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The Contribution of Enterprise Risk Management to Firm Value – Empirical Evidence from the North American and European Oil & Gas Sector

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Abstract

This master thesis examines the contribution of Enterprise Risk Management (ERM) to firm value within the upstream oil and gas sector in Europe and North America. Given the industry's high exposure to various risks, this study aims to evaluate whether the implementation of an ERM system can add value to firms operating in this sector. Notably, the upstream oil and gas sector, particularly in our chosen regions, has been strikingly understudied in existing literature, especially in relation to ERM's influence on firm-performance-related dependent variables. Using a dataset spanning several years and encompassing diverse financial and non-financial indicators, a panel data analysis with fixed effects was employed to establish the relationship between ERM adoption and firm value. The findings reveal a statistically and economically significant positive impact of ERM, equivalent to the predominate view of current research.

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1. Introduction

1.1 Motivation

Navigating today's increasingly complex and volatile business environment necessitates effective risk management. The necessity is amplified in high-risk sectors such as the oil and gas sector, where risk management has evolved from a mere operational function to a strategic imperative.

Consider the case of Equinor, a multinational energy company based in Norway, as an illustrative example. The company disclosed that its U.S. operations accrued losses amounting to roughly 21.5 billion USD from 2007 to 2019 (Equinor, 2020). Operational hitches, cost overruns, and sub-optimal investment choices were cited as major contributors to this financial setback. This case underscores the vital role that risk management plays in preserving the financial health of oil and gas firms. Events such as the 2008 global financial crisis and the ongoing war in Ukraine further emphasizes the urgency for robust risk management strategies.

These concerns are only a fragment of a more significant landscape of threats that could impact firms negatively. The Institute of Internal Auditors (2021) warned that socio-political unrest, regulatory shifts, persistent economic and political volatility, and climate change effects would render the future unpredictable. This complex panorama prompts a crucial question: why should risk management be a priority for managers and directors? The response lies within the inherent complexity of large corporations. Diverse risks across multiple departments can interact unpredictably, potentially triggering a ripple effect that could compromise the company's overall stability and profitability.

However, risk is not exclusively negative: it presents an opportunity for return (P. Kapstad, personal communication, June 1, 2023). Therefore, risk should be viewed as a potential source of benefit, provided it is managed effectively. As an example, consider the losses incurred by Equinor's U.S. operations. Neither the market nor the government could mitigate their risk exposure. Instead, to maximize their operational benefits, Equinor should have adopted an enterprise-wide risk management approach – leading us to the concept of Enterprise Risk Management (ERM).

Since the late 1990s and early 2000s, risk management has witnessed a significant transformation. Initially subtle, this shift gained momentum in the aftermath of the financial crisis, leading to a paradigm change. The executive management of risk, or risk governance, transitioned from a silo approach to a holistic one. This new paradigm emphasized all potential financial, economic, and strategic risks and opportunities.

A milestone in this transition was the 2004 release of the Enterprise Risk Management Integrated Framework by the Committee of Sponsoring Organizations of the Treadway Commission (COSO). This framework outlined ERM as a strategic process that involves the board of directors, management, and other personnel, with a focus on identifying and managing potential organizational impact events (SoxOnline, 2004). The framework also emphasized that ERM should create value.

Simultaneously, the New York Stock Exchange (NYSE) implemented new corporate governance rules requiring listed firms' audit committees to take a more proactive role in risk oversight. These developments highlight the growing importance of ERM as a crucial aspect of corporate governance and strategic decision-making.

Given its substantial capital investments, fluctuating market prices, environmental challenges, and regulatory complexities, the oil and gas industry stands as a sector that can greatly benefit from an enterprise-wise approach to risk management (Annamalah et al., 2018). The ultimate goal is to enhance firm value, thereby increasing investor trust and fiscal stability. However, the current body of research investigating ERM's contribution to firm value, particularly within the oil and gas sector, is surprisingly limited. A possible explanation could be the lack of legal mandate for implementing ERM, unlike the banking and insurance sectors. This lack of formal regulation might de-emphasize ERM's importance and result in less attention from internal and external stakeholders. Furthermore, the abstract nature of ERM and its non-immediate financial return might deter ERM's attention from analysts and investors.

Given the scarcity of existing research and the unique complexities of the oil and gas sector, the examination of ERM's contribution to firm value is both timely and relevant. Therefore, this study aims to fill the gap in existing literature. By

doing so, it is hoped that a more profound understanding of the potential benefits of ERM adoption will be generated, shedding light on the critical role it plays in enhancing firm value. This will likely heighten the awareness of ERM's significance among stakeholders and pave the way for more comprehensive, strategic risk management practices in the oil and gas sector.

1.2 Research Question

As we navigate through this domain of risk management, particularly within the volatile and complex oil and gas sector, the focus of this study is directed towards understanding the contribution of Enterprise Risk Management to firm value. This represents the core of our research - the exploration of the link between the implementation of ERM and subsequent changes in firm value. We are particularly interested in the transitional phase - when companies shift from a state without ERM to one where ERM is implemented.

Our interest is driven by the proposition that such a transition could influence companies' firm value, given the potential for ERM to be a competitive advantage (M. S. Beasley et al., 2005), by managing and mitigating risks inherent in the company and the industry. This brings us to our research question:

"***Does Enterprise Risk Management (ERM) influence firm value, when companies in the upstream oil and gas sector go from not having ERM to implementing ERM?***"

1.3 Structure

Our study is arranged in the following manner: First, we delve into an extensive literature review to construct the theoretical framework, upon which our hypotheses are based. Here, we comprehensively distinguish ERM from TRM (traditional risk management), elaborate on the relation between ERM and corporate governance, provide an example of how a large E&P (exploration and production of oil and gas) company executes ERM, and explain how and why the concept of ERM emerged. Finally, we analyze prior literature in terms of the

relation between ERM and firm-performance-related dependent variables to determine the optimal combination of variables to include in our econometric model.

The second segment of our work is assessing the methodology. Here, we elaborate our sample selection, justify the measurement of our variables, and explain our model specification. This section is particularly crucial for understanding the mechanics of our study and the rationale behind our methodological choices.

Following our methodological outline, we present a detailed descriptive analysis of our sample. Subsequently, we dive into the core empirical component of our study, presenting and interpreting the outcomes derived from our model. This segment forms the core of our work, examining the potential influence on ERM on firm value in the upstream oil and gas sector. Lastly, we finalize our study with a conclusion, summarizing our main findings and their implications.

1.4 Contribution

This study primarily contributes to the topic of risk management by examining the relationship between ERM and firm value in the upstream oil and gas sector in North America and Europe. Using this sector, as well as data from 2010 to 2020 we distinguish ourselves from prior research on the same topic. In contrast to most prior research, who proxied ERM by the S&P rating and by using CRO as proxy for ERM implementation, we employ the proxy for ERM by analyzing each company’s annual report.

1.5 Abbreviations

Given the technical nature of this study, it is inevitable that various abbreviations will be used throughout the text for brevity and clarity. For the ease of reading and understanding, we have included an abbreviation list at the beginning of the paper, to provide a comprehensive guide to all acronyms and abbreviations used in this study.

- CRO – Chief Risk Officer
- CEO – Chief Executive Officer
- CFO – Chief Financial Officer
- E&P – Exploration & Production
- ERM – Enterprise Risk Management
- TRM – Traditional Risk Management
- COSO – Committee of Sponsoring Organizations
- ISO – The International Organization for Standardization
- S&P – Standard & Poor's Index
- SOX – Sarbanes-Oxley Act
- NPV – Net Present Value
- KPMG – Klyneveld Peat Marwick Goerdeler
- EY – Ernst & Young
- Deloitte – Deloitte Touche Tohmatsu Limited
- PWC – PricewaterhouseCoopers
- VIF – Variance Inflation Factor
- COMPUSTAT – Market and corporate financial database
- NASDAQ – National Association of Securities Dealers Automated Quotations
- OLS – Ordinary Least Squares Regression
- CapEx – Capital Expenditures
- FERMA – Federation of European Risk Management Associations
- OECD – The Organization for Economic Cooperation and Development
- SEC – United States Securities and Exchange Commission
- KPI – Key Performance Indicator
- OBS – Observations
- PCAOB – Public Company Accounting Oversight Board
- U.S. – United States
- U.K – United Kingdom
- ROA – Return on Assets

2. Risk Management

2.1 Overview

Risk management refers to financial and operational activities that seek to identify, assess and implement appropriate actions to deal with risks an organization faces (Dionne, 2013). Various forms of risk management exist as organizations adopt different systems depending on several factors such as industry, firm size, competitive environment, organizational structure, and culture, etc. Despite this, the fundamental objective of risk management remains the same: to manage uncertainties and support decision-making. To increase the understanding of the role of risk management in organizations, it is helpful to use the analogy of a ship's captain. More specifically, general business management, guided and controlled by the board through their corporate governance practices, can be perceived as the captain navigating the ship toward its destination. In this context, the company's goals and overall strategy refers to the ship's destination and the board refers to the ship's captain. Conversely, risk management encompasses the captain's guiding and steering the ship clear of reefs, icebergs and disadvantageous weather conditions which may harm the ship and its capacity to reach its destination. As such, while the board directs the management towards the attainment of organizational objectives and augmentation of efficiency, risk management, and in particular enterprise risk management, contributes to this process as a corrective directive.

But what exactly is risk? This is an important question to answer since the perception of risk defines both the objective of the risk management program and its design. While FERMA, the Federation of European Risk Management Associations, emphasizes that there are many definitions of risk, it rests on the definition set by ISO 31000, a recognized standard in the field of risk management. In more detail, the standard defines risk as "the effect of uncertainty on objectives" and that this effect can be positive, negative or simply a deviation from what is expected (Hopkin, 2010). This, and in particular the aspect of upside risk, aligns with the risk perception of COSO, the Committee of Sponsoring Organizations (COSO, 2017), which, as we elaborate on in section 3, was a pivotal institution in the emergence and development of ERM. Furthermore, the Institute of Internal Audit, an international professional association in the field of

internal audit, defines risk in the following manner: “the possibility of an event occurring that will have an impact on the achievement of objectives. Risk is measured in terms of impact and likelihood.” (The Institute of Internal Auditors, 2023).

