of cashflow and subsequent returns to shareholders either, but the M-estimator and MM-estimator regressions both give a negative and at least moderately significant parameter estimate in the first time period and a significant positive parameter estimate in the second time period. The parameter estimates for the natural log of the book-to-market ratio were positive and significant in every time period except for 2010.

5.6 Discussion

This section begins by discussing how the findings of both univariate tests and regression analyses contribute to the understanding of the relationship between risk and performance; section 5.6.2 then discusses some of the practical implications of the findings; and section 5.6.3 acknowledges the limitations of the study, and suggests some useful areas for future research.

5.6.1 Developing the Theory of Risk and Return

The combination of conducting analyses over multiple time periods; using a novel set of risk measures (including a cashflow risk construct); using multiple performance measures (including RMVE); removing unobservable firm fixed effects; and applying a selection of robust correlation and regression techniques has revealed a much more complex relationship between risks and performance, contingent on the prevailing economic conditions, than has emerged from previous studies. Section 5.6.1.1 describes the changes in environmental conditions over the course of the study, which form the context for the discussion of the evolution of risk-return relationships which follows. The relationship between pure accounting measures of risk and return, derived from the univariate tests, is discussed in section 5.6.1.2; the relationships between the different risk components and returns to shareholders are discussed in section 5.6.1.3; and the relationships between the different risk components and a hybrid performance measure, RMVE, are discussed in section 5.6.1.4. The conclusions are summarised in section 5.6.1.5.

5.6.1.1 Environmental Uncertainty and Growth

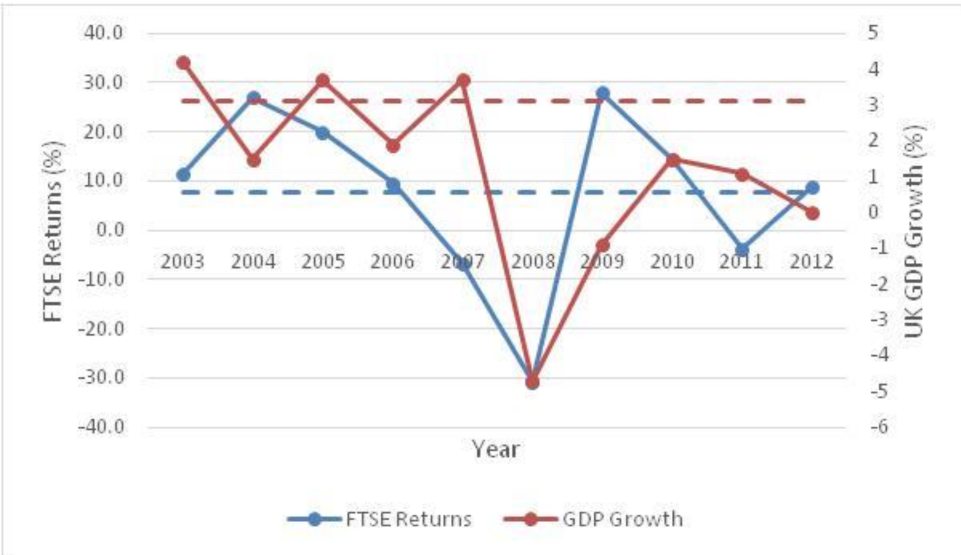
Table 4.15 in Chapter Four showed how various measures of environmental uncertainty changed over the period of the study; two of these measures are reproduced in table 5.30 (columns 2 and 3), together with two measures of growth: UK GDP growth and returns on the FTSE index.

Table 5.30 – Measures of Uncertainty and Growth

Period	SD of Quarterly GDP Growth	SD of FTSE[19] Monthly Returns	GDP Growth	FTSE Returns[19]
2008-12	0.84%	4.9%	-3.0%	6.4%
2007-11	0.95%	5.0%	0.6%	-8.7%
2006-10	0.96%	4.8%	1.4%	4.0%
2005-09	1.01%	4.5%	3.7%	9.0%
2004-08	0.93%	3.8%	6.2%	-4.9%
2003-07	0.42%	2.8%	16.1%	74.2%
1983-2002[63]	**0.60%**	**4.8%**	**16.7%**	**45.8%**

In the discussion below, it is argued that the observed patterns in risk-return relationships are primarily due to changes in the growth environment (rather than changes in environmental uncertainty): annual figures for the two growth measures are plotted in fig. 5.6.

Fig. 5.6 – FTSE Returns and GDP Growth 2003-12 (dashed lines show average over period 1983-2002)



It can be seen from fig. 5.6 that the first four years of the study period are characterised by average GDP growth and above average FTSE returns. FTSE returns were quicker to react to the financial crisis, turning negative in 2007 and 2008; and

[63] Growth rates and returns are adjusted to five-year equivalents.

then oscillating about the long-term average for the final four periods. GDP growth went negative in 2008 and 2009, before returning to low but fairly stable rates of growth in the final three periods. It is also important to note that this period of low growth was accompanied by unusually low interest rates in the UK (and elsewhere).

5.6.1.2 The Relationship Between Accounting Measures of Risk and Performance

Whilst relatively crude, the univariate tests in section 5.5.1 are important because they provide the only opportunity to directly examine the relationship between pure accounting measures of risk and return; which have previously been argued to be the salient measures for the managers of firms (Miller and Bromiley (1990)). These tests are also important because they directly address Bowman's (1980) "paradox". The results were both simple and striking: the significant negative correlations observed between the standard deviation of ROA and subsequent ROA disappear in all time periods once firm fixed effects are removed (by first-differencing). Indeed, significant positive correlations between the standard deviation of ROA and subsequent ROA were observed in the first two time periods. Following Bowman's (1980) original argument about well-managed firms being able to combine high profitability and low variability in profits, and Andersen et al's (2007) mathematical model of a "strategic responsiveness" capability; it would appear that the removal of such unobservable firm fixed effects is necessary to observe the underlying positive association between standard deviation of ROA and subsequent ROA (in support of hypothesis 2). It is argued that this positive relationship reflects the cumulative effect of the managers of firms requiring higher expected returns to invest in riskier projects.

5.6.1.3 Risk and Returns to Shareholders

In all of the regressions the regressions with (first-differenced) returns to shareholders as the dependent variable, the parameter estimates for market risk (beta) are positive and highly significant in both the first and last time period (when market returns are positive); and negative and highly significant in the middle two time periods (when market returns are negative). These observations are entirely consistent with the empirical results of Pettengill et al (1995), Morelli (2011) and Cotter et al (2015). Thus, even with the inclusion of a number of idiosyncratic risk measures; Pettengill et al's (1995) central argument, that the relationship between market risk and return is contingent on the performance of the market (hypotheses 1a and 1b), is supported. It is interesting to note that a similar conditional relationship between beta and returns is observed even when raw (not first-differenced) variables are used (see Appendix 2, table 5.38); although the parameter estimates for beta are insignificant in both 2010 and 2012 in these regressions.

Significant parameter estimates were also observed in these regressions for: the standard deviation of ROA (2009 and 2012); the standard deviation of cashflow (2009 and 2010); and book-to-market value of equity (2009, 2011 and 2012). Relationships between such idiosyncratic measures and returns to shareholders have been observed in many previous studies but there are no definitive explanations. The positive relationship between profit risk and returns (2009 and 2012) and cashflow risk and returns (2010) is consistent with Malkiel and Xu's (2002) version of the CAPM where investors are unable to diversify fully (due to structural, informational or behavioural constraints), which predicts a positive relationship between idiosyncratic risk and returns. It is also consistent with the results of Malkiel and Xu (2002) and Cotter et al (2015). The negative relationship between cashflow risk and returns in 2009 is more puzzling, although there are theoretical models that predict this; eg Ang, Hodrick, Xing and Zhang (2006) argued that what is really being observed is the (negative) pricing of market volatility risk. A positive relationship between book-to-market value of equity and returns to shareholders was first identified by Stattman (1980), and it was subsequently incorporated into Fama and French's (1992) "three-factor" model; but there is still no clear understanding of its meaning (one of Fama and French's (1992) suggestions is that it arises because market overreaction occurs and is subsequently corrected).

5.6.1.4 Risk and Return on Market Value of Equity

As explained in section 5.5.2.2, it was simply not possible to estimate equation 5.9 with pure accounting performance measures, RBVE and ROA, as the dependent variables; a hybrid accounting-market measure of profitability, RMVE, was therefore used as the dependent variable. However, this complicates the interpretation of the results of these analyses; as the denominator of the dependent variable is influenced by both the expected returns to and, critically, the risks to shareholders. In the discussion that follows, consideration of the salience of each individual risk measure to particular stakeholder groups is therefore critical in understanding the observed relationships.

The relationship between profit risk (the standard deviation of ROA) and subsequent profitability (RMVE) can best be understood in terms of the regimes of normal and low (or negative) GDP growth before and after the onset of the financial crisis respectively. Concentrating on the first and last five-year time periods, as the clearest exemplars of the normal and low-growth regimes respectively; it is useful to rearrange the parameter estimates for standard deviation of ROA and for the interaction term between prior performance and standard deviation of ROA to give separate parameter estimates for the standard deviation of ROA for high and low-performing firms (above and below median), as shown in table 5.31.

Table 5.31 – Parameter Estimates for First-Differenced Standard Deviation of ROA for High and Low-Performing Firms

	Δ(RMVE in 2012)		**Δ(RMVE in 2009)**	
	M-Estimator Regression	MM-Estimator Regression	M-Estimator Regression	MM-Estimator Regression
Low-Performing Firms	-0.121***	-0.194***	4.755***	4.432***
High-Performing Firms	0.193***	0.060	2.878***	3.111***

1. Table 5.31 presents separate parameter estimates for the standard deviation of ROA for low-performing and high-performing firms.
2. The figure for low-performing firms is simply the parameter estimate for standard deviation of ROA, copied from tables 5.24 and 5.25.
3. The figure for high-performing firms is the sum of the parameter estimates for standard deviation of ROA and for the interaction term with high performance, copied from tables 5.24 and 5.25.
4. Results for the median regression with first-differenced RMVE in 2012 as the dependent variable are not reported as the null hypothesis of the parameter estimates being jointly insignificant could not be rejected (see table 5.21).
5. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001 based on t-statistics (low-performing firms) and on a Wald test (high-performing firms).

In the conditions of normal growth that existed prior to the financial crisis (dependent variable first-differenced RMVE in 2009), there is a statistically significant positive relationship between profit risk (the standard deviation of ROA) and future profitability (RMVE) for all firms. Given the salience of profit risk to the managers of firms (Miller and Bromiley (1990)), it is argued that this finding supports the prediction that the managers of firms make risk-return trade-offs in their allocation of resources (hypothesis 2). However this study cannot differentiate between the competing explanations that managers make these trade-offs in the best interests of firm owners (Marsh and Swanson (1984)), or because of their own personal risk aversion (Bowman (1980)). The association between profit risk and subsequent

RMVE is not only statistically significant but highly economically significant: an absolute increase of 1% in the standard deviation of ROA leads to a predicted absolute increase in future RMVE of between 3 and 5% (compared to a mean RMVE of 7% in 2009). It appears then that in benign economic conditions, with many attractive opportunities for investment, there is an extremely high risk premium. However, there is no evidence for the hypothesised reduction in the magnitude of this positive association between profit risk and return for low-performing firms in this time period; indeed there is an unexpected and statistically significant increase.

This finding of a positive risk-return relationship, at least in the first time period, is perhaps the most significant contribution of the study: whilst consistent with theory and the results of the univariate tests in section 5.5.1, it contradicts the results of almost all previous studies (eg Miller and Bromiley (1990), who found a significant negative association between their "income-stream risk" construct and subsequent RBVE). It is therefore important to establish that this was not simply the result of the choice of RMVE as the dependent variable. As a robustness test, a further MM-estimator regression was conducted using raw (as opposed to first-differenced) variables. The full results of this regression are shown in table 5.37 of Appendix 2 and the key results are shown in table 5.32 below.

Table 5.32 – Comparison of Parameter Estimates for Standard Deviation of ROA for High and Low-Performing Firms with RMVE in 2009 and First-Differenced RMVE in 2009 as the Dependent Variables

	Δ(RMVE in 2009)	RMVE in 2009
Low-Performing Firms	4.432***	-0.156***
High-Performing Firms	3.111***	0.191

1. Table 5.32 presents parameter estimates for standard deviation of ROA for low-performing and high-performing firms.
2. Column 2 is derived from the estimation of equation 5.14 using MM-estimator regression.
3. Column 3 is derived from the estimation of equation 5.13 using MM-estimator regression.
4. The figure for low-performing firms is simply the parameter estimate for standard deviation of ROA, copied from tables 5.25 and 5.37.
5. The figure for high-performing firms is the sum of the parameter estimates for standard deviation of ROA and for the interaction term with high performance, copied from tables 5.25 and 5.37.
6. MM-estimator regression was performed using the user-defined mmregress function (Verardi and Croux (2009)).
7. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001 based on t-statistics (low-performing firms) and on a Wald test (high-performing firms).

It can be seen from table 5.32 that the use of the raw variables yields a statistically significant negative parameter estimate for low-performing firms and a non-significant parameter estimate for high-performing firms: the use of RMVE as the dependent variable on its own does not result in a finding of a positive association between profit risk and profitability. Rather, as was argued in section 5.6.1.2 in the context of the observed positive correlation between standard deviation of ROA and subsequent ROA; it would appear that the removal of unobservable firm fixed effects is necessary to observe the underlying positive association between profit risk and profitability.

As noted in section 5.5.2.5, the regression model works considerably less well in later time periods, but it still produces some interesting results. In the final period, representing the best exemplar of the conditions of unusually low growth that obtained during and after the onset of the financial crisis, there is still a positive relationship between profit risk and future profitability for high-performing firms; but the magnitude of this effect is reduced by an order of magnitude, indeed the parameter estimate is not even statistically significant in the MM-estimator regression (see table 5.31). Once again, based on the salience of profit risk to the managers of firms; it would appear that in such challenging conditions, where there are very limited opportunities for value-creating investments and interest rates close to zero, a much lower premium is required to invest in risky projects[64]. In addition, consistent with the predictions of Cyert and March (1992) and March and Shapira (1987) (and in support of hypothesis 4); the parameter estimates for the interaction term between the standard deviation of ROA and previous high performance are positive (and statistically significant in both the M-estimator and MM-estimator regressions). Indeed, the association between profit risk and future profitability is actually negative (and statistically significant) for poorly-performing firms. It would appear that, in such extreme conditions, behavioural arguments are applicable: as a result of "problemistic search" (Cyert and March (1992)) at the firm level and/or the "break-even effect" (Thaler and Johnson (1990)) at an individual level, the managers of poorly performing firms will actually accept an increase in profit risk with no corresponding increase in expected returns.

The M-estimator and MM-estimator regressions with (first-differenced) RMVE as the dependent variable (tables 5.24 and 5.25) both show the same pattern for beta: significant negative parameter estimates in the first and last time periods, and a significant positive parameter estimate in 2011. Whilst beta is primarily of interest

[64] This is different to Marsh and Swanson's (1984) argument that managers simply mirror the market risk premium in their risk-return decisions; but the effect is similar (see Chapter Two for more details).

as a risk measure to shareholders, this pattern is a complete reversal of that which was observed in the regressions with returns to shareholders as the dependent variable; so it cannot be explained in terms of the normal risk-return preferences of investors. However, if managers are also shareholders (or their pay is linked to the share price), the observed pattern can be understood by extending managers' desire to avoid specific negative outcomes for the firm (as hypothesised by, for example, Libby and Fishburn (1977), Amihud and Lev (1981), and Oswald and Jahera (1991)) to avoidance of personal financial distress. Managers in firms with higher values of beta experience greater loss to their personal wealth in the periods 2004-08 and 2007-11, when the stock market is falling, than their peers in low-beta firms; and, it is argued, react by making risk-averse decisions in the running of the firm. Given the positive relationship observed between profit risk and subsequent RMVE, this risk-aversion tends to lead to lower average performance[65]. Conversely, when the stock market is rising (2005-09 and 2006-10), managers in high-beta firms experience the greatest growth in their personal wealth; they therefore feel comfortable taking on more profit risk, and thereby achieve better average performance.