Depending on the objectives of risk management and the organization’s overall goals, the management thus needs to design a favorable risk management system, considering the nature of its business and how it sees risk. Despite the existence of various forms of risk management, organizations can essentially construct a risk management system in two fundamentally different ways: the traditional way of managing risks (TRM) or the more modern and holistically oriented approach (ERM). Section 2.2 and 2.3 distinguish these contrasting approaches, emphasizing that the inherent difference emerges from the perception of risk. In broad terms, this refers to whether organizations perceive risk solely through the negative lens, opting for risk mitigation, or largely through the positive lens, opting for less risk mitigation and more value generation.

2.2 Traditional risk management

Before delving into Enterprise Risk Management (ERM) details, it is vital to understand its predecessor - Traditional Risk Management (TRM). TRM primarily emerged as a protective mechanism, akin to a ship’s compass guiding it away from stormy weather. However, in contrast to the comprehensive approach of ERM, TRM has a narrower focus. It typically deals with insurable risks, such as property damage, legal liabilities, and employee injuries, and financial risk such as currency, commodity and credit risk (Dionne, 2013; Hoyt & Liebenberg, 2011). Moreover, it is generally characterized by its siloed approach, where different risks are managed in isolation, often by separate departments without a coherent overreaching strategy, ultimately leaving the responsibility to the head of each department (Eckles et al., 2011). In the context of the oil and gas sector, for instance, a company might address operational risks such as equipment failure separately from financial risks like currency fluctuations. This lack of integration could lead to an incomplete understanding of the full spectrum of risks and might cause inefficiencies and lost opportunities for risk mitigation.

Another essential feature of TRM is its reactive nature. Similar to a captain who only adjusts course when a storm is visible on the horizon, traditional risk managers often respond to risks once they materialize rather than proactively identifying and mitigating them in advance (Eckles et al., 2011).

TRM is like using a simple compass and a basic map; it offers some guidance but lacks the advanced tools needed to navigate complex environments. This approach may not be sufficient in the rapidly evolving and interconnected world of the energy sector, where risks can be multifaceted and interdependent (Deloitte US, 2013).

As companies grew and the business landscape became more complex, the limitations of TRM became increasingly evident (Aven, 2016). The demand for a more holistic approach to managing not just the individual risks but the interplay between them led to the development of ERM (Farrell & Gallagher, 2015). This transition is akin to a ship's captain upgrading from a basic compass to a state-of-the-art navigation system that accounts for various variables in real-time, enabling safer and more efficient journeys.

2.3 Enterprise risk management

Despite its prevalence in modern management, experts and practitioners still lack agreement on a uniform and concrete definition of ERM. While many concur that ERM aims to comprehensively manage all the risks a company faces, in contrast to the fragmented approach of traditional risk management (Hoyt & Liebenberg, 2003), perspectives differ regarding the nature of risk itself, leading to diverse definitions and applications of ERM. Consequently, akin to the manner in which perception of risk fundamentally distinguishes TRM and ERM, risk perception also defines the manner in which ERM is defined and what it entails.

According to McShane et al. (2015), these differences in perspective can be categorized into two primary distinctions. Firstly, there is a divergence between those who see risk as an independent concept and those who define risk in the context of achieving organizational objectives. For instance, Dickinson (2001)

represents the former, defining ERM as "*... a systematic and integrated approach of the management of the total risks a company faces*".

In contrast, D'Arcy and Brogan (2001) adopt the latter perspective, defining ERM as: "*the process by which organizations in all industries assess, control, exploit, finance and monitor risks from all sources for the purpose of increasing the organization's short and long term value to its shareholders*".

The second distinction emphasizes the differing perceptions of risk as either a challenge to be mitigated or an opportunity for value generation. For example, Verbrugge et al. (2020) lean towards the value generations perspective, defining ERM as: "*.. corporate-wide, as opposed to departmentalized, efforts to manage all the firm's risks — in fact, its total liability structure — in a way that helps management to carry out its goal of maximizing the value of the firm's assets. It amounts to a highly coordinated attempt to use the right-hand side of the balance sheet to support the left-hand side — which, as finance theory tells us, is where most of the value is created*".

Other significant contributors to the ERM literature are Hoyt and Liebenberg (2003), who studied the determinants of ERM, and Nocco and Stultz (2006), who studied the theory and practice of ERM. The latter study refers to ERM as a conceptually straightforward concept which manages all risks together within a coordinated strategic framework to effectively create a long-run competitive advantage over those firms that manage and monitor risks individually. However, while the definition is pretty "straightforward", the authors stress that the implementation of ERM is not.

Hoyt and Liebenberg, like Nocco and Stultz, also emphasize the potential upsides of ERM compared to traditional risk management in their definition: "*Unlike the traditional "silo-based" approach to corporate risk management, ERM enables firms to benefit from an integrated approach to managing risk that shifts the focus of the risk management function from primarily defensive to increasingly offensive and strategic. ERM enables firms to manage a wide array of risks in an integrated, holistic fashion*."

In essence, these definitions and distinctions provide nuanced insights into ERM. They illustrate that ERM addresses an array of risks and implies a strategic,

integrated approach towards risk management, which is adapted to organizational objectives and value creation. However, while the various definitions of ERM offer a clear understanding of what it entails, they do not address the key question of who is responsible for its initiation, implementation, and maintenance. This is where COSO's definition emerges, as it highlights that the board of directors, or the top management, through their corporate governance policies, play a crucial role in ERM. COSO has been instrumental in shaping corporate governance practices over the last three decades, making it imperative also to consider their definition of ERM:

"ERM is 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 risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives." (Altman, 2004)

By reviewing the various definitions, it is evident that the critical elements of ERM can be understood. Three points based on the various definitions are outlined below to summarize the emerging consensus.

First, traditional risk management typically views risk as a problem to be mitigated, often focusing only on the potential negative consequences (P. Kapstad, personal communication, June 1, 2023). However, as the well-known investment phrase "no risk, no reward" suggests, risk can also bring benefits. As such, ERM suggests that companies with the ability to manage risk effectively can gain a competitive advantage. The energy industry is a good illustration of this, as energy prices are often volatile. Instead of trying to reduce these inherent risks, companies with expertise in managing these price fluctuations can benefit by investing in energy or providing consulting services (M. McShane et al., 2015).

The second and most significant aspect of ERM is that it focuses on managing the entire risk portfolio of a company instead of managing risks in isolation. For example, a multinational company with subsidiaries in different countries would benefit from a holistic approach to risk management, as different currency fluctuations can have both positive and negative effects on the company. Petter Kapstad at Equinor identifies portfolio optimization as a cornerstone of ERM. A primary advantage of ERM is its capacity to streamline the capital structure,

which can be facilitated through portfolio optimization. Consequently, the company is better positioned to conduct a more efficient review of whether the risk-return trade-off offered by the portfolio aligns with acceptable risk appetite levels.

In addition to TRM, ERM also encompasses strategic risks. This shift in focus sets ERM apart from its counterpart, as it takes a more forward-looking and goal-oriented approach. This is reflected in the definitions of ERM, which prioritize managing risks in a way that supports the attainment of organizational objectives and drives value creation. The inclusion of strategic risks in ERM acknowledges the importance of considering both the need for a comprehensive and integrated approach to risk management.

In conclusion, we emphasize the relevance of COSO's definition since it captures the three key consensus points outlined above. Additionally, it has served as a benchmark in our data collection process in determining whether the company in question has an ERM program.

Now that we have ascertained what ERM constitutes, it seems natural to elaborate briefly on its history. The following section thus furnishes the emergence and subsequent development of ERM. In broad terms, ERM emerged in response to the increased complexity in business environments and regulatory amendments in terms of corporate governance. Accordingly, section 4 on corporate governance can be perceived as an extension of section 3, providing deeper insights into the relation between ERM and corporate governance.

3. The Evolution of ERM

Risk management emerged as a discipline shortly after World War II, evolving significantly to encompass a broad range of definitions and applications. However, this section focuses solely on Enterprise Risk Management, examining the key historical events that played a vital role in its emergence and development.

The origin of ERM can be traced back to the late 1980s and early 1990s, a period characterized by corporate scandals due to poor governance practices among large firms, leading to a loss of trust among investors, shareholders, regulators, and other stakeholders (Leech, 2003). This environment prompted an increased focus on internal control as a means of regaining trust and addressing stakeholders' concerns. Subsequently, financial institutions began developing internal risk management models (Dionne, 2013), and commissions were established to amend current practices to incorporate risk management into internal control (M. McShane, 2018).

The 1990s witnessed significant developments in corporate governance and risk management, such as the 1992 publication of the Cadbury Report (1992), the COSO Internal Control – Integrated Framework (2004), the 1998 Hampel Report (1998), and the 1999 Turnbull Report (1999). These developments were instrumental in shaping modern ERM by highlighting the importance of governance in risk management.

COSO, founded in 1985, played a particularly prominent role in evolution of ERM through its frameworks. In 1992, COSO published the Internal Control – Integrated Framework to help companies assess the effectiveness of their internal controls, which proved to be instrumental in improving financial reporting (Schandl & Foster, 2019). This framework became the standard, further cemented by the Sarbanes-Oxley Act (SOX) in 2002, which stipulated governance rules for listed U.S. Companies and mandated the use of recognized frameworks for reporting on internal control effectiveness (Dionne, 2013).

COSO responded to the changing landscape by publishing the Enterprise Risk Management – Integrated Framework in 2004, aiming for a more comprehensive approach to risk management. However, the distinction between internal control

and ERM blurred due to their similarities, causing ERM to initially receive limited attention. (Altman, 2004; Frigo & Anderson, 2011).

To sum up, ERM evolved from the internal control movement, significantly influenced by governance practices and regulatory developments. In the next section, we delve deeper into how corporate governance has continued to evolve and its strategic alignment with ERM.

4. Corporate Governance

4.1 Corporate governance and ERM

Corporate governance encompasses a wide range of definitions due to its broad reach and implications. It is generally understood as the system of rules, policies, and processes that guide the direction and control of an organization to achieve its objectives while considering the interests of its shareholders and other stakeholders (Gillan, 2006). The ISO 37000, a recognized international standard for governance guidance, provides another perspective. It defines corporate governance as a system by which organizations are directed and controlled, prioritizing ethical behavior, organizational performance, and compliance with laws and regulations (ISO Technical Committee, 2022). On the contrary, according to the OECD Principles of Corporate Governance, another international standard, it involves "a set of relationships between a company's management, its board, its shareholders and other stakeholders" and is primarily concerned with "providing the structure through which the objectives of the company are set, and the means of attaining those objectives and monitoring performance are determined (OECD, 2015).