5.6.1.5 Summary

The results of regression analysis with returns to shareholders as the dependent variable support the prediction that increased market risk (beta) is associated with higher future returns to shareholders when returns on the market portfolio are above the risk-free rate (hypothesis 1a); and lower future returns when returns on the market portfolio are below the risk-free rate (hypothesis 1b). The results of univariate analysis support the prediction of a positive relationship between increased profit risk and future profitability (hypothesis 2), at least in the period prior

[65] The possibility that managers' personal risk aversion may (be allowed to) influence behaviour is explored more directly in the next chapter.

to the financial crisis, but only when variables are first-differenced to remove firm fixed effects. The results of regression analysis with RMVE as the dependent variable also support this prediction but, once again, only when first-differenced variables are used. In addition, the results of regression analysis with RMVE as the dependent variable support the prediction that the risk-return relationship is less positive for lower-performing firms (hypothesis 4), but only in the environment of low growth that existed after the onset of the financial crisis. No evidence was found in support of the prediction that increased cashflow risk is associated with lower future profitability (hypothesis 3). It was noticeable in both univariate tests and regression analyses that there were frequent differences between the results obtained from robust and non-robust techniques: this highlights the potential for outliers to affect correlation and regression results, and justifies the use of these robust techniques.

5.6.2 Practical Implications

The most obvious practical use of the model developed in this chapter would be to compute a benchmark profitability level (in terms of RMVE) for a firm, given the level of profit risk that managers have chosen to bear, against which historical managerial performance[66] could be judged. As Nekrasov and Shroff (2009) argue: "...if the source of value generation and therefore the source of risk reside in economic fundamentals such as earnings, then it would make sense to measure risk directly from fundamentals"; so, whilst still using market value of equity, this approach should be a more useful way of risk-adjusting managers' performance than the use of beta or other risk measures derived purely from returns data. The application of the model in a forward-looking context, in line with the growing interest in accounting–based risk measures for valuation purposes (eg Gebhardt et al (2001),

[66] Note that individual firms deviating from the predictions of the model does not imply that the model in equation (5.6) was mis-specified, as firm-fixed effects such as managerial quality were deliberately removed by first-differencing.

Nekrasov and Shroff (2009), Toms (2012)); is not as straightforward, as the relationship between profit risk and profitability was demonstrated to be contingent on economic conditions. However, a risk-return relationship derived from a previous period of similar growth could be used to compare the attractiveness of different investment opportunities in the present.

5.6.3 Limitations and Directions for Further Research

The principal limitation of the study design was that it was not possible to conduct regression analyses with a pure accounting measure of performance as the dependent variable, because of the inability to find instruments for the lagged dependent variable. This may well represent a fundamental limitation on the utility of this approach: simply gathering more data is unlikely to mitigate the problem, so alternative methods may be required to make further progress. In particular, it may not be possible to apply this approach to the analysis of privately-held firms because of the lack of market data. In addition, the removal of firm-fixed effects precluded the direct examination of the effect of risk management, a long-term firm capability, on the relationship between risk and subsequent performance. Understanding the effect of a firm’s risk management capability on performance is a question of both theoretical and practical interest and this will be discussed further in Chapter Seven.

It is also important to recognise that the constant changes in environmental conditions over the period of the study reduces the overall power of the analysis, as parameters could not be estimated over multiple time periods. It would therefore be very useful to continue the study longitudinally, in order to attempt to gather data over a prolonged period of comparative stability. This is especially important for the model with RMVE as the dependent variable, as the explanatory power of the model was much reduced by the financial crisis. In particular, it would be interesting to further investigate the unexpected observation (in the first time period) that future RMVE was more positively associated with the standard deviation of ROA for low-performing firms. In addition, continuing the study longitudinally would permit testing of the hypothesis developed in section 5.6.1.4 about the dependence of future RMVE on beta. In the models with returns to shareholders as the dependent variable, continuing the study longitudinally would also permit a better understanding of the relationships between various measures of idiosyncratic risk and market performance (see section 5.6.1.3).

Whilst not central to the study, it was surprising to see statistically significant, negative parameter estimates for firm size in the M-estimator regression with (first-differenced) RMVE in 2009 and 2012 as the dependent variables (see table 5.24); although the parameter estimates were not significant in the corresponding median or MM-estimator regressions (see table 5.25). As noted earlier, the data for this study were derived from a period of extraordinary market conditions around the financial crisis beginning in 2008, where the normal drivers of performance may not apply. The relationship between size and performance during recessions seems to be a very under-researched area; however Picard and Rimmer (1999), in their study of the performance of US newspaper corporations during the recession of the early 1990s, found that firm size was negatively correlated with growth in revenues during the recession and that larger firms recovered more slowly afterwards. Given the very basic design of their study, and small sample size (15 firms), it is not possible to say with confidence what the underlying causes of the observed relationships might be; although the authors suggest, quite plausibly, that the results may be explained in part by the inertia of larger firms in reacting to changed macroeconomic circumstances. It would also be very interesting to explore this issue in more detail.

Appendix 1 – IV (2SLS) Regression Results for Dynamic Models

Equation 5.9 was estimated using IV (2SLS) regression with (first-differenced) RMVE in 2012 as the dependent variable; and (first-differenced) values of RMVE in 2010 and 2009 as instruments for (first-differenced) RMVE in 2011. The results are shown in table 5.33.

Table 5.33 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2012)

	Full Sample	**Winsorized (1%)**	**Winsorized (2.5%)**
Δ(L.RMVE)	13.913	0.004	-0.198
	(0.51)	(0.02)	(-0.68)
Δ(Size)	-2.238	-0.086*	-0.071+
	(-0.60)	(-2.15)	(-1.95)
Δ(Power)	-264.098	-7.364+	-5.839
	(-0.48)	(-1.71)	(-1.57)
Δ(SD of ROA)	28.003	2.101*	1.709*
	(0.54)	(2.39)	(2.00)
Δ(Beta)	26.878	0.443	0.227
	(0.79)	(1.19)	(0.82)
Δ(SD of Cashflow)	2.393	0.167	0.099
	(0.54)	(1.03)	(0.71)
High RMVE * Δ(SD of ROA)	-26.889	-1.600+	-1.220
	(-0.56)	(-1.82)	(-1.46)
Constant	0.199	0.035**	0.030*
	(0.19)	(2.58)	(2.42)
N	665	656	637
Wald Test of Joint Significance	F(7,657)=0.13	F(7,648)=3.49	F(7,629)=5.59
p>F	0.996	0.001	0.0000
K-P Statistic	0.189	9.91	3.26
Hansen-J	0.072	0.010	0.055
Chi-square p-val	0.79	0.92	0.82
C-Test	0.998	9.51	8.27
Chi-square p-val	0.32	0.002	0.004

1. Table 5.33 reports the results of the estimation of equation 5.9 using instrumental variables regression (2SLS).
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample period for (first-differenced) RMVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2007-11.
4. IV regression was estimated using the user-written Stata function ivreg2 (Baum et al (2007)).
5. R^2 values are omitted as they have no meaningful interpretation in IV regression.
6. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places)
7. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.
8. The Kleibergen-Paap rk statistic is the appropriate test for weak instruments where heteroscedastic errors are suspected; critical values for size are as follows (Stock and Yogo (2005)):

0.1	19.93
0.15	11.59
0.2	8.75
0.25	7.25

9. The Hansen J-test is used because of possible heteroscedasticity; the null hypothesis is that all instruments are valid.
10. The null hypothesis of the C-test (Eichenbaum (1988)) is that the instrumented variable is actually exogenous.

Equation 5.9 was then estimated with (first-differenced) RMVE in 2011 as the dependent variable; and (first-differenced) values of RMVE in 2009 and 2008 as instruments for (first-differenced) RMVE in 2010. The results are shown in table 5.34.

Table 5.34 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2011)

	Full Sample	**Winsorized (1%)**	**Winsorized (2.5%)**
Δ(L.RMVE)	-0.244	0.004	0.038
	(-1.55)	(0.06)	(0.77)
Δ(Size)	0.020	0.011	0.015
	(0.55)	(0.38)	(0.52)
Δ(Power)	-2.418	0.557	0.274
	(-0.73)	(0.44)	(0.23)
Δ(SD of ROA)	1.151*	1.781***	2.100***
	(2.13)	(3.86)	(8.76)
Δ(Beta)	0.350	-0.231	-0.092
	(0.75)	(-1.51)	(-0.84)
Δ(SD of Cashflow)	-0.697	-0.171	-0.069
	(-1.38)	(-0.54)	(-0.25)
High RMVE * Δ(SD of ROA)	-1.288*	-1.566**	-1.910***
	(-2.06)	(-2.66)	(-3.98)
Constant	-0.043+	0.002	0.007
	(-1.74)	(0.21)	(0.85)
N	601	591	575
Wald Test of Joint Significance	F(7,593)=3.82	F(7,583)=3.68	F(7,567)=15.6
p>F	0.001	0.001	0.0000
K-P Statistic	15.9	13.5	12.4
Hansen-J	1.03	1.72	0.332
Chi-square p-val	0.31	0.19	0.56
C-Test	0.580	8.28	10.3
Chi-square p-val	0.45	0.004	0.001

1. Table 5.34 reports the results of the estimation of equation 5.9 using instrumental variables regression (2SLS).
2. The sample period for (first-differenced) RMVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2006-10.
3. See also notes to table 5.33.

Equation 5.9 was then estimated with (first-differenced) RMVE in 2010 as the dependent variable; and (first-differenced) values of RMVE in 2008 and 2007 as instruments for (first-differenced) RMVE in 2009. The results are shown in table 5.35.

Table 5.35 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2010)

	Full Sample	**Winsorized (1%)**	**Winsorized (2.5%)**
Δ(L.RMVE)	0.035	0.035	0.021
	(1.61)	(1.62)	(1.00)
Δ(Size)	-0.330	-0.057	-0.040
	(-1.58)	(-0.74)	(-0.54)
Δ(Power)	7.796	1.223	0.681
	(1.54)	(0.60)	(0.35)
Δ(SD of ROA)	0.660*	0.547*	0.515*
	(2.02)	(2.11)	(2.06)
Δ(Beta)	0.055	0.061	0.094
	(0.28)	(0.44)	(0.67)
Δ(SD of Cashflow)	0.651	0.252	0.329
	(1.24)	(0.93)	(1.22)
High RMVE * Δ(SD of ROA)	0.438	0.022	0.334
	(0.35)	(0.02)	(0.34)
Constant	-0.018	-0.000	0.009
	(-0.71)	(-0.00)	(0.76)
N	601	592	576
Wald Test of Joint Significance	F(7,593)=2.11	F(7,584)=1.89	F(7,568)=1.78
p>F	0.04	0.07	0.09
K-P Statistic	1190	1150	888
Hansen-J	1.39	1.25	1.21
Chi-square p-val	0.24	0.26	0.27
C-Test	12.8	11.8	10.6
Chi-square p-val	0.0004	0.001	0.001

1. Table 5.35 reports the results of the estimation of equation 5.9 using instrumental variables regression (2SLS).
2. The sample period for (first-differenced) RMVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2005-09.
3. See also notes to table 5.33.

Equation 5.9 was then estimated with (first-differenced) RMVE in 2009 as the dependent variable; and (first-differenced) values of RMVE in 2007 and 2006 as instruments for (first-differenced) RMVE in 2008. The results are shown in table 5.36.

Table 5.36 – Results of Cross-Sectional IV Regression (Dependent Variable First-Differenced RMVE in 2009)

	Full Sample	**Winsorized (1%)**	**Winsorized (2.5%)**
Δ(L.RMVE)	1.158	1.067	0.415+
	(1.00)	(0.98)	(1.89)
Δ(Size)	-0.319	-0.399	-0.288
	(-0.52)	(-0.69)	(-0.72)
Δ(Power)	-8.461	-6.383	-4.723
	(-0.59)	(-0.49)	(-0.54)
Δ(SD of ROA)	16.127	16.108	10.799***
	(1.60)	(1.61)	(3.81)
Δ(Beta)	1.682	1.559	1.084*
	(1.51)	(1.51)	(2.42)
Δ(SD of Cashflow)	-0.939	-0.829	-0.494
	(-0.65)	(-0.60)	(-0.56)
High RMVE * Δ(SD of ROA)	-3.368	-4.062	-2.622
	(-0.54)	(-0.62)	(-0.65)
Constant	-0.154	-0.146	-0.114
	(-0.85)	(-0.84)	(-1.00)
N	555	545	526
Wald Test of Joint Significance	F(7,547)=2.12	F(7,537)=2.14	F(7,518)=5.37
p>F	0.04	0.04	0.0000
K-P Statistic	1.58	1.99	16.3
Hansen-J	0.847	0.961	1.81
Chi-square p-val	0.36	0.33	0.18
C-Test	2.98	1.17	1.65
Chi-square p-val	0.08	0.28	0.20

1. Table 5.36 reports the results of the estimation of equation 5.9 using instrumental variables regression (2SLS).
2. The sample period for (first-differenced) RMVE is described above; the sample period for all other (first-differenced) explanatory and control variables is 2004-08.
3. See also notes to table 5.33.

Appendix 2 – MM-Estimator Regression Results for Non-First-Differenced Model

Equation 5.11 was estimated using MM-estimator regression with RMVE in 2008, 2009, 2010, 2011 and 2012 as the dependent variable. The results are shown in table 5.37.

Table 5.37 – Results of MM-Estimator Regression (Dependent Variables RMVE in 2012, 2011, 2010, 2009 and 2008)

	RMVE in 2012	**RMVE in 2011**	**RMVE in 2010**	**RMVE in 2009**	**RMVE in 2008**
Size	0.008***	0.010***	0.009***	0.004*	0.037***
	(9.88)	(11.11)	(11.20)	(2.05)	(5.22)
Power	-0.226+	-0.238	0.017	-0.115	-1.237+
	(-1.80)	(-1.41)	(0.08)	(-0.70)	(-1.91)
SD of ROA	-0.114***	-0.134***	-0.061***	-0.156***	-0.183
	(-6.40)	(-7.46)	(-3.52)	(-3.53)	(-1.04)
Beta	-0.005	0.004	-0.016**	-0.058***	0.021
	(-0.75)	(0.38)	(-2.85)	(-4.77)	(0.50)
SD of Cashflow	-0.097***	-0.059	-0.071***	-0.143	0.322
	(-3.90)	(-1.38)	(-3.90)	(-1.46)	(1.25)
High RMVE * SD of ROA	0.142*	0.061	-0.028	0.347**	-0.091
	(2.18)	(1.32)	(-1.38)	(2.88)	(-0.16)
Constant	-0.015	-0.025**	-0.016	0.072*	-0.369***
	(-1.60)	(-2.69)	(-1.61)	(2.55)	(-3.75)
N	1003	889	776	617	525
Wald Test of Joint Significance	F(6,996) = 61.4	F(6,882) = 84.9	F(6,769) = 67.2	F(6,610) = 16.6	F(6,518) = 6.13
p>F	0.0000	0.0000	0.004	0.0000	0.000

1. Table 5.37 reports the results of the estimation of equation 5.11 using MM-estimator regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for RMVE are 2012, 2011, 2010 2009 and 2008; and the corresponding sample periods for explanatory and control variables are 2007-11, 2006-10, 2005-09, 2004-08 and 2003-07.
4. MM-estimator regression was performed using the user-defined mmregress function (Verardi and Croux (2009)).
5. t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Equation 5.11 was also estimated with returns to shareholders in 2008, 2009, 2010, 2011 and 2012 as the dependent variable. The results are shown in table 5.38.

Table 5.38 – Results of MM-Estimator Regression (Dependent Variables Returns to Shareholders in 2012, 2011, 2010, 2009 and 2008)

	RTS in 2012	**RTS in 2011**	**RTS in 2010**	**RTS in 2009**	**RTS in 2008**
Size	0.026***	-0.002	0.007	0.012+	-0.006
	(5.70)	(-0.26)	(1.18)	(1.96)	(-1.02)
Power	-1.397*	0.951	-1.189	-2.596**	1.881**
	(-2.19)	(1.50)	(-1.28)	(-2.84)	(2.87)
SD of ROA	0.034	-0.175***	-0.058	-0.175+	-0.047
	(0.75)	(-6.44)	(-0.73)	(-1.76)	(-0.31)
Beta	0.004	-0.231***	-0.059	0.423***	-0.287***
	(0.12)	(-5.08)	(-1.28)	(6.39)	(-4.38)
SD of Cashflow	-0.512***	-0.116	-0.713***	-0.183	-0.270**
	(-3.80)	(-0.76)	(-3.71)	(-1.03)	(-2.78)
Ln[Book to Market]	0.001	-0.013	0.005	0.024	-0.016
	(0.08)	(-0.57)	(0.25)	(1.65)	(-1.21)
Constant	-0.078	0.101+	0.190**	0.040	-0.220**
	(-1.60)	(1.82)	(3.07)	(0.49)	(-2.84)
N	996	884	773	665	599
Wald Test of Joint Significance	F(6,989) = 13.5	F(6,877) = 22.7	F(6,766) = 3.62	F(6,659) = 10.6	F(6,593) = 8.90
p>F	0.0000	0.0000	0.002	0.0000	0.000
FTSE Returns	**8.8%**	**-3.7%**	**14.4%**	**28.0%**	**-30.7%**

1. Table 5.38 reports the results of the estimation of equation 5.11 using MM-estimator regression.
2. All variable definitions are given in section 5.4.1 and summarised in table 5.2.
3. The sample periods for returns to shareholders are 2012, 2011, 2010 2009 and 2008; and the corresponding sample periods for explanatory and control variables are 2007-11, 2006-10, 2005-09, 2004-08 and 2003-07.
4. MM-estimator regression was performed using the user-defined mmregress function (Verardi and Croux (2009)).
5. t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Chapter Six - Risk Management Capabilities in UK FTSE 350 Companies

6.1 Introduction

The finding in Chapter Five of a positive association between profit risk and return (at least in normal market conditions) implies that the development of a firm's capability to mitigate "passive" (Merton (2005)) or "non-core" (Nocco and Stultz (2006)) risks would be valuable. In addition, as discussed in Chapter One, firms have experienced significant pressures over recent years to "formalize principles of risk management" (Power (2009, p.304)). Nevertheless, adoption of formalised approaches to risk management, such as Enterprise Risk Management (ERM) and Business Continuity Management (BCM), is far from universal; even amongst large, publicly-quoted companies. This chapter investigates why some firms develop specific risk management capabilities, whilst other firms appear not to. This question is not only of theoretical interest, but also of practical interest to the shareholders and directors of companies; and, increasingly, to governments and to various industry regulators.

The study uses a novel approach, in which the risk management capabilities of firms in the FTSE 350 are proxied by their employment of members of two professional institutions: the Institute of Risk Management (IRM) and the Business Continuity Institute (BCI). It is argued that the employment of such professionals provides evidence of a generic risk management capability or, at least, a genuine aspiration on the part of the firm's management to develop such a capability. This approach therefore represents a theoretical advance on previous studies that have focused purely on the firm's use of derivatives or insurance contracts to mitigate specific risks (eg Tufano (1996) and Aunon-Nerin and Ehling (2008)); or on public announcements, such as the appointment of Chief Risk Officers (eg Liebenberg and Hoyt (2003) and Pagach and Warr (2011)). The use of this particular proxy for risk management capability also has some practical advantages: it can be applied across all industry sectors (for example, it is not practical to use the possession of derivatives as a proxy for risk management within the financial services sector); and it provides information on the intensity of risk management which is not available from a simple binary distinction between firms with a Chief Risk Officer and those without.

The rest of the chapter is organised as follows. Building on the general discussion of risk management in Chapter Two, the first section develops the "'managerial' concept of risk management" (Power (2007, p.3)). Two formalised approaches to risk management, enterprise risk management (ERM) and business continuity management (BCM), are introduced and discussed; previous empirical tests on the adoption of risk management (measured in a number of ways) are also reviewed. Based on this discussion of the literature, a number of specific hypotheses are developed in the next section. The two different regression models used in the analysis are then described in detail, and the results of the regressions are presented. The final section discusses the significance of the empirical findings and policy implications; and considers some productive areas for future research.

6.2 The Managerial Concept of Risk Management

The theory of risk management was discussed extensively in Chapter Two, and specifically: the history of risk management; risk management as a value creating activity; the role of management; risk management in the context of the RBV and dynamic capabilities framework; and risk management and real options theory. This section builds on that discussion, focusing specifically on formalised approaches to risk management or, as Power (2007, p.3) put it: the "'managerial' concept of risk management." The section begins by introducing, and comparing, the two approaches to risk management upon which the empirical study is based, ERM and BCM; with reference to the strategic frameworks described in Chapter Two. This is followed by a review of previous empirical tests of theories concerning the adoption of risk management; and, in particular an explanation of the limitations in these studies which provide the motivation for the current empirical work.

6.2.1 Enterprise Risk Management and Business Continuity Management

6.2.1.1 Enterprise Risk Management

ERM has arisen from a growing appreciation that significant benefits can be derived from managing the portfolio of risks that a firm faces within an overall strategic framework, rather than addressing each type of risk individually. The benefits of adopting an integrated approach include the more effective use of the firm's capital (Merton (2005), Nocco and Stultz (2006)); ensuring that risks are owned at the appropriate level within the company; and ensuring that risk are managed in a consistent manner (Ward (2003), Nocco and Stultz (2006)). There is no single concept of ERM, but COSO (2004, p.2) provides probably the most widely used definition: "…a process, effected by an entity's board of directors, management, and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risks to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives." Even though this definition is widely accepted, there is still an ongoing debate regarding how to actually implement an ERM system and, in particular, how to determine an appropriate "risk appetite" for a firm.

Empirical studies into the implementation of ERM have highlighted significant practical problems in achieving a true enterprise-wide approach to risk management. Arena et al (2010) examined the success of implementation by conducting long-term case studies of three Italian companies that had adopted ERM. They found that, in two out of three cases, pre-existing approaches to risk management remained in widespread use and were not in any way linked to the ERM programme. The authors suggest that the persistence of these legacy approaches stems primarily from "…differing risk rationalities and their potential to challenge the conceptualization of uncertainty" (p. 673). Power (2007, p. 120) makes a very similar observation about the tension between the fundamentally different epistemologies of "Calculative idealists" and "Calculative pragmatists" in the implementation of operational risk management in the banking industry.

6.2.1.2 Business Continuity Management

BCM has grown out of a number of disciplines concerned with the management of operational disruptions such as disaster recovery (DR), crisis management and business continuity planning (BCP) (Herbane (2010)). Elliott et al (2002) is perhaps the first mention of BCM in an academic work; the title of the book - "Business Continuity Management: A Crisis Management Approach" – is also important for making an explicit link to the previous work of crisis management researchers. The authors trace the evolution of BCM through the stages of "technology mindset", “auditing mindset” and “value mindset” towards the goal of “normalization of BCM” as a core management activity. Building on this theme of BCM as a core management activity, Herbane et al (2004) emphasise the strategic nature of BCM; in contrast to both DR and BCP, which they categorise as purely operational activities. Referencing the RBV, they state that “BCM is not simply a functional process with a limited remit and impact. Instead, it can be considered as a capability (i.e. a mix of routines and skills that is observable but not necessarily tangible or transferable) that underpins organisational development in complex environments” (p.437). The development of theory has been accompanied by a progressive codifying of the practice of BCM in, for instance, BSI (2003, 2006, 2007) and ISO (2012). As with the previous discussion of ERM, empirical studies into the implementation of BCM (Herbane et al (1997), Herbane et al (2004)) have found significant variation in progress towards the BCM paradigm amongst different firms.

The problems of implementation, observed in studies of both ERM and BCM, are a very important issue in the design of empirical tests of the effect of risk management on firm performance; but are not a concern in the current study.

6.2.1.3 A Comparison of Enterprise Risk Management and Business Continuity Management

Despite the clear connection between the two disciplines, it is rare for BCM and ERM to be mentioned in the same article. There are however a few interesting exceptions to this pattern which directly compare and contrast the two approaches to risk management. Bonafede et al (2007) see the relationship as follows: “It is inside the BIA [Business Impact Analysis] that must be searched the principal interactions and the differences between Risk Management (RM) and Business Continuity Management. In fact the key parameters for BCM are Time and Impact, for RM they are Impact and Frequency” (p. 83). More generally, Power (2009), in analysing the failure of ERM to prevent the current financial crisis, suggests that BCM offers a better epistemological basis for managing risk, stating that "BCM is fundamentally unlike discrete risk management practices such as ERM in its self understanding. It is premised on the necessity of representing the interconnected nature of commercial life…" (p. 853). Similarly, Young (2011) suggests that BCM potentially represents a more effective approach to risk management than the accounting and compliance-driven approach of ERM, as embodied in COSO (2004). However, it is important to temper this last point with the observation that there is already an international auditable standard for BCM (ISO (2012)); whereas the corresponding standard for risk management (ISO (2009)) merely provides guidance on good practice. The ERM and BCM approaches are compared in table 6.1.

Table 6.1 – Comparison of ERM and BCM Approaches (Adapted from BCI (2008, p.7))

	ERM	BCM
Key Method	Risk analysis	Business impact analysis (BIA)
Key Parameters	Impact and probability	Impact and time
Type of Incident	All types of events	Events causing significant business disruption
Intensity	All from gradual to severe	Sudden or rapid events
Unit of Analysis	The firm	The whole value chain
Typical Professional Background of Practitioners	Insurance, finance, accounting	Military, emergency services, IT, facilities management, health and safety
International Standards	ISO 31000 (2009) – guidance and best practice	ISO 22301 (2012) – auditable standard

6.2.1.4 ERM and BCM in the Context of the Resource Based View

As mentioned in section 6.2.1.2, Herbane et al (2004) argue that BCM is a capability in the context of the resource based view (RBV), which was introduced in Chapter Two. Critically, the RBV may provide insights into how BCM and ERM may lead to a sustainable competitive advantage. However, it must be stressed that this chapter does not attempt to test whether the adoption of ERM or BCM does indeed lead to such superior firm performance. The implementation of both ERM and BCM requires the sort of "Capabilities as organizational routines" defined by Grant (1991, p. 122) as "…regular and predictable patterns of activity which are made up of a sequence of coordinated activities by individuals". However this does not, in itself, guarantee that either ERM or BCM creates a competitive advantage. In order to achieve a sustainable competitive advantage it is necessary to develop a (dynamic) capability that is difficult to imitate (Barney (1991)); it is argued below that two elements of developing a risk management capability can potentially create such barriers to imitation: organisational culture and relationships with stakeholders.

The need to foster an appropriate culture across the entire organisation is an important reason why imitating the successful implementation of risk management may be difficult. The importance of developing an appropriate culture is stressed in good practice guidance from both the IRM and the BCI, eg: "The BC [business continuity] professional has a number of approaches available to help develop a BC aware culture within an organization..." (BCI (2013, p.39)). The importance of organisational culture for effective risk management was also specifically identified by Kimborough and Componation (2009) as a factor in the successful implementation of ERM in their survey of 116 internal audit executives. In addition, as highlighted in Chapter Two, organisational culture has been discussed extensively in the crisis management literature: for example, Pauchant and Mitroff (1988) and Miller (1988) both sought to understand how organisational culture can predispose organisations to crises. Conversely, the High Reliability Organisations (HRO) school (eg Roberts (1990)), identified a number of important cultural similarities in risky organisations that functioned safely over extended periods.

Another potential barrier to imitation can be inferred from comparison with a study of the adoption of environmental management systems (specifically certification to ISO 14001). Delmas (2001, p.348) argued that "…involvement of stakeholders in the design and structure of ISO 14001 sets up a path dependency process generating the sort of causal ambiguity just described and, with it, increases the difficulty of imitating the process for other competing firms." Her empirical study found, in support of her hypothesis, that the involvement of external stakeholders in the design of the environmental management system had the greatest effect on the competitive advantage that firms derived from it, much more so than the involvement of employees of the firm. A similar argument could be applied to ERM, and particularly to BCM, where stakeholder involvement has long been considered absolutely critical (Power (2009)); and developing good relationships with a wide network of stakeholders is also going to be very difficult, and time-consuming, to imitate.

6.2.1.5 ERM and BCM in the Context of Real Options Theory

At a very practical level, risk management involves the use of both financial options and real options. The purchase of financial options to hedge risks has become a very important part of the risk management function over the last forty years; indeed much previous research (see section 6.2.2) has been based solely upon the use of derivatives holdings as a measure of risk management. Meanwhile, the contingency planning approach of BCM (described in section 6.2.1.2) involves the building up of a portfolio of real options, which can be exercised in the event of specific forms of disruption, such as IT disaster recovery solutions, back-up power and home-working arrangements. More importantly though, it is argued that investment in a risk management capability, as set out in the relevant guidance and standards for ERM (COSO (2004)) and BCM (ISO (2012)); provides the firm with a generic ability to react effectively to many forms of disruption. This represents a very important real option, the value of which will only increase with the level of environmental uncertainty to which the firm is exposed.

6.2.2 Empirical Tests on the Adoption of Risk Management

It follows from the discussion in Chapter Two on risk management as a value-creating activity (section 2.5.2), that firms that have a greater probability of financial distress; firms operating in sectors where the costs of bankruptcy are inherently high; and firms that have greater growth opportunities are more likely to actively manage risks. The effect of firm size on the propensity to adopt risk management was unclear: the proportional cost of bankruptcy is greater and tax functions are usually more convex for smaller firms; but larger size is generally associated with "increasing scope and complexity of risks" (Gatzert and Martin (2015, p.36)), and larger firms have more resources with which to implement risk management (Beasley et al (2005)). The discussion of agency theory (sections 2.3.2 and 2.5.3.1), produced a number of further predictions concerning the relationship between managerial compensation and risk-taking. It was also argued that institutional investors are likely to encourage managers to adopt good practice in corporate governance, of which formalised processes for risk management are a core component. Finally, the discussion of the behavioural theory of the firm (section 2.5.3.2) suggested that the adoption of risk management may be triggered by a failure to meet specific targets; and that informal conventions on acceptable levels of risk management may exist in some (or all) industry sectors.

The key challenge in all empirical studies of the adoption of risk management is that a firms' risk management capability is not directly observable[67]. A number of

[67] Molloy et al (2011) discuss the general problem of measuring intangibles in some detail.

different proxies for risk management have been used and these are discussed in section 6.2.2.1. It is important to bear in mind that many types of risk can be effectively mitigated in a number of distinct ways eg by purchasing insurance, hedging with derivatives or by an operational hedge; so tests based on different proxies may yield very different results. This is followed by discussions of the results of various studies of the effects of size (section 6.2.2.2) and the probability and expected costs of financial distress (section 6.2.2.3) on the propensity to adopt risk management; as these have been subjected to the most extensive empirical tests. Section 6.2.2.4 reviews the findings from tests of the predictions of agency theory; and section 6.2.2.5 summarises the findings of some empirical tests of other predictions. Finally, section 6.2.2.6 reviews how different studies have controlled for risk exposure.

6.2.2.1 Proxies for Risk Management

Early studies of the adoption of risk management were based on the possession of specific risk management resources: Nance et al (1993) and Géczy et al (1997), used a simple dichotomy between firms that used derivatives and those that didn't and used straightforward logistic regression. Haushalter (2000) improved on this approach by using the actual extent of derivatives usage as the dependent variable and applying a Tobit regression (in order to cope with the large number of firms that purchased no derivatives); he also focused on a single industry (oil and gas) to eliminate the variability in risk exposure between sectors. More recent studies have tended to focus on announcements in the media about the appointment of a CRO, taking this as a proxy for a risk management capability[68]. Early examples of these were similar in method to the first derivatives-based studies, performing cross-

[68] Beasley et al (2005) specifically test the relationship between presence of a CRO and maturity of ERM and find a significant positive relationship.

sectional analyses using logistic regression (eg Liebenberg and Hoyt (2003)); but Pagach and Warr (2011) made an important advance by using panel data and a Cox proportional hazard model[69]. Hoyt and Liebenberg (2011) refined the approach of searching media databases further, looking for a range of relevant phrases (such as "Chief Risk Officer", "Enterprise Risk Management" and "Strategic Risk Management") in order to form a more rounded view as to whether a firm had a risk management capability; Eckles et al (2014) used the same approach. The use of public announcements as a proxy for capability represents an attempt to move beyond crude indicators, based on the mitigation of specific risks; but it must be borne in mind that the content of such announcements may be "…less a response to specific risks and more a feature of what it is to be a legitimate (large) organisation" (Power (2007, p.86)). Beasley et al (2005) is somewhat unusual, in that they use a survey instrument to classify firms into five levels of ERM maturity: subject to the validity of the survey instrument, this is almost certainly the best measure of firms' risk management capability used in previous studies.

6.2.2.2 The Effect of Firm Size on the Adoption of Risk Management

Most studies into the effect of firm size on the adoption of risk management are in agreement but with one important exception, as discussed below. The simple approaches of Nance et al (1993) and Géczy et al (1997) both found a positive association between firm size and the likelihood of using derivatives. This initial finding was confirmed by the more advanced approaches of Haushalter (2000), Beasley et al (2005), Pagach and Warr (2011), Hoyt and Liebenberg (2011) and Eckles et al (2014). However, all of these results are challenged by Aunon-Nerin and Ehling's (2008) finding that smaller firms were actually more likely to purchase property insurance. All the studies were based on large, publicly-traded firms; and it

[69] The use of a hazard model removes assumptions about the independence of observations.

is impossible to dismiss this conflicting finding on methodological grounds as Aunon-Nerin and Ehling's (2008) approach is broadly similar to Hasuhalter's (2000), but with insurance coverage as the dependent variable and using GMM instead of Tobit regression (as all firms in the sample have some insurance coverage). The argument therefore centres on which is the most useful proxy for risk management: Aunon-Nerin and Ehling argue that insurance coverage is a better indicator as it can only be used to mitigate risk (as opposed to derivatives which can also be used for speculation). The authors then go on to suggest that the high fixed costs of implementing a derivatives programme simply make derivatives usage uneconomic for smaller firms (an argument previously advanced by Stultz (2003)); ironically this exposes a serious flaw in their own study in that larger firms have a wider range of options for managing risk open to them, so lower levels of insurance coverage may simply indicate the use of alternative risk transfer approaches.