Effective corporate governance requires a clear understanding of the roles and responsibilities of the board, management, and shareholders. The CEO and management are responsible for constructing, managing, and executing organizational strategies, including strategic planning, financial reporting, and risk management. The board, concurrently oversees the management and the company's strategies focusing on generating long-term value for stakeholders, and monitors and advises the CEO on key organizational areas such as strategy and risk management (The Harvard Law School, 2016).

The importance of effective corporate governance and risk management was historically highlighted through regulatory amendments such as the COSO Internal Control – Integrated Framework in 1992 and the SOX act in 2002, which was discussed in section 3. While these initiatives aimed to enhance corporate governance and risk management, they primarily focused on the importance of internal controls and regulatory compliance.

In response to the need for a more comprehensive approach to risk management, the concept of ERM gained increasing attention, emphasizing the importance of governance structures and processes in managing risks and creating value. ERM incorporates risk management into the organization's overall strategy and objectives, highlighting the collaboration between the board, management, and other stakeholders. In 2004, the COSO Enterprise Risk Management – Integrated Framework was introduced as a risk management standard, providing a holistic approach to identifying, assessing, and responding to risks (SoxOnline, 2004).

For companies operating in sectors like oil and gas that face complex and dynamic risks, understanding the principles of ERM and its relationship with corporate governance, through the various definitions and perspectives, is vital for creating long-term value for stakeholders. Strategic consideration is a key factor in this understanding.

4.2 The strategic aspect

As illustrated in Section 3, the importance of aligning risk management with corporate governance became apparent following regulatory amendments. The strategic aspect of this alignment is vital. Sobel and Reding (2004), and later Frigo and Anderson (2011), emphasized that for effective risk management, ERM and governance processes must evolve together. Specifically, they noted that the integration of strategic risks – "the top risks of an organization" – is foundational for improving both ERM and governance (OECD, 2014). This integration implies a dynamic interrelationship between ERM and corporate governance, which necessitates clearly delineated responsibilities for the board, its committees and management. For effective risk management, this could include establishing risk committees and risk manager positions, and ensuring efficient communication channels (The Institute of Internal Auditors, 2013).

Evidence of strategic integration is reflected in the evolving responsibilities of risk managers, as noted in the European Risk Manager Report of 2020 and 2022 (Federation of European Risk Management Association - FERMA, 2022). These reports reveal a persistent trend of incorporating risk management into strategy

setting and decision-making, especially in response to significant global events like the Covid-19 pandemic and geopolitical tensions.

The idea of strategically aligning risk management with governance is not new. Miller (1992), an early scholar in integrated risk management, the first form of enterprise risk management, highlighted the importance of this alignment, suggesting that a framework should identify and assess uncertainties relevant to strategy formulation (design). This emphasis on strategic considerations is now more important than ever and sets the stage for examining the pivotal role of the board of directors in risk management, which is covered in section 4.3.

In conclusion, incorporating ERM into corporate governance is not merely a compliance activity but a strategic necessity. As ERM has evolved, so too has its integration witch corporate governance, with an increased emphasis on aligning risk management with the organization's strategic goals. The next section, 4.3, further explores the central role of the board of directors in this alignment and in the risk management process.

4.3 The board of directors and risk management

As we transition from the strategic alignment between corporate governance and ERM, it's essential to emphasize the role of the board of directors in risk management. Sobel and Reding, whom we referenced earlier, highlighted the importance of the board's engagement in risk management processes, calling for robust risk oversight (DeLoach, 2010). This perspective was echoed by Beasley et al. (2016), who noted the escalating expectations for stronger risk oversight, especially after the financial crisis.

In 2010, the SEC mandated that public companies disclose the board's role in risk oversight in annual proxy statements (Securities and Exchange Commission, 2009). Consequently, boards were tasked with thoroughly evaluating whether management's risk management policies were aligned with the company's strategy and risk appetite, and whether these policies cultivated and enterprise-wide culture conducive to appropriate risk awareness and decision-making (Brownstein et al., 2018).

Understanding the implications of the board's role in risk oversight is critical. Firstly, it includes comprehending and approving the risk management processes initiated by the management. Secondly, the board should evaluate the risks identified by the management and oversee actions taken to govern these risks. Beasley et al. (2016) outlined critical questions that boards should consider to optimize their risk governance responsibilities. These questions encompasses understanding the characteristics of firms adopting ERM, the techniques included in an ERM process, and the role of internal audits. Furthermore, they should explore how ERM processes are incorporated with strategy and assess the impact of ERM on firm value and performance.

While an in-depth analysis of these questions is beyond the scope of this thesis, it is important to recognize that risk governance is not solely about compliance, but also about driving business value. The board must consider the strategic implications of risk governance and adopt a proactive approach to risk management. Through an integrated understanding of ERM processes and effective risk governance, boards can create significant value and foster sustainable organizational growth. A company to a large extent has successfully grasped this understanding is Equinor, which we provide further details on in section 5.

5. ERM in Practice – Equinor

Equinor, the largest company in Norway serves as an excellent example of effectively incorporating ERM as a crucial element within its corporate governance. Most of this section is based on Equinor's disclosure on risk management in their annual reports (Equinor, 2022). However, this insight is also garnered in part from a conversation with Petter Kapstad, a seasoned specialist in Risk Management at Equinor, who has an impressive 14-year tenure as the architect and custodian of the company's risk management function.

As an energy giant with a core focus on the E&P of oil and gas, Equinor operates within an environment fraught with a myriad of risks – some within its control, while others beyond. These risks span financial, security, business, and political domains. In response, Equinor has embraced an ERM framework that champions enterprise-wide accountability. The company diligently undertakes risk analyses, monitoring, and assurance across all branches of its operations to fend off adverse outcomes. At its core, Equinor's ERM is anchored in a holistic strategy that aligns all operational and corporate risks with optimal resolutions. This streamlines the risk management process, curtails the volume of risk management transactions, and circumvents sub-optimization that could arise from managing a diverse range of risks in tandem (P. Kapstad, personal communication, June 1, 2023). Moreover, this all-encompassing approach affords the management and board a panoramic view of capital allocation within the company. As Kapstad notes, this granular insight into capital deployment empowers Equinor to calibrate its capital structure as conveniently. With a keen understanding of the risks at play, the company is adept at perceiving if the potential returns are commensurate with the risks undertaken. The overarching aim is to navigate risk in alignment with the company's protocols, while concurrently sidestepping incidents that may affect human rights or business integrity.

Equinor's risk management methodology is based on the ISO 31000 standard, which accentuates the significance of risk management within strategic planning. This contrasts with the COSO framework, which is opted more toward overarching corporate governance and auditing of risk management activities (Gjerdrum & Peter, 2011). Adhering to the ISO standard equips Equinor with the tools to consistently evaluate risks and augment the efficacy of decision-making.

This comprehensive approach ensures risks are properly identified, explained, assessed, and managed. Accordingly, risk management is assimilated as an IT instrument within Equinor's managerial framework, encompassing the translation of its mission, vision, and strategy into strategic goals, risks, actions, and KPIs. Furthermore, it is worth highlighting the ingrained risk culture within Equinor (P. Kapstad, personal communication, June 1, 2023). With a rich heritage in risk management, all employees are familiar with the potential advantages and pitfalls pertinent to their roles. ERM is ever-present within the organization and utilizes instruments with which the entire workforce is proficient. This paves the way for the initiation of risk-adjusted actions and corresponding assurance measures, for sharp risk management.

Equinor's Corporate Risk Committee, headed by the CFO, is responsible for the company's ERM. This committee is charged with the oversight of internal controls and risk management. Alongside the Audit Committee, it evaluates and monitors the efficacy of the practices on place. Twice a year, the board is presented with an appraisal of the principal enterprise risks. In adherence to established protocols, all risk-related actions undergo scrutiny to ensure the company's risk profile is in sync with the desired thresholds.

The involvement of Equinor's board (the top management) in the ERM process indicates a top-down risk management structure which, as discussed in the corporate governance section, is a central aspect within successful ERM. It also sheds light on the importance of establishing governance structures and practices that foster an enterprise-wide risk management culture, effectively connecting general business management with risk management.

6. Development of Key Variables

Understanding ERM in the context of prior literature serves two essential purposes. First, it clarifies the evolving nature of ERM and its potential impact on firm value, which is the main objective of this study. By examining past studies, we can draw on a wealth of insights and findings to inform our approach and build upon the existing body of knowledge.
Secondly, diving into previous literature provides a clear path to navigate the various methodologies and theories used in the study of ERM. Given the inconsistencies in ERM measurement, as we elaborate on shortly, it is crucial to understand these different approaches and their implications. Similarly, it becomes pertinent to comprehend how firm value has been presented, often through Tobin's Q, and especially how different firm characteristics influence the decision to implement ERM.

In the subsequent sections, we explore these aspects in detail, drawing on past research to pave the way for our analysis. This section serves as a bridge that connects our study's goals with the larger discourse on ERM and its influence on firm value.

6.1 Measurement inconsistencies

According to McShane et al. (2011) and Hoyt & Liebenberg (2003), a significant difficulty in conducting ERM research is identifying a reliable and accurate measure of ERM. The lack of transparency concerning how firms manage risk in an integrated manner means that researchers must rely on perceived ERM indications obtained in a company's annual reports and press releases. This has resulted in various measures of ERM implementation being employed in research literature. For example, Beasley, Pagach, and Warr (2008) used the appointment of a CRO as a proxy for ERM implementation, while Gordon, Loeb, and Tseng (2009) developed their own ERM index based on a list of specific firm variables. Alternatively, Beasley, Clune, and Hermanson (2005) used surveys to determine whether a company had implemented ERM.

Despite all the potential advantages and disadvantages each measurement method brings, the empirical research on ERM has delivered contrasting results for years. The use of different ERM determinations may cause inconsistency and perplexity both in terms of reviewing existing knowledge as well as future research. Therefore, it is reasonable to divide ERM research into groups based on the method of measuring ERM implementation.