6.2.2.3 The Effect of the Probability and Expected Cost of Financial Distress on the Adoption of Risk Management

The results of studies into the effect of the probability of financial distress on the adoption of risk management are largely consistent, despite the wide range of proxies used. Nance et al (1993) found a positive association between leverage and the use of derivatives whilst Géczy et al (1997) found a negative association with the quick ratio. Once again, these early results were confirmed by the more rigorous approach of Haushalter (2000), who found that more highly leveraged firms (in the oil and gas sector) were more likely to hedge risks. More recently, Liebenberg and Hoyt (2003) found that more highly leveraged firms were more likely to appoint a CRO; and Aunon-Nerin and Ehling (2008) found that more highly leveraged firms were also more likely to purchase property insurance. However, using a maximumlikelihood treatment effects model, Hoyt and Liebenberg (2011) found that more highly leveraged firms were less likely to adopt ERM.

There doesn't appear to be any direct empirical evidence that the expected cost of bankruptcy drives adoption of risk management: even the most methodologically sophisticated study, Pagach and Warr (2011), failed to find a significant relationship with the proportion of intangible assets. However, Aunon-Nerin and Ehling (2008) assert that the negative association that they observed between size and purchase of property insurance is because of the relatively higher bankruptcy costs for smaller firms (but see comments in previous paragraph about larger firms having alternative ways to manage risk).

6.2.2.4 Tests of the Predictions of Agency Theory

The predictions from agency theory about the relationship between managerial incentives and risk taking have received considerable empirical support. Tufano's (1996, p. 1097) study of gold-price hedging amongst North American gold-mining firms found that: "…firms whose managers hold more options manage less gold price risk, and firms whose managers hold more stock manage more gold price risk…". Subsequent research has largely supported these initial findings with Sanders and Hambrick (2007) finding that a high proportion of share options in CEOs' compensation packages led to increasing investment in risky activities (R&D, capital investments and acquisitions); as well as more extreme financial performance and a greater likelihood of poor financial performance. Similarly, Low (2009) found that the general risk aversion of managers was reduced if the CEO's compensation was based more on share options; indeed he found some evidence that firms actively pursued this approach. Adams et al (2011, p.551) provide a further insight in their study of the usage of property insurance in Chinese firms in which they found that

"...the purchase of property insurance for managerial self-interest is only prevalent in firms subject to lax monitoring..."

However, it is important to reiterate that the purpose of corporate risk management is not to reduce overall risk per se[70]; rather it is to cost-effectively mitigate "passive" (Merton (2005)) or "non-core" (Nocco and Stultz (2006)) risks so as the firm can take on additional "value-adding" (Merton (2005)) risks. Thus, there is no basis to suspect a direct relationship between managerial risk aversion and the development of a risk management capability. However, two studies that have specifically attempted to investigate the relationship between managerial incentives and risk management have found negative associations. Pagach and Warr (2011) found that firms where the CEO's compensation is more sensitive to stock-price volatility were more likely to appoint a CRO; whilst Ellul and Yerramilli (2013) found that banks where the CEO's compensation is more sensitive to stock-price volatility tended to have higher scores in their "risk management index"[71]. Pagach and Warr (2011) speculated that the appointment of a CRO may indicate an attempt on the part of the board to address a potential agency problem. Whilst this is plausible in the specific context of the appointment of a CRO, the argument is not applicable to risk management more generally: managerial incentives are therefore not considered further as a driver in this study.

As regards the nature of ownership, Pagach and Warr (2011) found that companies with greater institutional ownership are more likely to appoint a CRO, and both Hoyt and Liebenberg (2011) and Eckles (2014) found that such companies were more likely to adopt ERM; however Ellul and Yerramilli (2013) found no significant

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[70] Although, of course, specific risk management activities (such as purchase of insurance) are used to mitigate particular risks that stakeholders do not wish to bear.

[71] The risk management index is based on the existence, status and compensation of the CRO; and the experience and activity level of the risk committee.

relationship between institutional ownership and adoption of ERM (amongst banks). As explained above, the fact that large block owners are generally institutional investors means that empirical studies of the effect of concentration of ownership are actually a joint test of the effects of concentration of ownership and of institutional ownership.

6.2.2.5 Other Tests

A number of other relationships have also been tested in some previous studies with differing results: in general the significant results from early derivatives-based studies have not been replicated in later work. Given the reservations outlined above about using derivatives usage as a proxy for risk management capability, it would therefore be unwise to make any generalisations about these relationships. The early studies of Nance et al (1993) and Géczy et al (1997) found a significant positive relationship between growth options and the use of derivatives; but neither Liebenberg and Hoyt (2003) nor Pagach and Warr (2011) found any significant relationship in their studies based on the appointment of Chief Risk Officers. Similarly, whilst both Nance et al (1993) and Haushalter (2000) found a significant positive relationship between the convexity of the tax function and usage of derivatives; more recent studies have all failed to find a significant relationship (eg Aunon-Nerin and Ehling (2008) and Pagach and Warr (2011)).

6.2.2.6 Controlling for Risk Exposure

As discussed in section 6.2.1.5, the development of a risk management capability creates real options, the value of which will increase with the risk exposure of the firm: it is therefore necessary to control for risk exposure in any regression model. Haushalter (2000) first attempted to address this issue by restricting his study to a single industry sector, oil and gas. Subsequent studies improved on this approach by including specific control variables for profit risk (Liebenberg and Hoyt (2003)), market risk (Liebenberg and Hoyt (2003), Pagach and Warr (2011), Eckles et al (2014)) and cashflow risk (Pagach and Warr (2011)); but no previous study has controlled for all three of the dimensions of risk identified in Chapter Four.

6.2.3 Summary

Following a discussion of the two risk management approaches of interest in this study, ERM and BCM, various previous empirical studies on the adoption of risk management were reviewed. In the course of this review, it became apparent that there were a number of shortcomings in prior empirical tests; and these provide the motivation for the current study. The principal concern centred around the suitability of the proxies used for risk management capability: this is addressed by the use of a novel dependent variable, the employment of members of professional risk management institutions, in this study (the use of this proxy is discussed in more detail in section 6.3.1). There are also concerns around how previous studies have controlled for the risk exposure of firms. This study will improve on prior work by including control variables for profit risk, market risk and cashflow risk; as derived in Chapter Four.

The review of previous empirical work highlighted one other area worthy of further investigation but the design of the current study precludes this. There is an interesting contradiction between arguments based on the costs of financial distress (and convexity of tax function), which predict that managers in smaller companies should be more likely to adopt risk management; and the majority of empirical evidence (generally based on using derivatives usage as a proxy for risk management capability) that larger companies tend to engage more in risk management. Unfortunately the use of the employment of members of professional organisations as the proxy for the intensity of firms’ risk management activity does not allow for a meaningful investigation of this particular question (although size will be controlled for in all regressions).

6.3 Developing the Model

This section begins with a discussion of the principal innovation of this study, the use of the employment of risk management professionals as a proxy for a firm's risk management capability, or at least the intention to develop one. This is followed by an explanation of a number of specific hypotheses concerning the drivers of risk management to be tested in this analysis.

6.3.1 Selection of an Appropriate Dependent Variable

As discussed in Chapter One, a firm's risk management capability cannot be directly observed; rather an appropriate proxy must be used. The use in many studies of the possession of derivatives (eg Nance et al (1993), Géczy et al (1997), Haushalter (2000) and insurance contracts (Aunon-Nerin and Ehling (2008)) as a proxy for a risk management capability is flawed for a number of reasons. Purchase of these resources indicates that particular risks are being mitigated somewhere in the organisation; but, in many cases, insurance and derivatives are substitutes for each other so reliance on one measure will not give a complete picture. Moreover, as noted in section 6.2.2, there are often alternative approaches to risk mitigation, eg operational hedges, which will not be captured by either metric. More fundamentally though, they give no indication of the development of an enterprise-wide approach to identifying and managing risks in an integrated manner; which is the subject of this study.

The use of public announcements by the firm as a proxy for risk management capability, eg the appointment of a CRO, represents an improvement on these early approaches, but it is important to recognise that these announcements may be primarily symbolic; as Power (2007, p.86) suggests: "...the category of CRO has become institutionalized as a standardized role for large organizations..." (p.86). It also suffers from the practical drawback that "it allows for no differentiation with respect to the level of ERM implementation" (Gatzert and Martin (2015, p.34)). As stated in section 6.2.2.1, Beasley et al's (2005) approach of using a survey instrument to measure a firm's risk management capability is attractive in many situations, although the labour involved in administering the survey limits the practical sample sizes that can be used (Beasley et al (2005) only examined 123 firms). Moreover, in addressing the specific research objective of this study; it suffers from the drawback that it (attempts to) measures the risk management capability that a firm has already developed, rather than the intention to develop such a capability.

The use of the employment of risk management professionals as a proxy for risk management capability addresses all of the concerns listed above. Hiring such a professional clearly implies an intention on the part of the firm's management to develop a risk management capability, as discussed in section 6.2.1. The evidence of this intention is updated annually in the membership records of the relevant professional institutions, even though it may be some years before the firm develops a substantive capability; but, crucially, this information is not generally made public. Beyond these theoretical benefits, the use of the employment of risk management professionals as a proxy has a number of practical advantages: it can be used in all industry sectors[72]; it can be used to measure the intensity of risk management as well as a simple binary decision to adopt or not; and membership information is already collated by the relevant professional institutions so data does not have to be collected from individual firms.

Clearly there are some important issues with the use of the employment of professionals as a proxy for the intention to develop a risk management capability;

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[72] Obviously this would be problematic if the sample included consultancy firms with large ERM or BCM practices but the FTSE 350 in July 2011 did not contain any such management consultancy firms.

the measures taken to address these issues are discussed below. Most importantly, it is possible that firms could be developing risk management capabilities, without directly employing any risk management professionals, through the use of contractors or consultants. It is argued that this is likely to be more prevalent in smaller firms; so by restricting the study sample to the largest firms in the UK, the FTSE 350, this effect will be minimised. Obviously though this means that the findings of the study cannot be generalised to smaller firms. It is also important to acknowledge that the IRM and BCI do not operate in a monopolistic environment, and that there are alternative organisations to which suitably qualified professionals may belong (or indeed individuals may choose not to join any organisation at all). In particular, there are two other membership organisations for BCM professionals but these are of limited relevance to the UK: the *Disaster Recovery Institute* is largely based in the US, whereas the *BCM Institute* is mainly focused on the Far East. In addition, the *Public Risk Management Association (ALARM)* and the *Emergency Planning Society* include large numbers of UK-based risk managers and BCM professionals respectively in their membership; but the overwhelming majority of these will be employed in the public sector.

It is also possible that a firm may recruit people who happen to be risk management professionals, even though they do not (currently) intend to make use of that particular expertise. Equally, people might be initially recruited to develop a risk management capability which is subsequently abandoned, but they are retained in the company in other capacities. Employees might also join one of the professional institutions of interest in this study, the IRM or BCI, for purely personal reasons (eg seeking employment elsewhere) without the encouragement (or even knowledge) of their employer. In order to minimise these effects, a data set based on the voluntary declaration of their employer's name by the employee is used: significant numbers of

IRM members (and a smaller proportion of BCI members) choose not to declare an employer in their membership entry. It is argued that if an employee is not using their professional risk management expertise for their employer, and/or feels that their employer is not truly committed to developing a risk management capability; they are less likely to declare their employer's name in their membership entry.

6.3.2 Hypotheses to be Tested

Four hypotheses, derived directly from theories of how risk management creates value for shareholders discussed in Chapter Two, are tested in this analysis; all of these have been subjected to numerous previous empirical studies. One further hypothesis, concerning the firm's possession of tangible assets; is derived from consideration of the specific nature of the risk management capabilities being studied (ERM and BCM). The final hypothesis investigates predictions relating to whether institutional investors influence managers to adopt formalised approaches to risk management.

Leverage is an important determinant of the likelihood of financial distress, which is one of the central motivations for firm owners to manage risk (Smith and Stultz (1985)). A number of previous empirical studies have found an association between leverage and the possession of risk management resources; for instance Liebenberg and Hoyt (2003) found that more highly leveraged firms were more likely to appoint a CRO.

> *Hypothesis 1a: Managers of highly leveraged firms are more likely to employ members of the IRM.*
>
> *Hypothesis 1b: Managers of highly leveraged firms are more likely to employ members of the BCI.*

A lack of liquidity may also result in financial distress. Once again, a number of previous empirical studies have found an association between liquidity and the possession of risk management resources; for instance Géczy et al (1997) found a negative relationship between the quick ratio and the use of derivatives.

Hypothesis 2a: Managers of firms with lower liquidity are more likely to employ members of the IRM.

Hypothesis 2b: Managers of firms with lower liquidity are more likely to employ members of the BCI.

Whilst both of these arguments were introduced from the perspective of creating value for the owners of the firm, it should be noted that the probability of financial distress is also of great interest to both lenders and managers. Logically, the expected costs of financial distress will also be a driver for risk management (Smith and Stultz (1985)); but, unlike the likelihood of financial distress, the costs are only really of interest to the shareholders of the firm (on whom they fall). A number of different measures have been applied in previous empirical studies; following Liebenberg and Hoyt (2003) and Pagach and Warr (2011), the market value of the firm is used as a proxy for the expected cost of financial distress as it captures investors' expectations about future growth opportunities.

Hypothesis 3a: Managers of firms with a high market-to-book ratio are more likely to employ members of the IRM.

Hypothesis 3b: Managers of firms with a high market-to-book ratio are more likely to employ members of the BCI.

However, it is important to acknowledge that high market-to-book values may also indicate a lower probability of financial distress: investors have confidence in the firm's long-term prospects so the firm should be able to access external funding if required. It is therefore necessary to also test the competing hypotheses.

Hypothesis 3c: Managers of firms with a low market-to-book ratio are more likely to employ members of the IRM.

Hypothesis 3d: Managers of firms with a low market-to-book ratio are more likely to employ members of the BCI.

Two previous studies (Pagach and Warr (2011) and Hoyt and Liebenberg (2011)) have used the proportion of intangible assets as a proxy for 'opacity'; reasoning that the more opaque a firm's assets are the more value will be lost in bankruptcy. The logic of this is questionable though, as intangible assets includes items such as patents, trademarks, internet domains and customer lists; which could actually be transferred to another owner without significant loss of value. Moreover, both ERM and BCM are primarily focused on the protection of physical and financial assets which can be insured, hedged or physically protected. The empirical evidence from previous studies is also inconclusive: Pagach and Warr (2011) found a positive association with the likelihood of appointing a CRO; and Hoyt and Liebenberg (2011) found a negative relationship with the likelihood of adopting ERM, but neither result was statistically significant. Given that the model already includes a proxy for the expected cost of financial distress, it is argued that the focus of ERM and BCM on the protection of tangible assets will dominate.

Hypothesis 4a: Managers of firms with a high proportion of tangible assets are more likely to employ members of the IRM.

Hypothesis 4b: Managers of firms with a high proportion of tangible assets are more likely to employ members of the BCI.

In many cases the effective tax rate for firms is a convex function of profit before tax: in these situations value can also be created by minimising fluctuations in earnings (Smith and Stultz (1985)). Once again, this is primarily of interest to the shareholders of the firm. Both Nance et al (1993) and Haushalter (2000) asserted that they found a significant relationship between the convexity of the effective tax function and the usage of derivatives; however, Plesko (2003) highlights some serious problems with deriving marginal tax rates from accounting data. Following Muff et al (2008)[73], it is simply argued that the higher the effective tax rate a firm experiences the more motivated managers will be to reduce fluctuations in earnings.

Hypothesis 5a: Managers of firms which have a higher effective tax rate are more likely to employ members of the IRM.

Hypothesis 5b: Managers of firms which have a higher effective tax rate are more likely to employ members of the BCI.

Finally, consistent with the hypothesis of Hoyt and Liebenberg (2011), supported by their empirical results and those of Pagach and Warr (2011); institutional ownership may be a significant driver for adopting formalised approaches to risk management.

Hypothesis 6a: Managers of firms with a high proportion of institutional owners are more likely to employ members of the IRM.

Hypothesis 6b: Managers of firms with a high proportion of institutional owners are more likely to employ members of the BCI.

[73] Muff et al (2008) use two additional tax measures: a dummy variable if the firm has experienced net operating losses (as a proxy for tax carry-forwards) and a dummy if the marginal tax rate is greater than 32.75%. Graham and Rogers (2002) dispute the validity of the former measure (and it is highly correlated with the standard deviation of ROA); the latter is not used because of the inherent unreliability of constructing marginal tax rates from accounting data (Plesko (2003)).

6.4 Data

6.4.1 Sample of Companies

The sample of companies used in the study is based on the 332 firms in the FTSE 350 as at 6th July 2011 for which the FAME and Datastream databases contain data[74]. In order to be included in the sample, firms had to have a positive turnover figure in 2010 and at least one employee; these validity criteria reduced the sample size to 298 firms. 30 of these firms did not have five years of accounting data, and a further two firms did not have sufficient market data; leaving a sample size of 266.

6.4.2 Dependent Variables

The IRM provided a list of the country and membership grade of the 1634 IRM members (as of July 2011) who have given details of their employers (this constitutes slightly less than 50% of the total membership of the IRM); 1120 of these members are UK-based. It is of course possible that a company might have IRM members in its overseas subsidiaries but none actually based in the UK although it is unclear precisely what this implies about the company's commitment to ERM. However, only 3 companies in the FTSE 350 fell into this category so the matter is not considered any further. The BCI provided a complete membership list as of July 2011 giving country, membership grade and employer (where members had given this). There are a total of 5798 entries, of which 2389 are UK-based; and 89% of these UK-based members have listed an employer. The numbers of firms within the sample which employ a member of the IRM (Certificant or above), a member of the BCI (Associate or above), neither and both[75] are shown in table 6.2.

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[74] Most of the FTSE 350 firms that are missing from the FAME database are registered overseas; only one firm that was in the FAME database did not have any data in Datastream.
[75] There were a small number of BCI members who listed their employer as "Blackrock" or "JP Morgan", but it was impossible to attribute these people to a specific firm in the FTSE 350.

Table 6.2 – Numbers of Firms Employing Members of the IRM and BCI

		IRM Member	
		Yes	No
BCI Member	Yes	15	25
	No	20	206

The number of firms employing IRM and BCI members by relevant industry sectors is shown in table 6.3.

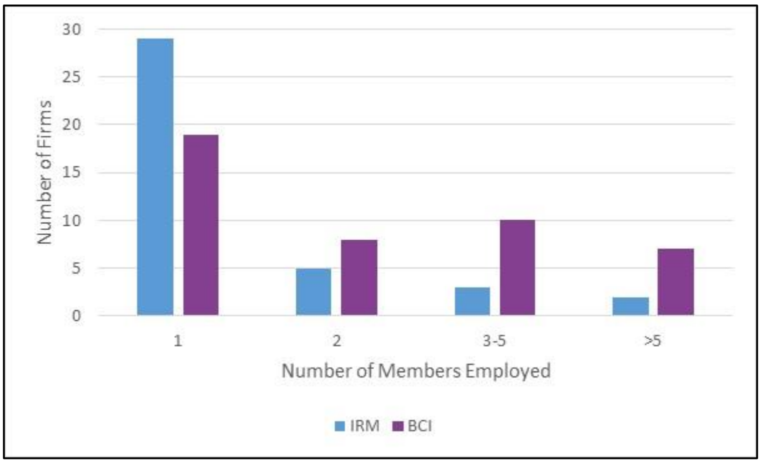
Table 6.3 – Number of Firms Employing IRM and/or BCI Members by Industry Sector

SIC Section	Number of Firms	IRM Member	BCI Member
Agriculture	0	0	0
Mining and Quarrying	18	2	2
Manufacturing	39	5	6
Electricity, Gas, Steam and Air Conditioning Supply	3	1	1
Water Supply; Sewerage, Waste Management and Remediation Activities	2	1	1
Construction	15	1	1
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	24	2	5
Transportation and Storage	6	1	0
Accommodation and Food Service Activities	10	0	2
Information and Communication	24	4	5
Financial and Insurance Activities	48	5	6
Real Estate Activities	4	0	0
Professional, Scientific and Technical Activities[76]	10	1	2
Administrative and Support Activities	13	2	2
Public Administration and Defence; Compulsory Social Security	4	2	1
Education	0	0	0
Human Health and Social Work Activities	1	0	0
Arts, Entertainment and Recreation	3	0	0
Other Services Activities	2	0	0
Activities of Households as Employers	0	0	0
Activities of Extraterritorial Organisations and Bodies	0	0	0
Total	**226**	**27**	**34**

[76] Firms in the sample with the SIC code 70100 ("Activities of Head Offices") are excluded from this breakdown.

The breakdown of the actual number of IRM and BCI members employed in the firms that employ at least one member is shown in fig. 6.1.

Fig. 6.1 Number of IRM and BCI Members Employed



6.4.3 Explanatory Variables

Accounting data are derived from the FAME database and market data from Datastream. Variable definitions are consistent with those used in previous chapters, where applicable; but definitions of all the variables are repeated below for completeness, and summarised in table 6.4. Data were collected over a five year period finishing with the last set of accounts published before 1st April 2011; for simplicity accounting periods ending between 1st April 2010 and 31st March 2011 are denoted 2010 and likewise for previous years. Unless otherwise stated, ratios are calculated annually and averaged over five observations from 2006 to 2010.

Debt-to-market-value-of-equity is used as the measure of leverage as this was previously found to be less skewed than debt-to-book-value-of-equity. The ratio was calculated as follows: short term loans and overdrafts (FAME field 52) plus long term liabilities (FAME field 85), divided by the market capitalisation (Datastream field MV – "Market Value (Capital)"). Liquidity was calculated as current assets minus current liabilities[77] (FAME field 67 – "Net Current Assets"), divided by total assets (FAME field 70). Market-to-book value is calculated by dividing the average market capitalisation (Datastream field MV – "Market Value (Capital)") over the period 2006-10 by the book value of equity (FAME field 93 – "Shareholders' Funds) averaged over the same period. The proportion of tangible assets is calculated by subtracting the average values of "Intangible Assets" (FAME field 35) divided by "Total Assets" (FAME field 70) from 1. Many firms had missing data for intangible assets and/or R&D in individual years: these missing values were not included in the calculation of the five-year average. However, where a firm had no data in any year from 2006 to 2010, the value for R&D is set to "0" and the value of tangible assets is set to "1".

The effective tax rate is calculated by dividing the total "Profit Before Tax" (FAME field 14) over the period 2006-10 by the total tax paid (FAME field 15 – "Taxation") over the period; in the small number of cases where this ratio was negative, the value from the nearest five-year period with a non-negative value was used[78]. Institutional ownership is calculated as 1 – the proportion of private ownership (FAME code I – "One or more named individuals") as of July 2011; note that as this is designed to be a measure of control, only voting shares are included.

6.4.4 Control Variables

As stated in section 6.2.3, profit risk, market risk and cashflow risk are all controlled for in the model: the outputs from the principal component analysis (PCA) in Chapter Four were used directly to control for profit risk and market risk (this leads to a further reduction in sample size to 229). Following Froot, Scharfstein and Stein's argument that variability in cashflows is only really of interest to firms that invest in

[77] Negative values are included.
[78] Salamander Energy had a negative effective tax rate in all time periods so is dropped from the study leaving a sample of 265 firms.

R&D; the cashflow risk component from the PCA is interacted with R&D intensity. R&D intensity was calculated by dividing R&D spending (FAME field 28 – "Research & Development") in each year by book value of equity[79] (FAME field 93 – "Shareholders' Funds"); a number of firms have negative values for book value of equity in some years, resulting in negative values of R&D intensity, these negative values were omitted from the calculation of the five-year average.

A number of other firm characteristics may also affect the likelihood of firms developing a risk management capability. Numerous previous studies have found a positive relationship between firm size and possession of risk management resources eg Nance et al (1993), Geczy et al (1997), Stultz (2003) and Pagach and Warr (2011). Because of the specific design of this study, no hypotheses about the effect of size can be directly tested; however size remains an important control variable. Previous studies of risk management have all used financial proxies for firm size eg "log [market value of equity + book value of debt]" (Aunon-Nerin and Ehling (2008)), or "total assets" (Pagach and Warr (2011)). However, it is judged that a measure based on the number of Employees" (FAME field 26) is much more appropriate in this context. This is calculated by averaging the "Number of Employees" (FAME field 26) over the period 2006-10 and taking the natural log.

It is also necessary to control for two regulatory issues that pertain in the UK. Financial Services firms are not only regulated in their management of market and credit risks; the UK Financial Services Authority[80] also states that a regulated firm "…should have in place appropriate arrangements, having regard to the nature, scale and complexity of its business, to ensure that it can continue to function and meet its

[79] See previous chapter for discussion of why this specific definition of R&D intensity is used.
[80] The Financial Services Authority ceased to exist and its responsibilities were split between two new bodies, the Financial Conduct Authority and the Prudential Regulation Authority, in April 2013.

regulatory obligations in the event of an unforeseen interruption." (FSA (2004, paragraph 3.2.19). A dummy control variable is therefore included for firms with SIC codes 64110-66300 (inclusive). The UK Civil Contingencies Act (2004) identified firms involved in the following areas of critical national infrastructure as "Category 2 Responders": electricity, gas, water, telecommunications, railways, airports and harbours. Whilst not placing any statutory risk management obligations on these firms (over and above what is already contained in their licence conditions), the fact that the externalities of a disruption to these services have been highlighted in this way may tend towards a greater emphasis on risk management. A dummy control variable is therefore included for firms with SIC codes 35110-37000 (electricity, gas and water supply), 49100-49310 (land transport), 51100 (scheduled passenger air transport), 51210 (freight air transport) and 61100-61900 (telecommunications).

As was previously mentioned (section 2.5.3.2) in the context of the behavioural theory of the firm (Cyert and March (1992)), there may be unwritten conventions on good practice in risk management within industry sectors. In order to control for this, dummy variables are included for the industry sectors with ten or more firms in the sample, as follows: "Mining and Quarrying" (SIC codes 05100-09900); "Manufacturing" (SIC codes 10110-33200); "Construction" (SIC codes 41100-43900); "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles" (SIC codes 45100-47990); "Accommodation and Food Service Activities" (SIC codes 55100-56300); "Professional, Scientific and Technical Activities" (SIC codes 69100-75000); and "Administrative and Support Service Activities" (SIC codes 77100-82900)[81].

[81] No dummy variable was included for "Information and Communication" as there is a significant overlap with "Category 2 Responders".

6.4.5 Summary of Variable Definitions

Table 6.4 – Definitions of Explanatory and Control Variables

Risk Measure	Definition
Debt to MVE	(Short term loans and overdrafts + long term liabilities) / market capitalisation. Annual ratios averaged over the period 2006-10.
Liquidity	(Current assets - current liabilities) / total assets. Annual ratios averaged over the period 2006-10.
Market to Book Value	Market capitalisation (averaged over the period 2006-10) / book value of equity (averaged over the same period.
Tangible Assets	1-(Intangible assets / total assets). Annual ratios averaged over the period 2006-10.
Effective Tax Rate	Profit before tax (summed over the period 2006-10) / total tax paid (summed over the same period).
Institutional Ownership	1 – the proportion of private ownership as of July 2011.
Profit Risk	Outputs from the PCA in Chapter Four for the time period 2006-10.
Market Risk	
Cashflow Risk	
R&D Intensity	R&D expenditure / book value of equity. Annual ratios averaged over the period 2006-10.
Size	Ln [number of employees (averaged over the period 2006-10)]
Financial Services Dummy	1 for SIC codes 64110-66300 (inclusive); 0 otherwise.
Critical National Infrastructure Dummy	1 for SIC codes 35110-37000, 49100-49310, 51100, 51210 and 61100-61900 (all inclusive); 0 otherwise.

6.4.6 Descriptive Statistics

Descriptive statistics for the explanatory and control variables are shown in table 6.5.

Table 6.5 – Descriptive Statistics for Explanatory and Control Variables

	N	Mean	Median	Min	Max	SD	MAD	Skewness	Kurtosis
Debt to MVE	265	1.09	0.397	0.000389	39.3	3.13	0.413	8.38	91.3
Liquidity	265	0.0791	0.0594	-0.547	0.805	0.194	0.124	0.789	5.62
Market-to-Book Value	265	4.83	2.18	0.189	123	12.1	0	6.48	52.3
Tangible Assets	265	0.793	0.870	0.0953	1	0.210	1.79	-0.876	2.88
Effective Tax Rate	265	0.311	0.275	0	6.58	0.482	0.0809	9.75	117
Institutional Ownership	265	0.944	0.995	0.190	1	0.127	0.00682	-3.14	13.7
Profit Risk	229	-1.15	0.0499	-135	7.92	10.6	1.16	-9.06	112
Market Risk	229	5.88	5.13	1.78	16.2	3.34	1.59	2.73	16.9
Cashflow Risk * R&D Intensity[82]	229	-1.82	0	-326	0.00857	21.6	0	-14.7	221
Size	265	8.10	8.50	1.39	13.3	2.56	2.20	-0.987	3.72

[82] The median and MAD values are impacted by the high proportion of zeros in the distribution of R&D intensity.

As in previous chapters, the distributions of some variables depart very noticeably from the normal distribution. In particular, the distributions of debt-to-market value of equity and effective tax rate are both highly positively skewed; the distributions of profit risk and the interaction between cashflow risk and R&D intensity are both very negatively skewed; and all four distributions exhibit very high kurtosis. In order to understand these distributions better, quantile plots are shown in figs. 6.2 to 6.5.

Fig. 6.2 – Quantile Plot of Debt-to-Market Value of Equity

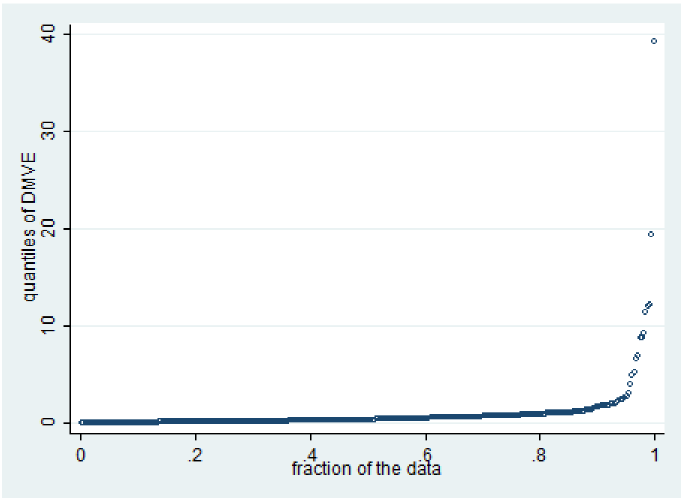


Fig. 6.3 – Quantile Plot of Effective Tax Rate

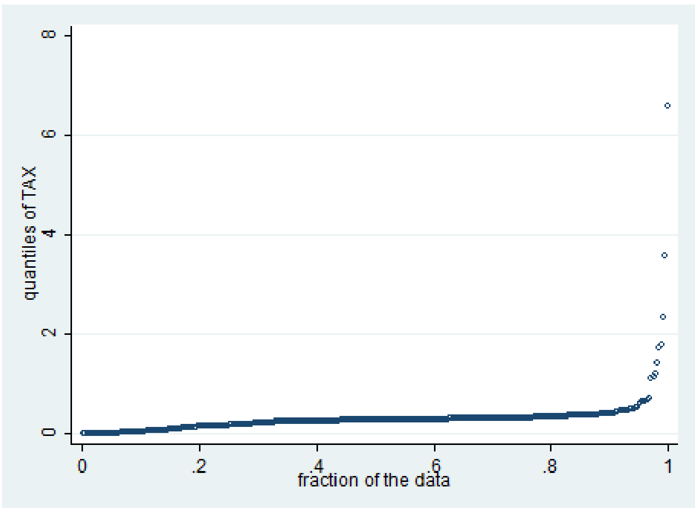


Fig. 6.4 – Quantile Plot of Profit Risk

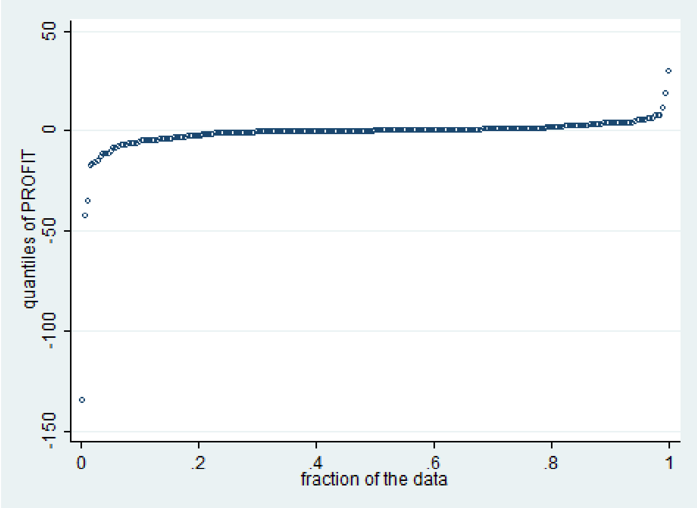
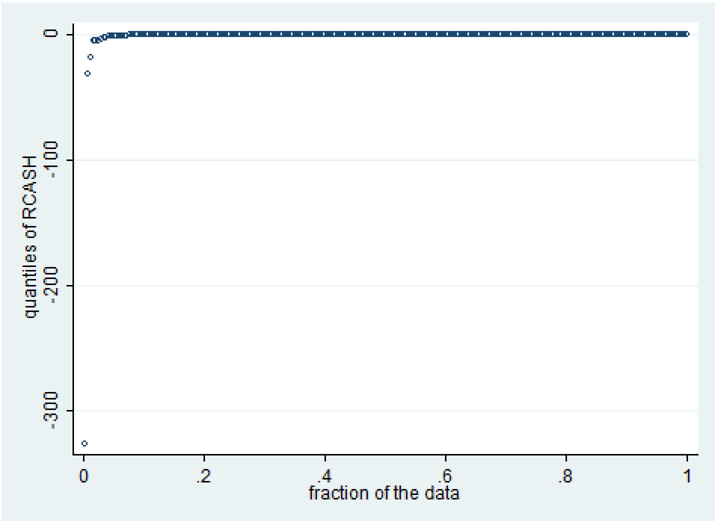


Fig. 6.5 – Quantile Plot of Cashflow Risk * R&D Intensity



In addition, various percentiles of the four distributions are shown in table 6.6, expressed in terms of median absolute deviations from the median (the customary measure of standard deviations from the mean is not appropriate as neither of these estimators are themselves robust to outliers). In each case it is clear that there are small numbers (5 to 10) of extreme outliers, the inclusion or removal of which may greatly affect any regression results.