6.1.1 CRO as proxy for ERM

The first category uses the appointment of CRO as a signal for ERM implementation. The primary role of the CRO is to manage the coordination of the ERM program and to communicate goals and results to the board (Hoyt & Liebenberg, 2003). Examples of such studies are (M. Beasley et al., 2008; Hoyt & Liebenberg, 2003, 2011; Pagach & Warr, 2011).
According to Hoyt & Liebenberg and Beasley et al., firms appoint CROs to implement and manage the ERM program. In this way, the announcement of a CRO appointment signals that the firm has, or will, establish an ERM program. However, firms without CROs may in fact have implemented ERM, thus providing grounds for questioning the reliability of the proxy. Some firms use a committee system or a risk manager or incorporate the ERM responsibility in the CFO or CEO function. Consequently, observing and determining whether CEOs, CFOs, risk managers, or risk committees are in fact head of the ERM implementation is complicated. Most companies disclose minimal details of their risk management programs. Therefore, using CRO as a signal is affirmative, following the argument that firms appoint CROs to manage their ERM program.

Empirical research confirms that the presence of CRO is associated with a greater stage of ERM implementation within a company (M. S. Beasley et al., 2005). Because of its scope and impact, ERM implementation requires strong support from senior management, which coincides with the hiring of a CRO (Adam et al., 2023). Additionally, Beasley et.al (2008) listed three possible reasons for why firms may appoint CROs. First, to fulfill a newly created CRO position in the organizational structure, making it reasonable to assume that the firm is about to adopt ERM, or has started to recognize opportunities with risk management. Second, the need to replace an existing CRO, which to some extent indicates that

ERM already is a part of the company's management. Third, to reflect the officer's responsibility properly by changing the title to CRO. In sum, these three arguments provide valid reasons for why CRO appointments are used as proxies for ERM, as they highlight the correspondence between the presence of a CRO and the fact that a company is engaged in ERM activities. On the contrary, there is no denying the validity of the criticism against the use of the CRO as a proxy for ERM. They are not mutually exclusive since one may exist without the other, thus potentially laying grounds for erroneous analysis.

6.1.2 Modelling ERM index based on firm-specific information

The second category of studies uses firm-specific information to determine ERM adoption and level of implementation. Examples of studies from this category include Gordon et al. (2009) and Alawattegama (2017), who used the COSO framework to determine ERM adoption. Gordon created an ERM index based on COSOs four objectives of ERM: strategy, operations, reporting, and compliance. Alawattegama, on the other hand, modeled an ERM index using COSOs eight interrelated components of ERM: objective settings, event identification, risk assessment, risk response, information and communication, control activities, and monitoring. Both studies demonstrate that the effectiveness of ERM implementation is dependent on its ability to fit within the COSO framework.

Moreover, a sub-category of this category is reflected by studies that rely on externally produced ERM indexes. Standard and Poor's (S&P) ERM evaluation index is a commonly used measure which is, for instance, used in McShane et al.'s (2011) study on the relationship between ERM implementation and firm value, to indicate ERM adoption and implementation. The researchers argued that the use of Standard and Poor's ERM index provides an extensive view of firms' ERM implementation since the index is based on a careful review of the firms' risk management culture, risk control processes, emerging risk management, and economic capital models, and strategic risk management.

Baxter et al. (2013) investigated the determinants of ERM program quality using the S&P-ERM index as a proxy for ERM. In line with McShane et al. (2011), the researchers argue that the S&P index truly reflects a firm's ERM status due to the

comprehensive nature of methodology used, combined with the access to non-public information about risk management processes within the firm. However, using the S&P index has its restrictions. The index is only available to specific industries and countries with mainly developed economies (Baxter et al., 2013). Moreover, the rating agencies have been criticized for their subjectivity, as ratings have been distorted by their business relationship with clients, which may weaken the credibility of the S&P-ERM index assigned to firms (M. K. McShane et al., 2011). Although rating agencies publish their rating methodologies, client confidentiality makes independent validation difficult, as the extent of necessary public information to make reliable ratings may not be sufficient.

Another sub-category detects ERM implementation by, first, manually searching for ERM-related terms in annual reports such as “strategic risk management”, “enterprise risk management”, “corporate risk management”, “enterprise-wide risk management”, “integrated risk management”, “risk committee”, “risk manager”, “chief risk officer”, “holistic risk management”, and second, subsequently contextually analyzing their relevance to affirm that they do in fact reflect ERM activities (Anton & Nucu, 2020; Hoyt & Liebenberg, 2011; Lechner & Gatzert, 2018). This is the ERM measurement method employed in our study, and we used COSO’s ERM definition as a benchmark to decide whether companies had ERM systems in place.

6.1.3 Survey responses to determine ERM

The last category of research utilizes surveys and questionnaire responses to determine ERM adoption and implementation. For instance, both Beasley et al. (2005) and Annamalah et al. (2018) used a survey and questionnaires, respectively to determine the extent of firms’ ERM adoption. Beasley et al. studied the impact of ERM adoption on the internal audit function, using COSO’s ERM components as design for the survey. A broad set of questions allowed them to obtain comprehensive information on each firm’s ERM practices, after which the responses were used to determine the extent of ERM implementation based on COSOs ERM components.

Annamalah et al. conducted a questionnaire using senior officials of companies with at least some experience with ERM in the Malaysian oil and gas sector. Even though questionnaires enable loads of information to be obtained, the expertise and ERM commitment of the respondents is critical to producing a survey that provides relevant and proper information on firms' ERM. This reduces the number of possible respondents to a limited number of senior officials and top management staff involved in a company's ERM implementation (Adam et al., 2023). A restricted number of respondents makes it challenging to conduct a comprehensive survey, which reduces the quality and quantity of information on ERM obtained in a survey, making it challenging to construct an ERM measure.

In conclusion, while there are various methods of measuring ERM, and each method has advantages and disadvantages, no method is universally applicable given the intricate nature of ERM itself. For instance, we have chosen to manually scan annual reports, which is a method that may not be favorable in other contexts.

6.2 Firm value - Tobin's Q

Firm value, or enterprise value, represents the total value of a company, which should not be confused with market value. Although these two concepts are often used interchangeably, the distinction between them is important. While market value reflects the perceived value of a company by investors, it can provide a limited and potentially misleading view of the company's overall worth. In contrast, firm value considers a broader range of factors, including debt and cash reserves, thus providing a complete measure of the company's value. Precisely, firm value is calculated as the market value of the company's equity plus its outstanding debt, less the amount of cash and cash equivalents it holds (Corporate Finance Institute, 2023). As such, it represents the total value of the company that would be required for its acquisition and is a crucial metric for evaluating a company's financial health and performance.

Calculating firm value can be a highly complicated process. As such, it is customary to use Tobin's Q as a proxy for firm value, which has been consistently successful in a broad spectrum of studies examining firm value in various contexts

(Bertinetti et al., 2013; Hoyt & Liebenberg, 2011; Lechner & Gatzert, 2018; M. K. McShane et al., 2011). Tobin's Q compares the market value of a firm's assets to its replacement cost and has been used to measure the value effects on, for instance, board size, inside ownership, and industrial diversification. Unlike other measures, Tobin's Q does not require risk adjustment or normalization and is relatively free from managerial manipulation, making it predominant compared to stock returns (Hoyt & Liebenberg, 2011). Moreover, Tobin's Q reflects investors' future expectations, distinct from historical accounting measures such as ROA. The future expectations are crucial, as the benefits of ERM implementation are not expected to be immediately realized; thus, a lag between implementation and realization should be expected. Based on existing literature, Tobin's Q as a proxy for firm value is the most used measure in empirical risk management studies. Accordingly, Tobin's Q is our model's dependent variable.

In the realm of ERM literature, a limited number of studies have directly investigated the relationship between ERM and firm value, with an even smaller subset addressing the oil and gas sector. Anton and Nucu (2020) classify the ERM literature into three primary streams: 1) ERM implementation, 2) ERM effectiveness in relation to performance, and 3) determinants of ERM adoption. They emphasize the need for industry diversity in existing literature. Hoyt and Liebenberg are pivotal scholars in the ERM field, providing valuable theoretical and empirical insights into ERM, especially into the two latter streams. Specifically, their paper on "The value of Enterprise Risk Management" from 2011, suggests that enterprise risk management theoretically could increase firm value by improving coordination, identification of risk interdependencies, and enhancing capital efficiency (Hoyt & Liebenberg, 2011). While their discussion includes specific mention of US insurers, these principles are broadly applicable and highly relevant for the oil and gas sector, which faces a complex web of operational, environmental, and regulatory risks. Based on our perceptive talk with Petter Kapstad, we can confirm the relevance of all three principles. For example, Kapstad assures that ERM's portfolio management facilitates more efficient use of a company's capital. Specifically, he mentions the use of "efficient frontiers" as ERM tools since they detect sub-optimal portfolios (located below the frontier) that do not offer enough return for the level of risk. Furthermore, according to Hoyt and Liebenberg, the signaling aspect of ERM in

communicating a firm's risk profile and commitment to risk management can be particularly beneficial for oil and gas companies in engaging stakeholders and navigating regulatory environments. Hence, since oil and gas companies to a large extent face scrutiny in terms of environmental and safety practices, this aspect in particular may enhance value.

6.3 Firm characteristics of ERM adoption and determinants of firm value - key variables

As we delve into the details of ERM adoption and its impact on firm value, it is imperative to consider the literature pool that has been developed over the years. Anton and Nucu's (2020) extensive literature review study suggests that despite some ambiguous outcomes, the prevailing opinion leans toward a positive relationship between ERM and firm performance (Farrell & Gallagher, 2015; Florio & Leoni, 2017; Hoyt & Liebenberg, 2011; Pagach & Warr, 2011). However, the literature also reveals that this relationship is not uniform and can be influenced by various factors such as the appointment of a CRO, the sophistication of the ERM program, corporate governance, and firm characteristics (M. S. Beasley et al., 2005; Bertinetti et al., 2013; Gordon et al., 2009; Pagach & Warr, 2011). In particular, understanding the role of firm characteristics is essential as they often shape an organization's risk profile and risk management approach. Pagach and Warr, and Beasley et al. emphasize the importance of considering firm-specific and contextual factors in understanding the relationship between ERM and firm performance. This section critically analyzes some of these firm characteristics based on existing literature and discusses their relevance to ERM adoption and their correlation with firm value, finalizing the foundation for our hypothesis development.

Firm size is an essential characteristic that several research articles have found to influence the adoption of ERM (M. S. Beasley et al., 2005; Farrell & Gallagher, 2015; Hoyt & Liebenberg, 2011; Pagach & Warr, 2011). Both Hoyt & Liebenberg and Pagach & Warr compared a set of firm characteristics on firms that had appointed a chief risk officer to guide their risk management. The two studies found that, on average, CRO-hiring firms are much larger than non-CRO-hiring,

and that these firms tend to be among the largest in their specific industry. This aligns with the findings of Farrell & Gallagher (2015), Lin (2011), and Lechner & Gatzert (2018), who claimed that larger firms have sufficient institutional size, such as financial, technological, and human resources, to support the administrative cost of an ERM program. Furthermore, Kinyar's (2020) findings revealed that firm size has a positive and significant impact on firm value of firms adopting ERM in the North American energy sector. The positive effect on firm value was more substantial in larger firms, indicating that larger firms benefit more from implementing ERM compared to smaller ones. On the other hand, Aldoseri (2022) found a positive but insignificant effect on firm value. This indicates that the size of a company alone is insufficient to enhance its overall value.

Moreover, Pagach & Warr (2011) articulated that firms characterized by a high degree of asset opacity may be more willing to implement ERM. During periods of financial distress, liquidating these opaque assets can be challenging due to the associated information asymmetry, which often results in undervaluation. Furthermore, Hoyt & Liebenberg (2003) suggest that opaque firms may find ERM advantageous to effectively communicate their risk management objectives and strategies to outsiders, which is a crucial step for firms that understand the difficulty outsiders face in evaluating opaque firms. Opaque assets may, as mentioned, lead to firms being underestimated and undervalued. It is therefore reasonable to believe that a higher degree of opaque assets leads to reduced firm value. Although previous literature suggests that opacity may increase the likelihood of ERM, the statistical results are quite ambiguous (Gatzert & Martin, 2015; Lechner & Gatzert, 2018). Based on the arguments outlined in this section, we believe that larger firms are more likely to achieve higher firm value. Contrastingly, we believe that asset opacity reduces firm value. We therefore hypothesize:

H1: *Firm size positively affects Tobin's Q*

H2: *Asset opacity negatively affects Tobin's Q*

Correspondingly, CRO-hiring firms are generally more levered than non-hiring firms (Hoyt & Liebenberg, 2003). Leveraged firms face agency costs to a large extent because of conflicting interests between shareholders and lenders. Moreover, these firms face a greater probability of financial distress due to

increased financial leverage and therefore are more likely to adopt ERM (Pagach & Warr, 2011). On the other hand, due to ERM implementation, Hoyt & Liebenberg (2011) claim that companies may increase their financial leverage as ERM improves risk appreciation. Accordingly, financial leverage can increase firm value to the extent that it reduces the surplus cash flow, which self-interested managers might otherwise have allocated towards projects that do not optimally serve the company's interests. However, previous literature has yielded ambiguous results on the relationship between ERM implementation, financial leverage, and firm value. Pagach & Warr argues that companies with an ERM program can allocate internal resources more efficiently, reducing the financial leverage and subsequently the probability of default. Alternatively, as already described, firms can increase debt in their financial structure because ERM enables better risk monitoring. Both Aldoseri (2022) and Kinyar (2020) found a relation between leverage and ERM in the North American and Saudi energy sectors, respectively. The first article showed that leverage negatively and significantly affected firm value, implying that leveraged firms bear higher levels of financial risk and reduced firm value. Consequently, Kinyar found that a positive effect of ERM adoption on firm value is more pronounced for firms with higher leverage, indicating that firms with more leverage are more exposed to financial risks and thus could benefit from ERM implementation to increase firm value. Despite the ambiguity of ERM and leverage, we follow Lechner & Gatzert (2018), and hypothesize the following:

H3: *Increased financial leverage increases Tobin's Q*

The positive relation between profitability and firm value is generally accepted in most prior studies. Return on assets (ROA), for instance, is widely discussed (Aldoseri, 2022; Bertinetti et al., 2013; Hoyt & Liebenberg, 2011; Lechner & Gatzert, 2018; M. McShane, 2018). Bertinetti et al., Aldoseri, and Lechner & Gatzert found a positive and significant relation between ROA and firm value in their respective studies, indicating that, intuitively, increased profitability enhances firm value. Additionally, the consensus underscores that firms with high ROA tend to be more inclined to allocate sufficient financial resources for ERM implementation. In sum, ROA is recognized as a positive influential factor on firm value, and we therefore hypothesize the following.

H4: *Increased ROA increases Tobin's Q*

The correlation between dividend payment and firm value has been found to differ across various research studies. As outlined by Hoyt & Liebenberg (2011) the anticipated impact on firm value is unclear. On one hand, cash distributions in the form of dividends could be perceived as an indication that the company has exhausted its growth opportunities, which could potentially diminish firm value. Similarly, Bertinetti et al. (2013) claims that dividend payment can signal a lack of new projects with positive NPV, which also could reduce firm value. On the other hand, dividend payment may decrease the amount of surplus cash available that might be directed towards discretionary spending by the management (Hoyt & Liebenberg, 2011). Furthermore, dividends can send a positive message to the capital market about the company's financial health, suggesting they could potentially enhance firm value (Lechner & Gatzert, 2018). In previous literature, the impact of dividends on firm value illustrates a mixed picture. While Hoyt & Liebenberg found a positive impact, Lechner & Gatzert's research indicated a negative effect, aligning with Bertinetti et al. who did not find a positive correlation.

However, we believe that dividend payments signal an efficient business, representing the prevalent determinant ROA in terms of sufficient financial resources to invest in ERM, and hence increase firm value. We therefore hypothesize the following:

H5: *Dividend payment increases Tobin's Q*.

Liquidity is rarely used as a determinant for ERM implementation and even less frequently as an influential component of firm value. This might be due to the possible relationship between liquid assets and ROA, which partially represents the company's efficiency and hence illustrates the likelihood of implementing ERM to increase firm value. This claim corresponds with Anton & Nucu (2020) and Lechner & Gatzert (2018), who suggest that firms with higher liquidities may have more possibilities to undertake profitable investments, such as adopting sophisticated ERM systems. However, the limited use of liquidity in relevant academic research raises concerns about whether the effect of liquidity can be isolated or if previous research found it more explanatory and relevant to use ROA as a measure of firm's willingness to use financial resources on actions that increase firm value. However, given that, on one hand, the literature argues for liquidity's ability to facilitate investments, and on the other, that ERM is a costly

investment, we believe that it could influence firm value positively, and hypothesize the following.

H6: *Increased liquidity increases Tobin's Q.*

International diversification is another factor that has been extensively examined in a significant body of existing pertinent literature (M. S. Beasley et al., 2005; Farrell & Gallagher, 2015; Hoyt & Liebenberg, 2011; Lechner & Gatzert, 2018). Risk management has become increasingly important for companies with international operations, due to the diverse and complex risks they face. As such, firm size and international diversification are related in terms of the increased complexity that both constitute. For example, Beasley et al. found that larger companies, those with a higher degree of complexity, and those operating internationally, are more likely to adopt ERM. Lin (2011) claimed that by expanding their business, companies encounter new risk factors that can be inherently different from the already existing risk portfolio. Both arguments call for a systematic and integrated approach to manage risk properly in the globalized business environments and to some extent, describe why international diversification is a characteristic of firms that adopt ERM. Moreover, Lechner & Gatzert provide ambiguous results on international diversification's influence on firm value. On one hand, diversification will likely result in performance enhancement due to economies of scope. On the other hand, difficulties in implementing ERM across national borders, combined with agency problems, may reduce firm value. This aligns with Farrell & Gallagher, who claims that international operations may dilute operational performance. In that manner, we believe that firms are more likely to implement ERM if they are diversified internationally, and thus enhancing their business performance. We therefore hypothesize that

H7: *International diversification increases Tobin's Q.*

In previous literature, growth opportunities are also commonly used firm characteristics of firms that adopt ERM. According to Hoyt & Liebenberg (2003), companies with greater growth opportunities face higher levels of uncertainty and require effective risk management practices to not only manage risks, but also to steer growth in the most advantageous direction. Congruent with the challenges of firm size and diversification, firms with growth opportunities tend to face higher levels of uncertainty as they may be expanding their business into, for example,

new markets. Furthermore, growth may also lead to greater regulatory scrutiny, mainly if they operate in industries subject to extensive regulations, as Pagach & Warr (2011) exemplified. However, hardly any studies find evidence of a positive relationship between the implementation of ERM and growth opportunities. In Bertinetti et al.'s (2013) study, firm value was not affected by growth opportunities, prompting us to hypothesize the following.
H8: *Growth opportunities reduce Tobin's Q*.

Surprisingly, hardly any prior research has considered sales growth as a determinant on firm value. Indeed, Hoyt & Liebenberg (2011) included sales growth but it was utilized to estimate growth opportunities, not as an independent variable representing sales growth. Nevertheless, we believe some qualified reasons exist to control for the effect of sales growth on firm value. Intuitively, a company's increase or decrease in sales will affect the overall firm value positively or negatively. If the company manages to increase its revenues yearly, it is likely that it also will have the opportunity to enhance its operating results and hence increase its value. Moreover, investors often use sales growth as an indicator of a company's future profits. High-growth firms may, for example, often have higher price-to-earnings ratios, which increases the company's stock price, and therefore its market value. Accordingly, we hypothesize the following.
H9: *Sales growth increases Tobin's Q.*

Another aspect considered in previous literature is the selection of a firm's annual editor. More precisely, studies have been conducted on whether firms are more likely to implement ERM if the Big Four KPMG, EY, Deloitte or PWC audit their annual reports. Lechner & Gatzert (2018) found that ERM-adopting firms are more frequently audited by one of the Big Four auditing firms. Similarly, Beasley et al. (2005) showed that firms audited by the Big Four auditors are likely to be further into ERM implementation than those audited by non-Big Four auditors. One reason stated in the literature is that the Big Four auditors are more careful regarding the firms' annual reports to sustain their reputational level. Another possible explanation is that Big Four auditors may be more proactive in identifying, assessing, and managing risk, leading to an increased possibility of adopting comprehensive ERM systems. Moreover, the superior expertise and resources possessed by the Big Four auditors enhance the firm's ability to identify potential both down- and upside risks, which we believe contributes to enhancing

firm value. We therefore hypothesize the following.

H10: *Being audited by one of the Big Four auditors increases Tobin's Q.*

In summary, prior research has identified a set of firm and financial characteristics associated with ERM adoption. High financial leverage, opaque assets, and large firm size, along with international diversification, growth opportunities, and whether the firm is audited by one of the Big Four auditors, are some of the characteristics that have been found to increase firm complexity and risk profile, which in turn requires a more holistic approach and sophisticated risk management systems.