Table 6.6 – Quantiles of Debt to Market Value of Equity, Effective Tax Rate, Profit Risk[83] (Expressed in Median Absolute Deviations from the Median)

	1%	**2%**	**3%**	**4%**	**5%**	**95%**	**96%**	**97%**	**98%**	**99%**
Debt to MVE	-0.958	-0.952	-0.926	-0.910	-0.882	8.20	12.8	20.1	24.9	34.4
Effective Tax Rate	-3.40	-3.39	-3.333	-3.28	-3.21	3.87	4.61	5.31	11.2	26.3
Profit Risk	-34.9	-14.7	-12.9	-9.91	-9.14	4.71	5.05	5.66	6.68	14.2

The Spearman correlation coefficients of the explanatory and control variables are shown in table 6.7. It is important to note that, in particular, the three controls variables for risk exposure have a number of highly significant correlations with the explanatory variables. This is not surprising given that these control variables are linear combinations of a number of risk measures, including the explanatory variables in this study; the correlations may however have important implications for the conduct of regression analysis (see section 6.5).

[83] It is not possible to calculate this measure for the interaction of cashflow risk and R&D intensity because of the zero value of MAD.

Table 6.7 – Correlation of Explanatory and Control Variables

	Debt to MVE	Liquidity	Market-to-Book Value	Intangible Assets	Effective Tax Rate	Institutional Ownership	Profit Risk	Market Risk	Cashflow Risk * R&D Intensity	Size
Debt to MVE	1									
Liquidity	-0.27***	1								
Market-to-Book Value	-0.30***	0.01	1							
Tangible Assets	0.03	-0.01	-0.42***	1						
Effective Tax Rate	0.07	0.14*	0.18**	-0.13*	1					
Institutional Ownership	0.14*	-0.16*	0.01	0.02	-0.12	1				
Profit Risk	-0.06	-0.02	-0.51***	0.45***	-0.02	-0.11	1			
Market Risk	0.42***	0.13*	-0.10	-0.08	0.12	-0.03	-0.12	1		
Cashflow Risk * R&D Intensity	-0.06	-0.06	-0.20**	0.35***	0.02	-0.25***	0.55***	-0.20**	1	
Size	0.31***	-0.19**	0.27***	-0.44***	0.17**	0.19**	-0.41***	0.05	-0.21**	1

1. Table 6.7 reports the Spearman correlation coefficients between each pair of independent variables.
2. All variable definitions are given in sections 6.4.3 and 6.4.4 and summarised in Table 6.4.
3. Significance levels are indicated as follows: * $p < .05$, ** $p<.01$, *** $p<.001$.

6.5 Method and Results

In common with previous studies based on the announcement of the appointment of a CRO (eg Pagach and Warr (2011)), this section begins by developing a binary outcome model; which is then estimated with a probit regression using both the employment of one or more members of the IRM and one or more members of the BCI as the dependent variable. However, managing risk is not in reality a binary decision: all firms manage risk (even if they have no formal processes for doing so) but some firms manage risk more than others. Therefore, in order to study the intensity of risk management, count-data models are also estimated using the actual number of IRM (or BCI) members employed as the dependent variable.

6.5.1 Binary Outcome Model

6.5.1.1 Developing the Binary Outcome Model

The following binary outcome models are estimated using a probit model:

$$IRM_i = f\{\text{explanatory variables}_i, \text{control variables}_i\} + \varepsilon_i \qquad (6.1)$$

$$BCI_i = g\{\text{explanatory variables}_i, \text{control variables}_i\} + \varepsilon_i \qquad (6.2)$$

Where IRM is a binary variable which takes the value one if the firm employs one or more members of the IRM (Certificant and above); BCI is a binary variable that takes the value one if the firm employs one or more BCI members (Associate and above); the explanatory and control variables are defined in sections 6.4.3 and 6.4.4 respectively; and ε_i is a random error term.

It is possible that ERM or BCM might be used simply to reduce net risk; so there is a potential issue of reverse causality in having controls for risk exposure in the model. In order to test for endogeneity it is necessary to instrument the variables of concern: following the approach of Peters and Wagner (2014), these variables could potentially be instrumented using their respective weighted averages for each industry sector. Firm values for profit risk and market risk were weighted by "Turnover" (FAME field 1), averaged over the period 2006-10, to calculate sector averages for each of the 21 sections within the SIC classification. In order to improve robustness to outliers, median values of the profit risk and market risk for each industry sector were also investigated as potential instruments; the results of OLS regressions using each set of potential instruments for profit risk and market risk are shown in table 6.8.

Table 6.8 – Results of OLS Regression of Sector Weighted Averages and Sector Medians on Profit Risk and Market Risk

	Profit Risk	**Market Risk**	**Profit Risk**	**Market Risk**
Sector Median of Profit Risk	2.509***	-0.075		
	(6.88)	(-0.61)		
Sector Median of Market Risk	0.948	0.807***		
	(1.43)	(3.64)		
Weighted Average of Profit Risk			0.872***	-0.052
			(8.13)	(-1.36)
Weighted Average of Market Risk			0.726*	0.096
			(2.15)	(0.81)
N	229	229	229	229
Wald Test of Joint Significance	F(2,226)=23.8	F(2,226)=8.15	F(2,226)=33.1	F(2,226)=1.74
p> $X^2(2)$	0.000	0.000	0.000	0.18
R^2	0.17	0.07	0.23	0.02

1. Table 6.8 reports results of the estimation of OLS regressions of two sets of potential instruments for profit risk and market risk.
2. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
3. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

The sector medians appear to be much better instruments, and were therefore used as the instruments in a Smith and Blundell (1986) test of the exogeneity of profit risk and market risk. As can be seen from table 6.5 (and illustrated in figs. 6.2-6.4) debt-to-market value of equity, effective tax rate, profit risk and the interaction between cashflow risk and R&D intensity all had highly skewed distributions. Because of the possibility for results to be unduly influenced by extreme outliers, regressions were performed with the full sample and with two Winsorized samples; in which observations with the lowest and highest 1% (2.5%) of values[84] of debt-to-market value of equity, effective tax rate, profit risk and the interaction between cashflow risk and R&D intensity were removed. The results are shown in table 6.9.

Table 6.9 – Results of Smith and Blundell (1986) Test of Exogeneity in a Probit Model

Dependent Variable		Full Sample	Winsorized (1%)	Winsorized (2.5%)
IRM	S&B X^2 Test Statistic (2df)	0.230	2.00	2.31
	p> $X^2(2)$	0.89	0.37	0.32
BCI	S&B X^2 Test Statistic (2df)	2.48	2.73	2.35
	p> $X^2(2)$	0.29	0.26	0.31

1. Table 6.9 reports results of the Smith and Blundell (1986) test of exogeneity in a probit model.
2. The dependent variable is the employment of one or more members of the IRM/BCI.
3. The test was conducted using the user-defined STATA function probexog (Baum et al (2003)).
4. The null hypothesis is that all variables of interest are exogenous.

Based on the results of the Smith-Blundell test (table 6.9), the probit regressions were conducted without instrumental variables. However, given the high correlation between some of the explanatory variables (see table 6.7), the extent to which multicollinearity might be affecting the results was also investigated by calculating the variance inflation factors; the results for each of the three samples are shown below.

[84] Note that there are a large number of zeros in the distributions of effective tax rate so a lower cut-off point cannot always be identified.

Table 6.10 – Variance Inflation Factors

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Profit Risk	7.26	4.20	4.49
R&D Intensity * Cashflow Risk	6.70	3.99	3.43
Market Risk	2.64	2.12	1.72
Financial Services	2.39	2.27	2.05
Debt to MVE	2.08	2.02	1.66
Size	1.87	2.04	1.87
Tangible Assets	1.55	1.55	1.56
Market-to-Book	1.51	1.65	1.24
Construction	1.51	1.54	1.67
Liquidity	1.48	1.38	1.45
Manufacturing	1.41	1.38	1.41
Retail	1.34	1.38	1.36
Mining	1.31	1.37	1.37
Critical National Infrastructure	1.26	1.16	1.18
Accommodation and Food Services	1.26	1.30	1.30
Administration and Support Services	1.16	1.19	1.18
Professional Services	1.14	1.17	1.21
Institutional Ownership	1.10	1.09	1.11
Effective Tax Rate	1.09	1.30	1.21
Mean VIF	**2.11**	**1.79**	**1.71**

1. Table 6.10 reports the variance inflation factors calculated using the Stata vif function (uncentred).

There is clearly a degree of multicollinearity so it is important to bear in mind the potential for standard errors and t-statistics to be slightly inflated. However, no individual VIF values are particularly high so it is not possible to significantly reduce the mean VIF by simply dropping the variables with the highest VIF values.

6.5.1.2 Probit Regression Results

The results of the probit regressions with employment of one or more members of the IRM and employment of one or more members of the BCI as the dependent variables are reported in tables 6.11 and 6.12 respectively.

Table 6.11 – Results of Probit Regression with Employment of one or more Members of the IRM as the Dependent Variable

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Debt to MVE	0.077	0.721**	0.679**
	(0.85)	(3.29)	(2.68)
Liquidity	-0.145	-0.215	-0.196
	(-0.22)	(-0.28)	(-0.25)
Market-to-Book	0.010	0.028*	0.043*
	(1.18)	(2.33)	(2.25)
Tangible Assets	2.450***	2.295**	2.326**
	(3.61)	(3.23)	(3.20)
Effective Tax Rate	0.058	-0.695	-1.136
	(0.29)	(-1.04)	(-1.09)
Institutional Ownership	5.617**	5.999**	6.535**
	(3.13)	(2.68)	(2.65)
Profit Risk	0.019	-0.010	0.051
	(0.75)	(-0.16)	(0.61)
Market Risk	0.026	-0.023	-0.032
	(0.48)	(-0.32)	(-0.41)
R&D Intensity * Cashflow Risk	-0.008	0.174	-0.237
	(-0.74)	(1.24)	(-0.65)
Size	0.271***	0.272***	0.262***
	(4.34)	(3.97)	(3.78)
Constant	-10.964***	-11.311***	-11.688***
	(-4.73)	(-4.17)	(-4.11)
N	219	209	188
Wald Test of Joint Significance (18df)	74.9	66.9	49.7
$p > X^2(18)$	0.000	0.000	0.000
Pseudo-R^2	0.27	0.36	0.30
Wald Test of Joint Significance (8df)	7.93	9.13	9.73
$p > X^2(8)$	0.44	0.33	0.28

1. Table 6.11 reports the parameter estimates from the estimation of equation (6.1) using probit regression.
2. The dependent variable is "1" if the firm employs one or more members of the IRM as of July 2011. Definitions of explanatory and control variables are given in section 6.4.3 and 6.4.4 and summarised in Table 6.4.
3. Parameter estimates for the industry dummies are not reported but the result of a Wald test of joint significance is. Note that it is not possible to estimate a parameter for the accommodation and food services industry dummy so this test has only eight degrees of freedom. Note also that the ten observations from this sector are automatically dropped.
4. Pseudo-R^2 is McFadden's (1974) likelihood ratio index (see below for a discussion).
5. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 6.12 – Results of Probit Regression with Employment of one or more Members of the BCI as the Dependent Variable

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Debt to MVE	0.329**	0.309**	0.444**
	(3.22)	(2.91)	(2.91)
Liquidity	-0.632	-0.699	-0.334
	(-0.96)	(-1.03)	(-0.48)
Market-to-Book	0.032**	0.035**	0.050**
	(3.05)	(3.01)	(3.06)
Tangible Assets	1.126	1.293+	1.142
	(1.57)	(1.75)	(1.46)
Effective Tax Rate	-0.699	-0.630	-0.484
	(-0.90)	(-0.73)	(-0.41)
Institutional Ownership	1.226	1.073	1.056
	(0.70)	(0.53)	(0.51)
Profit Risk	0.020	-0.043	0.064
	(0.48)	(-0.74)	(0.95)
Market Risk	-0.370***	-0.380***	-0.420***
	(-5.43)	(-5.11)	(-5.30)
R&D Intensity * Cashflow Risk	-0.040*	0.092	-0.538+
	(-2.32)	(0.77)	(-1.73)
Size	0.312***	0.291***	0.328***
	(4.57)	(4.11)	(4.31)
Constant	-4.628*	-4.427+	-4.720+
	(-2.14)	(-1.88)	(-1.85)
N	229	219	197
Wald Test of Joint Significance (19df)	88.3	60.5	54.3
p > X^2(19)	0.000	0.000	0.000
Pseudo-R^2	0.38	0.36	0.36
Wald Test of Joint Significance (9df)	7.81	7.64	8.58
p > X^2(9)	0.55	0.57	0.48

1. Table 6.12 reports the parameter estimates from the estimation of equation (6.1) using probit regression.
2. The dependent variable is "1" if the firm employs one or more members of the BCI as of July 2011. Definitions of explanatory and control variables are given in section 6.4.3 and 6.4.4 and summarised in Table 6.4.
3. Parameter estimates for the industry dummies are not reported but the result of a Wald test of joint significance is.
4. Pseudo-R^2 is McFadden's (1974) likelihood ratio index (see below for a discussion).
5. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

The parameter estimates for key variables are fairly consistent across the different samples (tables 6.11 and 6.12); suggesting that the results are not unduly influenced by a small number of outliers. In all cases the null hypothesis that the parameter estimates are jointly insignificant can be rejected; however the null hypothesis that the parameter estimates for the industry dummies are jointly insignificant cannot be rejected in any of the regressions. The pseudo-R^2 values (McFadden's (1974) likelihood ratio index) are marginally higher for the regressions with employment of one or more members of the BCI as the dependent variable (36-38%) than those with employment of one or more members of the IRM as the dependent variable (27-36%). Some care must be taken in the interpretation of these values, whilst bounded by 0 and 1, the likelihood ratio index is not a measure of the proportion of variance explained by the model; Windmeijer (1995, p.105) shows instead that it represents the "empirical percentage uncertainty explained". It is also important to highlight an issue with this model due to the unbalanced nature of the sample: only 14.4% of firms in the sample employ one or more members of the IRM; and only 16.2% of firms in the sample employ one or more members of the BCI. In these circumstances it is found that the estimated prediction probabilities for firms not employing an IRM (BCI) member will be higher, potentially very much higher, than the estimated prediction probabilities for firms employing an IRM (BCI) member (Cramer (1999))[85].