7. Research Design

The purpose of this study is to quantitatively investigate the impact of ERM on firm value. By utilizing a quantitative approach, we aim to provide an objective assessment of this relationship, leveraging numerical data to yield measurable outcomes. Our research adopts a deductive approach, meaning that we use existing theory on ERM's influence on firm value to test specific hypotheses drawn from this theory. Our hypotheses propose specific relationships and trends that can be statistically tested with the data we have collected. The quantitative approach allows us to process large volumes of numerical data, and find patterns that might not be immediately visible, as well as enabling statistical comparison between various groups. This methodology is particularly suited to our research question, as they focus on quantifiable factors such as firm financial performance and ERM implementation.

The upcoming section, 7.1, delves into the process of data collection for our analysis. This involves data gathering through two distinct methods, each carrying its unique set of advantages and limitations. Moreover, we provide a detailed examination of our variable of interest, ERM, outlining the procedure through which we obtained the results. Furthermore, in 7.2, we furnish our control variables, explaining both the method of collecting them, as well as how they are calculated. Our dependent variable, Tobin's Q, is comprehensively detailed in section 6, hence, it will not be the focus of discussion in this section.

7.1 Data collection

The data collection procedure encompassed gathering financial information from 134 upstream companies in the energy sector spanning the period from 2010 to 2020, initially yielding 1419 observations. After excluding observations with missing values, the final sample comprises 957 observations across 113 companies. Of these, 76 companies have their headquarters in North America, while the remaining 37 are based in Europe. The rationale behind selecting companies form these two regions was to offer an extensive perspective of the effects of ERM om firm value across diverse geographical and regulatory

environments. The incorporation of firms from different regions enhances comparability, as it broadens our dataset.

The way the sample of 113 firms was assembled diverged based on the region. For North America, COMPUSTAT via Wharton Research Data Services (WRDS) was the primary source, consistent with methodologies employed by Hoyt & Liebenberg (2011) and Pagach and Warr (2011). WRDS' database provided us with a wide array of financial information such that we could compute the ratios required for generating variables pertinent to our study. Conversely, for the European sample, a more hands-on approach was adopted. Financial data from companies listed on various exchanges including Oslo Børs, NASDAQ Stockholm, NASDAQ Copenhagen, London Stock Exchange, and Borsa Italiana were manually collected, and the relevant financial ratios computed, following the approach taken by Bertinetti et al. (2013). Although this method is considerably more labor-intensive than utilizing databases like COMPUSTAT, it provides the benefit of thoroughly verifying each observation and monitoring variations over time.

Concerning the main variable of interest, ERM, substantial effort was spent in collecting adequate documentation to ascertain if the firms had implemented ERM. Given that ERM adoption disclosure is not mandatory in either the US or Europe, an extensive search for evidence of ERM was undertaken within each annual report. Following Hoyt and Liebenberg (2011) and Lechner and Gatzert (2018), firms employing ERM were identified by scanning for specific keywords in the annual reports including enterprise risk management, strategic risk management, corporate risk management, traditional risk management, chief risk officer, risk management, holistic risk management, risk committee, integrated risk management and COSO. Hoyt and Liebenberg (2003, 2011) posit that "chief risk officer" and "risk committee" are central terms for the establishment and oversight of an ERM framework, and other terms are frequently employed interchangeably with ERM, which underpins the selection of these specific keywords. All instances of these keywords were carefully evaluated in context to determine if ERM had been adopted. In instances where ERM evidence was not overtly visible, the entirety of the risk management section was reviewed to gain an in-depth insight into the firm's risk management practices. The ERM definition by COSO was used as a benchmark in this process.

Furthermore, we observed that several companies had only partially implemented ERM. For example, searches for “integrated risk management” or “strategic risk management” frequently yielded results such as “foreign exchange rate risk” and “interest rate risk management”. In such instances, the related ERM variable was assigned the value 0 since, in our empirical analysis, the ERM variable is binary, assuming the value 1 if evidence suggests ERM implementation, and 0 if not.

The S&P ERM rating discussed in the literature review could also have been used as a proxy for ERM. However, access to this database was restricted. In addition, this rating has been criticized for its subjectivity as reflected by business relations with clients. Accordingly, we chose to scan all annual reports for ERM evidence manually to obtain a reliable estimate of whether companies had implemented ERM.

7.2 Variables and measurement

7.2.1 Control variables

Most of the variables employed in our study align with prior literature, encompassing firm size, asset opacity, leverage, ROA, dividend, international diversification, growth opportunities, and the company’s annual auditor. Additionally, we have chosen to incorporate liquidity and annual sales growth to control for both the cash and revenue trend on an annual basis with respect to Tobin’s Q.

Consistent with the predominant research in this domain (Bertinetti et al., 2013; Gatzert & Martin, 2015; Gordon et al., 2009; Hoyt & Liebenberg, 2003, 2011; Lechner & Gatzert, 2018; McShane et al., 2011), we employed the natural logarithm (LN) of the book value of assets as a basis to compute the size variable. The rationale behind this choice is the plausible assumption that larger firms are more inclined to utilize ERM as a strategic tool for enhancing their aggregate value. Consequently, the inclusion of the size variable is aimed at capturing any fluctuations in Tobin’s Q attributable to the scale of the company. In alignment with Pagach & Warr (2011) and Hoyt & Liebenberg (2003), we also addressed issues associated with firms with a high degree of opaque assets. As explained in

the literature review, the presence of opaque assets could invertedly lead to undervaluation of firms, thereby diminishing the aggregate value of the firm. Concerning methodologies employed in previous literature, we assessed asset opacity by computing the ratio of intangible assets to total assets. Subsequently, we instituted controls for information asymmetry and risk pertaining to the impact of the firm's assets on Tobin's Q.

Additionally, following the majority of prior research, we accounted for the effect of leverage on Tobin's Q. A significant proportion of preceding studies (Bertinetti et al., 2013; Farrell & Gallagher, 2015; Hoyt & Liebenberg, 2003, 2011; Lechner & Gatzert, 2018) rely on the ratio of the book value of liabilities to the book value of shareholder's equity as a means of computing leverage, a methodology we found to be well suited. We posit that the debt-to-equity ratio bears relevance to both ERM and firm value, given that it appraises the firm's financing strategy in terms of the balance between debt and equity – an important consideration since ERM is fundamentally concerned with risk management and value creation.

Moreover, we integrated dividends, ROA, and liquidity as control variables to account for any potential ramifications associated with cash generation and distribution on Tobin's Q. The variable for dividends takes binary form assuming a value of 1 of the company distributed dividends during the fiscal year, and 0 otherwise. ROA is incorporated as a metric of firm profitability, computed as the ratio of annual net income to total assets, consistent with methodologies employed in previous studies (Bertinetti et al., 2013; Hoyt & Liebenberg, 2011; Lechner & Gatzert, 2018).

While liquidity is not a frequently encountered variable in prior literature, we still regard it as a potentially important factor. Drawing on insights from Anton and Nucu's (2020) and Lechner & Gatzerts' (2018) studies, it can be inferred that firms with enhanced liquidity possess expanded avenues to embark on profitable investment endeavors. We computed this variable as the ratio of cash, cash equivalents and short-term investments to current liabilities.

Earlier studies tend to embed variables such as diversification and auditor type within their analysis. In contrast to our approach, an array of studies (M. S. Beasley et al., 2005; Gatzert & Martin, 2015; Hoyt & Liebenberg, 2011; Lechner & Gatzert, 2018) incorporate a variable indicative of the firm's operation across

multiple industries. Given that out sample is confined to companies operating within the same industry, we did not perceive this inclusion as relevant. Pertaining to international diversification, it is operationalized as a binary variable, assuming the value 1 if the company engages in operations in international markets beyond their base country, and 0 otherwise. In addition, the variable of auditor type is mentioned in, for instance, Anton & Nucu (2020), Beasley (2005), and Lechner & Gatzert (2018) studies. Following this body of research, we have integrated a binary variable that takes the value 1 if the firm's audit is conducted by one of the Big Four auditing companies (KPMG, EY, Deloitte, and PWC), and 0 otherwise.

Our final two variables, growth opportunities and sales growth, show significant variation in their application in prior literature. Notably, growth opportunities are prevalently employed and are customarily estimated using the average market-to-book ratio (Bertinetti et al., 2013; Gatzert & Martin, 2015; Hoyt & Liebenberg, 2003; Pagach & Warr, 2011). We, however, have elected to calculate it through the ratio of capital expenditure (CapEx) to total revenue. This methodology is congruent with the original conceptualization of Hoyt & Liebenberg (2011), albeit they employed the sales growth ratio due to the unavailability of CapEx data for multiple years within their sample. Considering the capital-intensive nature of the oil and gas sector, evaluating the returns generated by companies' CapEx on an annual basis offers a more discerning lens through which to assess growth opportunities. Diverging from the majority of relevant research, we have included sales growth as an independent variable. Our goal was to account for the ramifications of changes in annual revenues on Tobin's Q, thus aiming for a departure from previous literature where it is generally contained within the growth opportunities variable. There exists a plausible conjecture that an increase in annual sales would increase firm value. As such, our aim was to control for the influence of this variable. The ratio is computed by deducting the sales of the preceding year from the current total sales, followed by dividing the outcome by the total sales of the preceding year.

8. Model Specification

This section outlines and discusses specification of the econometric models utilized in our investigation. The model is designed to furnish a statistical embodiment of our research paradigm, thus facilitating our examination and interpretation of the empirical correlations between our variables of interest. Additionally, we carry out an evaluation of the model's validity.

8.1 Unbalanced panel data

Panel data, sometimes referred to as longitudinal data, provide observations on multiple phenomena observed over multiple time periods for the same firms or individuals (Baltagi & Song, 2006). Panel data models are beneficial as they enable the control for variables that fluctuate over time and are not directly observable or quantifiable, referred to as fixed effects.