Both regressions show support for theories that development of a risk management capability is driven by considerations of protecting shareholder value. Firstly, there are significant positive parameter estimates for debt to MVE with all but one sample (in support of hypothesis 1). There are also significant positive parameter estimates for market-to-book value in all but one sample, in support of hypotheses 3a and 3b:

[85] This also means that goodness-of-fit measures based on prediction probabilities are problematic with unbalanced samples.

the competing hypotheses 3c and 3d are thus rejected. The parameter estimates for liquidity were all negative, as predicted by hypothesis 2, but universally insignificant; and the parameter estimates for effective tax rate varied in sign and were all insignificant, so there is no support for hypothesis 5. There are also significant positive parameter estimates for the proportion of tangible assets and the proportion of institutional ownership in all the regressions with IRM members as the dependent variable (in support of hypotheses 4a and 6a); but the parameter estimates are insignificant (although universally positive) in all the regressions with BCI members as the dependent variable.

As regards the control variables, the parameter estimates for the three risk exposure controls are all insignificant for the regressions with IRM members as the dependent variable. However, in the regressions with BCI members as the dependent variable there is a negative and highly significant negative parameter estimate for market risk with all three samples: this will be discussed further in section 6.6.1. There is also a moderately significant negative parameter estimate for the interaction of cashflow risk and R&D intensity in the regression with BCI members as the dependent variable using the whole sample. The parameter estimates for size were all positive and highly significant, as expected from the structure of the model. As remarked above, the parameter estimates for the industry sector dummies were jointly insignificant in all regressions.

6.5.2 Count-Data Models

6.5.2.1 Developing the Count-Data Models

As stated previously, managing risk is not, in reality, a binary decision. In order to understand the inter-firm variation in the intensity of risk management (and to enable) more direct comparisons with previous studies based on the extent to which insurance or derivatives are used (eg Haushalter (2000)); it is desirable to also analyse the total number of IRM or BCI members employed by each firm. The following count-data models were therefore estimated.

$$IRM_i = f\{\text{explanatory variables}_i, \text{control variables}_i\} + \varepsilon_i \qquad (6.3)$$

$$BCI_i = g\{\text{explanatory variables}_i, \text{control variables}_i\} + \varepsilon_i \qquad (6.4)$$

Where IRM is the number of IRM members (Certificant and above) employed by the firm; BCI is the number of BCI members (Associate and above) employed by the firm; the explanatory and control variables are defined in sections 6.4.3 and 6.4.4 respectively; and ε_i is a random error term.

Inspection of fig. 6.1 would suggest that the distributions of IRM and BCI members may be over-dispersed so a formal test was conducted, based on regressing the generated dependent variable on the estimated mean: a significant parameter estimate indicates over-dispersion (Cameron and Trivedi (2005, p.670)). The results of this test with each sample are shown in table 6.13.

Table 6.13 – Mean and Standard Deviation of IRM and BCI Members per Firm

		Full Sample	**Winsorized (1%)**	**Winsorized (2.5%)**
Dependent Variable IRM Members	t	1.16	0.97	1.35
	p>t	0.25	0.33	0.18
Dependent Variable BCI Members	t	0.80	1.80	2.50
	p>t	0.42	0.07	0.01

1. Table 6.13 reports the results of a Cameron and Trivedi (2005) test for over-dispersion.
2. A significant parameter estimate indicates over-dispersion.

The results would suggest that the number of BCI members is significantly over-dispersed in the Winsorized samples; a Poisson regression is therefore not appropriate to estimate equation 6.4 in these cases, and a negative binomial regression was also used.

6.5.2.2 Poisson and Negative Binomial Regression Results

The results of the Poisson regressions to estimate equation 6.3 and 6.4, and negative binomial regression to estimate equation 6.4, are shown in tables 6.14 to 6.16.

Table 6.14 – Results of Poisson Regression with IRM Members per Firm as the Dependent Variable

	Full Sample	**Winsorized (1%)**	**Winsorized (2.5%)**
Debt to MVE	0.115	0.166+	0.318*
	(1.18)	(1.73)	(2.57)
Liquidity	0.084	-0.312	0.357
	(0.13)	(-0.43)	(0.47)
Market-to-Book	0.012*	0.014*	0.019*
	(2.21)	(2.58)	(2.47)
Tangible Assets	3.360***	3.001***	2.841***
	(3.80)	(3.52)	(3.35)
Effective Tax Rate	-0.058	-0.208	-1.591
	(-0.13)	(-0.18)	(-1.28)
Institutional Ownership	7.321*	6.991*	6.869*
	(2.30)	(2.33)	(2.35)
Profit Risk	0.019	-0.006	0.036
	(0.61)	(-0.08)	(0.38)
Market Risk	-0.126	-0.129	-0.158
	(-0.78)	(-0.70)	(-0.88)
R&D Intensity * Cashflow Risk	-0.020	0.076	-0.230
	(-1.37)	(0.39)	(-0.52)
Size	0.342***	0.282***	0.320**
	(4.04)	(4.32)	(3.23)
Constant	-13.446***	-12.339***	-12.090***
	(-3.85)	(-3.74)	(-3.94)
N	229	219	197
Wald Test of Joint Significance (19df)	2500	2130	1520
$p > X^2(19)$	0.000	0.000	0.000
Pseudo-R^2	0.24	0.23	0.17
Wald Test of Joint Significance (9df)	1420	1260	1210
$p > X^2(9)$	0.000	0.000	0.000

1. Table 6.14 reports results of the estimation of equation (6.3) with Poisson regression.
2. The dependent variable is the number of IRM members employed by each firm as of July 2011. Definitions of explanatory and control variables are given in section 6.4.3 and 6.4.4 and summarised in Table 6.4.
3. Parameter estimates for the industry sectors dummy variables are not reported but the result of a Wald test of joint significance (with 9 degrees of freedom) is.
4. Pseudo-R^2 is based on log-likelihoods, note that Pseudo-$R^2_{max} < 1$.
5. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 6.15 – Results of Poisson Regression with BCI Members per Firm as the Dependent Variable

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Debt to MVE	0.420***	0.533***	0.371
	(5.42)	(5.52)	(1.59)
Liquidity	-1.211	-2.289*	-1.707
	(-1.19)	(-2.00)	(-1.37)
Market-to-Book	0.039***	0.042***	0.046***
	(5.85)	(6.48)	(5.31)
Tangible Assets	0.759	0.673	0.497
	(0.82)	(0.78)	(0.55)
Effective Tax Rate	-0.091	-0.512	-0.476
	(-0.15)	(-0.36)	(-0.25)
Institutional Ownership	5.242	5.202	5.597
	(1.03)	(0.93)	(0.97)
Profit Risk	-0.015	-0.078	0.021
	(-0.33)	(-0.99)	(0.22)
Market Risk	-0.583***	-0.647***	-0.663***
	(-4.87)	(-5.11)	(-4.59)
R&D Intensity * Cashflow Risk	-0.045*	0.023	-0.543
	(-2.49)	(0.14)	(-1.58)
Size	0.472***	0.376***	0.366***
	(4.10)	(3.90)	(3.40)
Constant	-9.820+	-8.635	-8.750
	(-1.85)	(-1.51)	(-1.51)
N	229	219	197
Wald Test of Joint Significance (19df)	1020	301	142
$p > X^2(19)$	0.000	0.000	0.000
Pseudo-R^2	0.66	0.51	0.45
Wald Test of Joint Significance (9df)	24.0	21.1	20.8
$p > X^2(9)$	0.004	0.01	0.01

1. Table 6.15 reports results of the estimation of equation (6.4) with Poisson regression.
2. The dependent variable is the number of BCI members employed by each firm as of July 2011. Definitions of explanatory and control variables are given in section 6.4.3 and 6.4.4 and summarised in Table 6.4.
3. Parameter estimates for the industry sector dummy variables are not reported but the result of a Wald test of joint significance (with 9 degrees of freedom) is.
4. Pseudo-R^2 is based on log-likelihoods, note that Pseudo-$R^2_{max} < 1$.
5. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
6. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

Table 6.16 – Results of Negbin Regression with BCI Members per Firm as the Dependent Variable

	Full Sample	Winsorized (1%)	Winsorized (2.5%)
Debt to MVE	0.444***	0.508***	0.430+
	(4.69)	(4.90)	(1.91)
Liquidity	-1.511	-1.962+	-1.505
	(-1.45)	(-1.74)	(-1.32)
Market-to-Book	0.039***	0.042***	0.048***
	(5.87)	(6.32)	(5.22)
Tangible Assets	1.212	1.232	0.893
	(1.25)	(1.22)	(0.84)
Effective Tax Rate	-0.302	-0.464	-0.177
	(-0.48)	(-0.39)	(-0.10)
Institutional Ownership	3.849	3.511	3.714
	(0.80)	(0.67)	(0.68)
Profit Risk	-0.012	-0.081	0.029
	(-0.25)	(-1.12)	(0.33)
Market Risk	-0.591***	-0.639***	-0.655***
	(-5.31)	(-5.46)	(-5.27)
R&D Intensity * Cashflow Risk	-0.047*	0.042	-0.534+
	(-2.46)	(0.27)	(-1.66)
Size	0.479***	0.420***	0.423***
	(5.01)	(4.42)	(4.17)
Constant	-8.673+	-7.750	-7.813
	(-1.71)	(-1.46)	(-1.40)
N	229	219	197
Wald Test of Joint Significance (19df)	879	194	130
$p > X^2(19)$	0.000	0.000	0.000
Wald Test of Joint Significance (9df)	17.9	17.0	16.0
$p > X^2(9)$	0.04	0.05	0.07

1. Table 6.16 reports results of the estimation of equation (6.4) with negative binomial regression.
2. The dependent variable is the number of BCI members employed by each firm as of July 2011. Definitions of explanatory and control variables are given in section 6.4.3 and 6.4.4 and summarised in Table 6.4.
3. Parameter estimates for the interaction terms between industry sector and unsystematic risk are not reported but the result of a Wald test of joint significance (with 9 degrees of freedom) is.
4. Heteroscedastic-robust t-statistics are shown in parentheses (2 decimal places).
5. Significance levels are indicated as follows: + p<.1, * p < .05, ** p<.01, ***p<.001.

The parameter estimates for key variables in the Poisson regressions (tables 6.14 and 6.15) are fairly consistent across the different samples; the parameter estimates for Poisson and negative binomial regressions (tables 6.15 and 6.16) are also very consistent. In all cases, the null hypothesis that the parameter estimates are jointly insignificant can be rejected; the null hypothesis that the parameter estimates for the industry dummies are jointly insignificant can also be rejected in the Poisson regressions, but not in the negative binomial regression with BCI members as the dependent variable (table 6.16). The Pseudo-R^2 values in the Poisson regressions are much higher for the regressions with employment of one or more members of the BCI as the dependent variable (0.45 to 0.66) than those with employment of one or more members of the IRM as the dependent variable (0.17 to 0.24).

The sign and significance of the parameter estimates are also largely consistent with the results of the probit regressions in section 6.5.1 (tables 6.11 and 6.12). All three regressions have significant positive parameter estimates for market-to-book value with all samples; and significant positive parameter estimates for debt-to-market values of equity with at least one sample. The parameter estimates for liquidity were generally negative (with one significant negative value in the Poisson regression with BCI members as the dependent variable); and the parameter estimates for effective tax rate were all negative and insignificant. There are also significant positive parameter estimates for the proportion of tangible assets and the proportion of institutional ownership in the Poisson regressions with IRM members as the dependent variable; and the parameter estimates are insignificant (although universally positive) in all the regressions with BCI members as the dependent variable. As regards the control variables, the parameter estimates for the three risk exposure controls are all insignificant for the regressions with IRM members as the dependent variable. However, in the regressions with BCI members as the dependent variable there are negative and highly significant negative parameter estimates for market risk with all three samples in both the Poisson and negative binomial regression. There is also a moderately significant negative parameter estimate for the interaction of cashflow risk and R&D intensity in both regressions with BCI members as the dependent variable using the whole sample. The parameter estimates for size were all positive and highly significant, as expected from the structure of the model.

6.6 Discussion

This study set out to understand the drivers for the development of a risk management capability, amongst firms in the UK FTSE 350, by analysing their employment of members of the IRM and BCI. It was argued that these measures are more useful proxies for a firm's risk management capability in this context than the possession of specific financial assets, such as insurance or derivatives contracts, or the announcement of the creation of a CRO position. The initial analysis consisted of a binary outcome regression based on a distinction between firms that employed one or more members of the IRM/BCI and those that didn't; this was complemented by count-data regressions based on the total number of IRM/BCI members employed by each firm. The results of the two analyses were very consistent and will therefore be discussed together below.

6.6.1 Development of Theory

The main finding of this study is the strong support for the traditional arguments for the adoption of risk management, based on protecting value for firm owners (eg Smith and Stultz (1985)). In particular there was a positive (and generally statistically significant) association between both debt-to-market value of equity and market-to-book value and the development of a risk management capability in all tests: thus, both the likelihood and expected costs of financial distress appear to be important drivers. This finding is consistent with a considerable body of previous empirical work, including: Nance et al (1993), Géczy et al (1997), Haushalter (2000), Liebenberg and Hoyt (2003), Aunon-Nerin and Ehling (2008), Hoyt and Liebenberg (2011) and Pagach and Warr (2011).

The study also found, as predicted, that the development of an ERM capability was positively associated with the proportion of tangible assets (there was also a positive effect on the development of a BCM capability but this was not significant); in support of the argument that ERM is primarily applicable to mitigating the risks to tangible assets. In addition, and in line with the findings of Hoyt and Liebenberg (2011) and Pagach and Warr (2011), firms with a higher proportion of institutional investors were found to be significantly more likely to be developing an ERM capability (there was also a positive effect on the development of a BCM capability but this was not significant). This supports the argument that institutional investors value formal risk management processes. Specifically, these results suggest that institutional investors view the adoption of ERM as a signal of good corporate governance; but it is not clear if BCM is viewed in the same way.

As regards risk exposure, there was no evidence that risk exposure was a significant driver of the decision to develop an ERM capability; however, there was strong evidence of a negative association between market risk and the development of a BCM capability. This observation can be understood if one considers that investors expect higher returns from firms that experience higher market risk, so managers must set a higher benchmark return for investing in projects. It is therefore less likely that a BCM project will meets the required level of return to be approved in a high market risk firm.

6.6.2 Practical Implications

As observed in Chapter One, considerable heterogeneity persists in risk management capabilities across firms. The appropriateness of firms' risk management capabilities are of significant interest to shareholders and, by extension, to anybody whose pension fund is invested in the stock market. The finding that the observed heterogeneity in risk management capabilities can largely be explained by considerations of the likelihood and expected costs of financial distress is therefore very positive; in that it suggests that managers of firms are acting, as they should, in the interests of shareholders. However, the finding that the proportion of institutional investors is a significant driver of the development of ERM capabilities could either suggest that managers require some prompting to carry out their fiduciary responsibilities in this regard; or that institutional investors are requiring managers to develop risk management capabilities in excess of what is required in pursuit of corporate legitimacy (Power (2007)). The fact that there was no significant effect of institutional ownership on the development of BCM capabilities would tend to favour the latter; but either explanation has important implications for corporate governance. Finally, the fact that there was no significant association between the proportion of tangible assets and the development of BCM capabilities would suggest that there is now a recognition that BCM is an effective approach to managing a broad range of risks to the firm (Young (2011)); rather than simply a means of mitigating threats to physical assets (eg buildings and IT systems).

6.6.3 Areas for Further Research

Despite the useful insights provided by this study, there is one obvious area where further work could usefully be conducted in order to better understand the heterogeneity of risk management capabilities across firms. As discussed in section 6.2.3, the choice of dependent variable in this study precluded any meaningful analysis of the relationship between firm size and the propensity to adopt risk management; and the restriction of the sample to FTSE 350 firms means that the results cannot be generalised to smaller firms anyway. Thus it was impossible to resolve the contradiction between theoretical arguments based on the costs of financial distress and convexity of tax function, which predict that managers in smaller companies should be more likely to adopt risk management; and the majority of empirical evidence that larger companies tend to engage more in risk management. However, this remains an important issue to resolve. It would also be of great interest to examine the relationship between risk management and firm performance; as Gordon et al (2009) found with their contingency model, it is likely that value creation is dependent on the correct fit between the firm, the environment in which it operates and the extent of its risk management. The measurement of the relationship between risk management and performance is discussed further in section 7.5.

Appendix 1 – The Institute of Risk Management and The Business Continuity Institute

The Institute of Risk Management and Business Continuity Institute are, respectively, the preeminent professional bodies for ERM and BCM practitioners working in the private sector in the UK. Critically, for the purposes of this study, they have well-established and rigorous entry criteria, requiring new members to demonstrate both knowledge and professional experience. As discussed extensively in section 6.3.1, whilst employment of such an IRM or BCI member doesn't in itself constitute a risk management capability; at the very least, it indicates an intention to build such a capability.