Our research incorporates unbalanced panel data in which the count of observations is not uniform across cross-sectional units, or, in our context, companies. This discrepancy can materialize due to diverse causes. For example, certain companies may be included into our dataset midway through the span of interest, or others might depart prior to its conclusion, resulting in dissimilar temporal spans for different companies (Baltagi & Song, 2006). Moreover, the absence of data for particular companies or years can also contribute to the unbalanced nature of panel data. Our dataset encompasses data from 113 firms spanning 2010 to 2020, configured as an unbalanced panel due to instances of absent data throughout the sample duration. For instance, Petronor E&P ASA displays absent values for 2011 and 2012, Borr Drilling's data is restricted to three years, and Block Energy Plc's data is documented solely for 2019 and 2020.

While unbalanced panel data may introduce analytical challenges such as potential bias or inconsistency in estimation, modern econometric techniques have been developed to handle these efficiently. The key benefit of using an unbalanced data panel is that it avoids the loss of valuable information if we were to exclude companies with incomplete data, thus optimizing our sample size and enhancing the reliability of our results (Baltagi & Song, 2006).

8.2 Model selection

Choosing the correct model for our panel data is imperative to guarantee accurate and insightful results. Several models are conventionally deployed for panel data, including the Seemingly Unrelated Regression (SUR) framework, pooled Ordinary Least Squares (OLS), random effects model, and fixed effects model.

8.2.1 SUR Framework

The Seemingly Unrelated Regression (SUR) framework is generally employed when numerous equations with disparate dependent variables are interconnected across the same equations through the incorporation of one or more explanatory variables (Moon & Perron, 2006). A prerequisite for the functioning of this model is that the count of time-series observations for each cross-sectional entity must be at least the number of said entities. In our situation, this is unattainable as the quantity of cross-sectional units (companies) surpasses our time-series observations (years).

8.2.3 Pooled OLS

The pooled OLS model is amongst the most elementary models to estimate and explain. It processes the data as a basic cross section, amalgamating all observations and disregarding the panel structure of the data (Collischon & Eberl, 2020). Furthermore, it postulates homogeneity across all cross-sectional units, implying that all companies exhibit the same level of variance in their error terms. Conversely, if the variance in the error terms differs across companies, heteroskedasticity is evident (Olvera Astivia & Zumbo, 2019). The main advantage of the pooled OLS is its straightforwardness and simplicity. It computes a single equation for the entire dataset by assembling the dependent variables into one column. Likewise, the regressors for each independent variable are consolidated into a single column. Consequently, it entails fewer assumptions compared to more intricate models, making it a clear and intuitive method of analysis.

Nonetheless, the pooled OLS possesses considerable drawbacks. The model neglects heteroskedasticity and fails to accommodate the distinct time-invariant traits of each cross-sectional entity in the panel data (Collischon & Eberl, 2020; Hsiao, 2007). In our context, it does not factor in the distinct attributes of each company that may affect the relationship among the variables. Moreover, due to the pooled OLS not accounting for the unobserved company-specific characteristics in our sample, it may culminate in the miscalculation of thee coefficient, term as omitted variable bias (Wilms et al., 2021). Accordingly, despite its simplicity, the pooled OLS may not be appropriate for our research due to its inability to account for heteroskedasticity and the potential for omitted variable bias.

8.2.4 Fixed effects model

The fixed effect model is one of the most prevalently used models for panel data analysis. An important attribute of the model is its allowance for correlation between the entity-specific or time-specific effects and explanatory variables (Hsiao, 2007). In essence, each cross-sectional unit in the panel displays distinct characteristics that could affect the explanatory variables.

A notable advantage of the fixed effects model is its proficiency in controlling for time-invariant attributes of each variable (Hsiao, 2007). For instance, every company in the sample inherently possesses certain attributes correlated with size, leverage, and growth opportunities, that remain relatively static over time but may differ among various companies. The fixed effects model deletes the impact of these time-invariant attributes, thus facilitating a more precise analysis of the influence of variables of interest.

However, the fixed effects model does have some limitations. Since it controls for time-invariant characteristics, it cannot provide estimates of the effects of the time-invariant variables. In other words, it does not consider any variable that does not change over time.

8.2.5 Random Effects model

The random effects model constitutes another extensively used methodology for explaining panel data. It accounts for individual diversity by positing that each cross-sectional entity (company) in the panel bears its unique effect, indicating that variations among companies are stochastic and unassociated with the independent variables in the model (Borenstein et al., 2010).

Contrary to the fixed effects model, the random effects model regards individual effects as stochastic variables, assuming the effects are drawn from a larger population and are unrelated to the explanatory variables. A principal characteristic of the random effects model is its capacity to estimate the influence of time-invariant variables as explanatory variables, which the fixed effects model is unable to achieve due to its elimination of individual effects (Hsiao, 2007).

Nonetheless, the main disadvantage of the random effects model is the assumption that the individual effects are uncorrelated with the explanatory variables. If this assumption is breached, it can culminate in biased and inconsistent estimates (Hsiao, 2007). Given that unobserved individual-specific effects could intuitively be related to explanatory variables in economic and business studies, this presumption can often be problematic.

8.3 Model specification test

It is a conventional practice to execute various model specification tests to determine which panel data to employ. However, given our data's characteristics, we can effortlessly rule out some models based on theory. For example, the SUR framework can be disregarded due to a better alternative since our sample's companies outnumber the number of years. Likewise, pooled OLS can also be eliminated as it fails to accommodate heteroskedasticity, a typical attribute present in panel data (Stock & Watson, 2020), which we elaborate on in the validity section. In sum, our arguments narrow the choice down to either the fixed or the random effects model.

To decide which of the two models to employ, we conducted a Hausman test, in line with prior panel data literature. The test operates on the following basis: it

presumes that individual effects are uncorrelated with the independent variables. If this null hypothesis is true, then both fixed and random effects estimators would be consistent. However, the random effects would be more efficient due to its ability to exploit both within and between variation in the dataset (Ahn & Low, 1996).

On the other hand, the alternative hypothesis assumes that the individual effects are correlated with the independent variables. In this scenario, the random effects estimator would be inconsistent, whereas the fixed effects estimator would yield consistent estimates. By comparing both estimates, the Hausman test can statistically determine whether the difference between the two sets of estimates is systematic (corresponding to the alternative hypothesis) or due to sampling variability (corresponding to the null hypothesis).

The Hausman test shows a statistically significant result (p-value: 0.0), leading us to reject the null hypothesis. In sum, this result indicates that the individual effects are correlated with the explanatory variables, suggesting that the fixed effects model is the appropriate choice of our data.

8.4 Model Building

In this section we present the two fixed effects models employed in our study and their specification. While we chose to only use one of the models in discussing the results in section 10, it is important to present both to, on one hand, ensure transparency, and on the other, to ensure grounds for comparability in terms of results.

8.4.1 Firm fixed effects vs country fixed effects

Our choice to use two distinct models, one controlling for firm fixed effects (Model 1) and another controlling for country fixed effects (Model 2), results from the nature of how ERM observations were assigned during our data collection. During this process we decided that, if ERM was identified for a given year, then we assigned ERM = 1 for all the remaining years, reasoned by the

assumption that the costly and complex nature of ERM constitutes a long-term commitment which cannot easily be discarded after implementation.

Furthermore, and most importantly, this assignment method facilitates two distinct effect interpretations of ERM on firm value. First, model 1 measures the change in firm value when a company initiates ERM activities. In other words, the model aims to capture the value of adopting ERM in a company by controlling for time-invariant firm specific effects, such as organizational culture, that do not change over time but can differ between companies. Accordingly, the model uses each company as its own control before and after the change in ERM status, where the ERM coefficient estimates the average change in Tobin's Q when a company goes from not having ERM to having ERM, controlling for other variables.
Second, model 2, independent of when ERM was initiated, measures the effect merely of having ERM on firm value by controlling for time-invariant country-specific effects such as regulatory environment, culture, or the specific nature of a country's economy. Hence, model 2 seeks to capture the firm value effect of ERM irrespective of when the corresponding activities were initiated.

The use of these two models thus broadens our analysis to consider different aspects of the influence of ERM on firm value, enriching the study as well as making it more robust.

8.4.2 Model specification for firm fixed effects

$$\begin{aligned} Tobin'sQ_{it} = {} & \beta_0 + \beta_1 ERM_{it} + \beta_2 Size_{it} + \beta_3 Liquidity_{it} + \beta_4 ROA_{it} + \beta_5 Dividend_{it} \\ & + \beta_6 Leverage_{it} + \beta_7 Growthopp._{it} + \beta_8 Divint._{it} + \beta_9 Bigfour_{it} \\ & + \beta_{10} Assetopacity_{it} + \beta_{11} Salesgrowth_{it} + \gamma_i + \delta_t + \varepsilon_{it} \end{aligned}$$

In this model:

* "γ" refers to the firm specific effects, capturing unobserved time-invariant characteristics of firm i.
* "δ" refers to the time fixed effects, taking into account unobserved factors that vary over time but not between companies (constant across companies)
* "ε" refers to the error term for company i at time t.

8.4.3 Model specification with country fixed effects

$$Tobin'sQ_{it} = \beta_0 + \beta_1 ERM_{it} + \beta_2 Size_{it} + \beta_3 Liquidity_{it} + \beta_4 ROA_{it} + \beta_5 Dividend_{it} + \beta_6 Leverage_{it} + \beta_7 Growthopp._{it} + \beta_8 Divint._{it} + \beta_9 Bigfour_{it} + \beta_{10} Assetopacity_{it} + \beta_{11} Salesgrowth_{it} + \alpha_c + \delta_t + \varepsilon_{it}$$

In this model:

* "α" refers to the country-specific fixed effects, capturing unobserved time-invariant characteristics of country c.

8.5 Validity

After determining the model to be used, it is important to evaluate the model's validity. Essentially, model validity refers to the capacity of the model to accurately represent the relationships it is designed to estimate (Roberts & Bilderback, 1980). In the context of our research, this entails verifying whether the assumptions inherent in the fixed effects model hold for our dataset. Subsequent sections delve into these assumptions to validate our conclusions.

8.5.1 Addressing selection bias

Selection bias pertains to the skewness that arises when the sample is not drawn randomly, thus failing to accurately represent the target population (Mummolo & Peterson, 2018). This may arise due to non-random attrition, for example, if companies exit the sample due to bankruptcy, or if they enter the sample at varying times.

It is vital to ensure that the process of choosing the sample does not systematically exclude certain observations based on the value of the dependent or independent variables. In our study, we have tried to alleviate the potential for selection bias through random sampling. According to the fixed effects model's assumption, variables are distributed evenly and independently across units, thus meeting the criteria essential for mitigating selection bias. It is noteworthy that complete elimination of selection bias is not achievable. However, by maintaining transparency regarding the process through which our sample was selected, we aim to increase confidence in the findings.