The Institute of Risk Management

"The Institute of Risk Management (IRM) is the world's leading enterprise-wide risk education Institute" (IRM website). It focuses primarily on delivering training and providing professional recognition in risk management, but it also represents a professional network for its members. The IRM defines risk management, in line with the general concept of ERM, as follows:

> *"…the process whereby organisations methodically address the risks attaching to their activities with the goal of achieving sustained benefit within each activity and across the portfolio of all activities."* (IRM (2002, p.2))

At the time of the study,[86] there were six classes of IRM membership, as follows.

Fellow - Fellowship is open to all full members of the Institute who hold the MIRM designation. It is achieved by demonstrating the achievement of 250 Continuing Professional Development (CPD) points and having at least five years risk

[86] Membership information was downloaded from the IRM website on 8th November 2012; the IRM significantly revised its membership structure in 2014.

management experience, two of which must have been achieved while a Member of the Institute.

Member - IRM full membership is recognised worldwide as the hallmark of a risk management professional. It is awarded to those who have successfully completed the International Diploma in Risk Management and who have 3 years relevant professional experience.

Certificant - members who have successfully completed the IRM International Certificate in Risk Management may apply to become Certificant members of the Institute.

Specialist - members who have completed the Risk Management in Financial Services qualification or completed one of the specialist modules of the International Diploma and who have 5 year's risk management experience may apply for Specialist Membership and the use of the designation SIRM.

Affiliate membership is open to those working in risk management, or those with an interest in risk issues, and who wish to be involved in risk management activities as a member of IRM. There are no formal entry requirements for Affiliate membership.

Student membership is available to those wishing to study for the International Certificate in Risk Management or International Diploma in Risk Management.

The Business Continuity Institute

The BCI was founded in 1994 "To enable individual members to obtain guidance and support from fellow business continuity practitioners" (BCI website). The BCI has continued to pursue this aim but it now also offers formal training courses and, critically for this study, professional recognition for its members. In addition, the BCI lobbies governments and other relevant bodies and works directly with companies and public sector organisations through the BCI partnership. BCM has grown out of a number of disciplines concerned with the management of operational disruptions such as Disaster Recovery, Crisis Management and Business Continuity Planning (Herbane (2010)); and is defined as:

> *"[An] holistic management process that identifies potential threats to an organization and the impacts to business operations that those threats, if realized, might cause, and which provides a framework for building organizational resilience with the capability for an effective response that safeguards the interests of its key stakeholders, reputation, brand and value-creating activities*." (BCI (2010, p.3))

At the time of the study[87] there were six classes of BCI membership, as follows:

Fellow – this senior membership grade is currently held by c125 BCM practitioners. Applications or nominations to this grade are considered from very experienced MBCIs or SBCIs who can provide evidence of a significant contribution to the Institute and the BCM discipline. There is no direct entry into Fellowship.

Member – those wishing to attain this well respected certification need to demonstrate experience of working as a BCM practitioner for 3+ years across all six

[87] Membership information was downloaded from the BCI website on 8th November 2012; the BCI removed the Specialist membership grade and added a new membership grade, Associate Fellow, in 2014.

Business Continuity Competencies and hold the BCI Certificate credential of CBCI with merit or other recognised credentials.

Associate Member – this entry level certification is for those with at least one year's general experience within BCM across all six Business Continuity Competencies. Applicants need to obtain a Pass in the BCI Certificate examination or hold other recognised credentials.

Specialist – this membership grade was developed to allow certification to those practitioners who specialise in aspects of BCM or who work in associated disciplines. Two years specialist experience, a Pass in the BCI Certificate examination and a professional qualification from another awarding body will enable the applicant to enter one of the six Specialist Faculties.

Affiliate - this membership is often taken by those very new to the profession who do not yet have the experience to apply for Statutory membership or those who do not work as BCM practitioners but have a general interest in the discipline.

Student - applicants for Student membership are accepted from those who are undertaking a course of study, either full or part time, on a programme of any BCM related subject which leads to a qualification.

Chapter 7 – Conclusions

7.1 Overview

This final chapter aims to integrate the findings of the three separate empirical chapters into a cohesive narrative; from which some overall conclusions can be drawn. The chapter begins by summarising the main findings of each chapter; the overall theoretical contribution of the study is then described; followed by a discussion of the most important implications for practitioners. The penultimate section discusses the limitations of the current research, and suggests some fruitful areas for future work; and the chapter concludes with a short summary.

7.2 Summary of the Main Findings

7.2.1 Chapter Four - Measuring Corporate Risk

One of the first themes to emerge from the discussion in Chapter One was that, in any given situation, different stakeholder groups experience different risks: the investigation of the measurement properties of a variety of corporate risk measures in Chapter Four identified the best ways to measure these different risks. The robust principal component analysis (PCA) of nineteen risk measures yielded a compact set of components (three or four in each time period) that accounted for the majority of variation in each of the six overlapping five-year time periods. Components relating to variability in profits, variability in share price and variability in cashflow were retained in each period; and these were interpreted as “profit risk”, “market risk” and “cashflow risk” respectively. It was argued that profit risk is the most important measure of risk from the point of view of managers, whilst market risk captures a key risk to investors. In 2003-07 an additional component was retained, “distress risk”, which, it was argued, captures an important component of the risk to both lenders and managers. These components were then successfully applied as risk measures in

Chapter Five and Chapter Six; in investigations into the relationship between risk and performance, and the drivers for developing a risk management capability respectively.

It was also evident from the PCA that both the composition and relative importance of the risk components change over time, as a result of changes in the environment; in particular a marked change in the component structure was observed between the 2003-07 and 2004-08 time periods. This is at variance with the findings of Miller and Bromiley (1990), who found a consistent component structure across two non-overlapping five-year periods (1978-82 and 1983-87). It was argued that the change in component structure was a result of the step change in environmental uncertainty that occurred with the onset of the financial crisis in 2008. More forward-looking risk measures (eg beta or unsystematic risk) reacted to the significant change in environmental uncertainty more quickly than rearward-looking measures (eg the standard deviation of ROE or ROA); and thus the relationships between risk measures that had previously existed were disrupted until a new equilibrium is reached. In addition, in the conditions of extreme uncertainty that existed during the financial crisis, some variables simply ceased to be useful measures of risk.

7.2.2 Chapter Five - The Relationship Between Corporate Risk and Performance

Environmental conditions were also seen to be an important mediating factor in the relationships between risk and subsequent performance investigated in Chapter Five; although the precise mechanism of interaction differed depending on which measure of performance was used. A positive relationship between profit risk and future profitability (return on market value of equity) was observed for both high and low-performing firms in the environment of high growth that persisted before the financial crisis. However, as growth opportunities became much reduced and interest rates fell to close to zero, it appeared that managers required a much lower premium to accept risk; indeed managers in poorly-performing firms required no premium at all. This latter observation provides support for the idea of "problemistic search" within the behavioural theory of the firm; but it is interesting to note that this was only observable in the truly exceptional economic conditions arising from the financial crisis. As regards the relationship between market risk and future returns to shareholders; a positive relationship was observed when overall market returns were above the risk-free rate. However, when overall market returns were below the risk-free rate, a negative relationship was observed between risk and realised future returns to shareholders in common with a number of previous studies (eg Pettengill et al (1995)). In addition to the above, relationships between market risk and return on market value of equity, between profit risk and returns to shareholders, and between cashflow risk and returns to shareholders were observed in one or more time periods in the study.

7.2.3 Chapter Six - Risk Management Capabilities in UK FTSE 350 Companies

The finding in Chapter Five of a positive association between risk and subsequent return (at least in normal market conditions) implies that investment in the development of a firm's capability to mitigate "passive" (Merton (2005)) or "non-core" (Nocco and Stultz (2006)) risks would be attractive. In common with many earlier studies, based on various different proxies for risk; the study in Chapter Six found evidence that theories based on protecting value for shareholders were significant in explaining the observed heterogeneity in risk management capabilities amongst firms in the UK FTSE 350. In particular, both the risk of financial distress (proxied by leverage) and the availability of growth opportunities (proxied by market-to-book value) were significant drivers for the development of both an enterprise risk management (ERM) capability and a business continuity management

(BCM) capability. As predicted, the proportion of tangible assets and the proportion of institutional investors in a firm were both found to be significant drivers for the development of an ERM capability too.

7.3 Contribution

The investigation of the measurement properties of a variety of corporate risk measures in Chapter Four makes a contribution in terms of the overall understanding of what different risk measures represent, how they are related and, crucially, that these relationships are not static but are functions of environmental uncertainty. The analysis also identified a set of corporate risk measures, relevant to different stakeholder groups; that can be used in future research, as demonstrated in Chapters Five and Six.

In trying to explain the apparent paradox of the negative relationship between accounting measures of risk and return that he observed; Bowman (1980) suggested that it arose because well-managed firms were able to combine high profitability with low variation in profits: ie the quality of management was a missing variable. Andersen et al (2007) subsequently developed a mathematical model to demonstrate that a "strategic responsiveness" capability, if heterogeneously distributed between firms, gives rise to a negative risk-return relationship. The main contribution from Chapter Five is the finding that, when firm fixed effects are removed (by first-differencing), there is a positive correlation between profit risk (standard deviation of ROA) and subsequent accounting performance (ROA) in the pre-crisis period, as predicted by theory; and no significant correlation thereafter. The results of regression analyses with return on market value of equity as the dependent variable supported these findings, and also suggested that the relationship between profit risk and subsequent profitability is contingent on the prior performance of the firm. The regression analyses with returns to shareholders as the dependent variable confirmed the findings of Pettengill et al (1995), and others, that the relationship between market risk and realised return is contingent on the overall performance of the market.

Chapter Six contributes to an understanding of the observed heterogeneity in risk management capabilities across firms. Specifically, the study provides evidence that, at least within this sample of large, listed UK firms, the desire on the part of managers to develop risk management capabilities (as opposed to simply mitigating specific risks) is driven by traditional arguments based on protecting shareholder value.

In addition to the findings from individual studies, taken as a whole, the thesis makes a further methodological contribution to the academic study of risk and risk management. The comparison of results using different data samples (with and without outliers) throughout the thesis, highlights the influence of extreme values in the distributions of risk measures on the results of various techniques of statistical analysis. Moreover, the studies in Chapters Four and Five demonstrated how some readily-available robust techniques can successfully be applied to address this problem.

7.4 Implications for Practice

As stated in Chapter One, persistent pressure on firms to "... codify and formalize principles of risk management..." Power (2009, p.304) has led to an increased focus on how to measure risk more effectively. The investigation of the measurement properties of a variety of risk measures in Chapter Four, proposed a number of new criteria for selecting the most appropriate risk measure in any given situation including: relevance to a particular stakeholder group, the degree to which a measure is forward-looking and resolution. Furthermore, the risk components developed in the chapter may be of direct use to practitioners in risk management and associated disciplines (such as internal audit and corporate governance) as measures of risk; although it is important to bear in mind that the components change over time, and are only valid for the time period in which they were constructed.

The pay and bonuses of senior executives have become matters of considerable public and shareholder concern in the UK and beyond in recent years[88]: the model developed in Chapter Five, relating profit risk and subsequent profitability (return on market value of equity) could potentially contribute towards addressing this disquiet. The model could be applied to compute an expected level of profitability for a firm, given the level of profit risk that managers have chosen to bear; against which the past performance of managers can be judged. The application of the model in a forward-looking context is not as straightforward, as the relationship between profit risk and profitability was demonstrated to be contingent on economic conditions, particularly growth rates; but a risk-return relationship derived from a previous

[88] See, for example, Gregory-Smith et al's (2014) study of voting dissent by shareholders in UK firms on remuneration arrangements.

period of similar growth could be used as a benchmark against which to judge the attractiveness of different investment opportunities in the present.

As observed in Chapter One, considerable heterogeneity persists in risk management capabilities across firms. The appropriateness of firms' risk management capabilities are of significant interest to shareholders and, by extension, to anybody whose pension fund is invested in the stock market. The finding in Chapter Six, that the heterogeneity in risk management capabilities can largely be explained by a simple model based on protecting shareholder value; is therefore very positive, in that it suggests that managers are acting in the interests of shareholders. However the finding that the proportion of institutional investors is a significant driver of the development of ERM capabilities has important implications for the design of corporate governance systems.

7.5 Limitations and Recommendations for Further Research

The restriction of the analysis to publicly listed firms[89] represents a significant limitation of the current study, in that it limits the extent to which the findings of the study can be generalised: it is not possible to say with any certainty how applicable any findings are to small, privately-held firms, charities or public-sector organisations. It is superficially attractive to conduct similar analyses to those in Chapter Five, with models that simply omit the market-based risk measures, so as the study could be extended to a much wider range of firms; however, as discussed in section 5.5.2.2, it was not possible to estimate models with pure accounting measures of performance as the dependent variable. Indeed this may represent a fundamental limit on what is achievable with this particular approach. Also, even if it was somehow possible to estimate the model with pure accounting measures of performance; the regressions analyses with return on market value of equity as the dependent variable found very different parameter estimates for market risk than the regressions with returns to shareholders as the dependent variable. It would therefore appear that market risk is salient to managers in publicly listed firms, and there is a distinct possibility that models that simply omit risk measures relevant to owners will be mis-specified. Some further thought is required on how to construct a risk measure relevant to owners of firms that are not quoted; particularly in closely-held firms, where the dividend policy may be determined by unobservable personal preferences of the owners. Extending the analysis to charities and public-sector organisations would also be of both theoretical and practical interest, but is even more challenging as there is no direct analogue for profitability: a large accounting surplus may indicate a failure to deliver necessary services rather than efficiency.

[89] In the case of Chapter Six, the study was further restricted to the largest listed firms.

Most previous research on risk at the firm level has been conducted on US firms so it is interesting to explore another market; and the UK provides an attractive environment for such research as there are a large number of listed companies, compared to other European countries. Nevertheless, it is important to acknowledge that there may be idiosyncratic national issues that may, for instance, influence the relationship between risk and return; so the findings of this study cannot be generalised to other countries. It would therefore be interesting, and should be perfectly feasible, to conduct similar studies in other countries and compare and contrast the results.

A further important limitation arises due to the specific period, 2003-12, over which the study was conducted. The onset of the global financial crisis in 2008 was characterised by immediate significant falls in UK GDP growth and market returns, together with substantial increases in the volatility of both measures; the values of all of these measures then continued to fluctuate widely over the remainder of the study period (compared to historical norms). Whilst this step-change in environmental conditions constituted an important natural experiment, and yielded a number of useful insights, it also meant that a number of conclusions had to be drawn (tentatively) from the results of a single time-period. In both Chapter Four and Chapter Five it was noted that it would be useful to continue the empirical work longitudinally as macroeconomic conditions evolve and stabilise again (potentially returning towards historic norms). In particular, this might help in interpreting the component structures for the period 2008-12 in Chapter Four; and in understanding the relationships between accounting-based measures of risk and market-based measures of performance (and vice versa) in Chapter Five. If it was possible to compile a panel data set over an extended period of stable environmental conditions; (dynamic) panel techniques could usefully be applied, which should be more analytically efficient. The highly unusual environmental conditions existing over the course of the study also limit the extent to which the results can be generalised to other time periods.

The final limitation of the study concerns the difficulties in exploring the effect of risk management on performance, an issue of both theoretical and practical interest. The difficulties arise from the recognition of the fundamentally long-term nature of risk management. An apparently simple approach would be to include a risk management measure in the models for risk and performance in Chapter Five; but the need to eliminate firm-fixed effects (see section 7.3) means that risk management, which on the timescale of the study is effectively fixed, is also removed. More generally, as discussed extensively in the resource based view literature (see Chapter Two), the measurement of the performance effects of capabilities presents formidable methodological challenges. Empirical tests are confounded by difficulties in operationalising capabilities; selection of an appropriate dependent variable; and alternative explanations for superior performance. Each capability that could potentially influence performance would have to be separately proxied and included in the model; in addition, many of these proxies would have to be instrumented as the capabilities may be co-determined with performance.

7.6 Summary

This concluding chapter has attempted to capture how the study has contributed to both theory and practice. As stated in Chapter One, the overall aim of this study was to improve the understanding of how to measure and manage corporate risk more effectively; the study therefore began with a detailed investigation of the measurement properties of a variety of risk measures. This identified a novel set of risk measures, the utility of which was demonstrated in subsequent chapters; and it is hoped that these measures will be of value to both researchers and practitioners in the future. Perhaps the most important finding of the whole study was the positive correlation between profit risk (standard deviation of ROA) and subsequent accounting performance (ROA), contrary to numerous previous studies; this finding was supported by the results of regression analyses with return to market value of equity as the dependent variable. However it is important to note that this relationship is mediated by environmental conditions; as is the relationship between market measures of risk and subsequent market returns. Finally, turning to look at the management of risk, it was shown that the heterogeneity in the development of risk management capabilities across large listed firms in the UK can largely be explained by traditional arguments based on protecting value for shareholders.

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