8.5.2 Addressing omitted variable bias

Omitted variable bias refers to the distortion that arises when significant variables are excluded from the regression model (Wilms et al., 2021). This exclusion violates a core assumption in regression analysis, which asserts that the error term must be uncorrelated with the independent variables. If an omitted variable is both correlated with independent variables and influences the dependent variable, this can inject bias in the estimates of the regression coefficient, leading to erroneous conclusions and results.

It is crucial to acknowledge that the fixed effects model is unable to control for unobserved factors that vary over time. This limitation underscores the significance of thorough model specification, which encompasses the careful selection and inclusion of pertinent independent variables grounded in economic theories and empirical evidence from prior studies. In our study, we have incorporated variables that have been employed in established research in this domain. Consequently, there is no reason for us to infer that our model is compromised by omitted variable bias.

However, despite basing our selection of independent variables on prior studies, the possibility of omitted variable bias persists. First, it is essential to recognize that no research can capture all conceivable determinants of a dependent variable. Certain factors may be inherently unobservable or challenging to quantify, albeit theoretically relevant. Secondly, variables deemed significant in earlier research may not encompass all the elements that are vital in our specific context. It is important to note that our research is centered on the oil and gas market, which has historically been under-examined, especially the upstream segment.

We acknowledge that, akin to any empirical research, our study is likely to be influenced by omitted variable bias. While we are confident that our model is adequately specified, we interpret our findings with the understanding that there may be unaccounted-for factors influencing the relationship between ERM and firm value.

8.5.3 Addressing multicollinearity

In multiple regression analysis, multicollinearity is the phenomenon where two or more independent variables are highly correlated with each other. This correlation makes it challenging to isolate the individual effects of these variables on the dependent variable, consequently leading to unreliable and untrustworthy estimates (Shrestha, 2020). Moreover, multicollinearity enhances the variance of the coefficient estimates, which could result in these estimates being volatile and statistically insignificant, despite being economically significant, i.e., the estimated coefficient shows a meaningful effect on the dependent variable.

In our study, we explain the relationship between ERM and firm value, considering variables such as size, leverage, international diversification. This makes it imperative to examine multicollinearity. For example, firm size and leverage could be correlated since larger firms might possess more assets that can be used as collateral for debt, thus potentially having higher leverage. Additionally, larger firms may be more inclined to diversify their operations internationally by leveraging their more extensive asset base.

To investigate the relationship among our independent and dependent variables, we have employed a correlation matrix in our study. As outlined in section 9, the correlation matrix reveals that the highest pair-wise correlation is 0.6. This value is substantially below the commonly accepted threshold of 0.8 (Bashatweh & Ahmed, 2021), which suggests that significant multicollinearity is not present within our dataset. Although the Variance Inflation Estimator (VIF) test is typically used to assess multicollinearity issues, it is not applicable for our specific regression model. As such, we posit that the correlation matric offers an adequate approximation.

It is worth noting that, while multicollinearity can yield unreliable estimates, some degree of correlation among variable is expected and can be beneficial in multivariate analysis (Kraha et al., 2012). However, alarm bells should ring in cases of perfect multicollinearity, where one or more of the variables are exactly correlated, making it impossible to produce reliable estimates. Imperfect multicollinearity could also be problematic, occurring when one or more variables are highly but not perfectly correlated. In such cases, the models R-squared value might be high, but the significance of the coefficient would be low.

Hence, it is vital to monitor multicollinearity during construction of a regression model by using tools such as the correlation matrix. Additionally, it is essential to interpret the results of these models with caution, especially when high multicollinearity is present.

8.5.4 Examining error terms in panel data: stationarity and serial correlation, and heteroskedasticity

When conducting a panel data analysis, paying close attention to the characteristics of error terms is important, as these attributes can affect the validity of the regression outcomes (Griliches & Hausman, 1986). Specifically, three principal properties warrant consideration: stationarity, serial and heteroskedasticity.

Stationarity, concerning error terms, implies that the properties remain constant over time, denoting a consistent means and variance (Griliches & Hausman, 1986). Non-stationary errors could invalidate standard statistical inferences and give rise to potentially deceptive results. In our model, we assume the idiosyncratic errors to be stationary, a common assumption in fixed effects model (Kapetanios et al., 2011).

Serial correlation, or auto correlation, is a scenario in which the error term in one period correlates with the error term in a different period (Bhargava et al., 1982; Wursten, 2018). The existence of serial correlation can culminate in inefficient and inconsistent estimators, making standard hypothesis tests untrustworthy.

Additionally, heteroskedasticity is a vital consideration for the validity of a study. It denotes a situation in regression analysis where the variation of error terms, or residuals, is not consistent across various levels of independent variables (Olvera Astivia & Zumbo, 2019). The Ordinary Least Squares (OLS) estimation, frequently used in fixed effects models, presumes homoskedasticity, meaning a constant variance of error terms. Should this assumption be violated, the OLS estimates will continue to be unbiased but will lose efficiency, meaning they will not have the smallest conceivable standard errors. The inefficiency can potentially

lead to untrustworthy hypothesis tests and confidence intervals (Olvera Astivia & Zumbo, 2019).

Our model, termed the high definition regression model with fixed effects, accounts for both serial correlation and heteroskedasticity through the inclusion of clustered standard errors on firm level (stata code: vce(cluster company_id). In fact, they are valid whether heteroskedasticity is present, serial correlation is present, or both. Specifically, while clustering the standard errors on firm level allows the regression to have correlations within a cluster (a specific company), the regression errors across clusters (companies) are assumed to be uncorrelated. Hence, our model's clustered standard errors allow for heteroskedasticity and serial correlation without invalidating the second fixed effects assumption, which states that the variable observations are independent and identical draws from a joint distribution (Stock & Watson, 2020, pp. 375–376).

8.5.5 Addressing measurement errors

Measurement error, which is the difference between the observed and the true value of a variable, is a notable challenge in regression analysis. This error can originate from various sources such as imprecisions in data collection, data processing, or the employment of flawed measurement instruments.

In the context of our study, measurement error could be particularly conspicuous due to the methodology employed for data collection. As elaborated on in section 7, we engaged in manual calculations of ratios for companies in the European sample. Additionally, we hand-verified whether a company had implemented ERM by carefully evaluating each company on an annual basis across the entire sample. However, we must concede that our assessment of ERM adoption might not be absolutely precise. As indicated by Kapstad from Equinor (personal communication, June 1, 2023), ascertaining if a company has instituted ERM is far from a binary "yes" or "no" question; the reality is substantially more nuanced. Furthermore, the manual calculation of financial ratios can be subject to errors, which could notably impact the results, especially for the companies in the European sample.

Given the backdrop, it is important to exercise caution when interpreting the results of our analysis, taking into consideration the potential influence of measurement error. This situation emphasizes the necessity for thorough validation processes, coupled with a systematic and impartial approach to data collection and processing. Moreover, it serves as a reminder of the importance of continuously refining and augmenting these processes to mitigate measurement error. Such efforts are crucial for increasing the reliability and validity of our findings.

In interpreting the results of our analysis, it is therefore important to consider the potential impact of measurement error. This underscores the need for rigorous validation processes, along with a consistent and unbiased approach to data collection and processing. It's also a reminder of the importance of refining and improving these processes to minimize the extent of measurement error, thereby enhancing the reliability and validity of our findings.

In sum, while the presence of selection bias and omitted variable bias can never be discarded in empirical research, we believe our study addresses these concerns sufficiently. Moreover, multicollinearity does not pose a threat to the validity of our study, which we provide further details on in section 9.2. While measurement errors in the data collection on European firms could exist, due to manually collecting observations, we ascertain that the process has been carried out diligently. Finally, given that our model allows for serial correlation and heteroskedasticity, the presence of these features will not disturb our analysis.

9. Data Analysis

In this section we delineate the descriptive statistics of our study to increase knowledge of the nature of our sample. We include customary statistics like the mean, standard deviation, range, median, quartile 1 and 3, after which we briefly comment on the key findings. Furthermore, we also provide a table comparing the variable means of companies with ERM and without (Table 2). The discussion of these findings is presented in section 10 together with the discussion of the econometric results. Finally, we also present the correlation matrix (Table 3) to address multicollinearity and examine interesting correlations between the variables employed in our study.

9.1 Descriptive statistics

9.1.1 Description of data

The statistics in Table 1 visualizes the summary statistics of the dependent variable firm value as proxied by Tobin's Q, the main independent variable ERM and the rest of the independent control variables. We have also included another descriptive statistic, Table 2, reflecting a difference-in-mean comparison between firms with ERM and firms without ERM. However, Table 2 is also placed in the results section as it intuitively makes sense to discuss the difference-in-means results with the regression results. Hence, we only choose to include a description of Table 2 in the data analysis section. Furthermore, the data is collected over an 11-year period from 2010 to 2020, largely of North American and European oil and gas companies engaged in the E&P of oil and gas. While most of the sample are companies directly engaged in either production or exploration, a small minority of the sample comprises companies that are engaged in the value chain of E&P, i.e., companies which provide services in the E&P process such as for instance drilling.

Variable	Obs	Mean	Std. dev.	Min	Max	Q1	Median	Q3
Tobinsq	957	1.3667	0.9394	0.1890	6.8997	0.8758	1.1131	1.5560
ERM	957	0.3406	0.0474	0.0000	1.0000	0.0000	0.0000	1.0000
Size	957	21.3330	2.4506	14.7779	26.7400	19.5563	21.5767	23.1000
Liquidity	957	2.4686	6.9463	0.0000	60.9130	0.2954	0.7911	1.8606
ROA	957	-0.0804	0.3127	-1.9952	0.35000	-0.1061	0.0000	0.0581
Dividend	957	0.5005	0.5003	0.0000	1.0000	0.0000	1.0000	1.0000
Leverage	957	1.2005	3.4955	-17.0598	18.9645	0.5066	1.0072	1.6019
Growth opp.	957	0.6355	1.2731	0.0000	11.7828	0.1284	0.3141	0.6724
Diversified int.	957	0.5517	0.4976	0.0000	1.0000	0.0000	1.0000	1.0000
BigFour audit	957	0.7607	0.4269	0.0000	1.0000	1.0000	1.0000	1.0000
Asset opacity	957	0.0599	0.1123	0.0000	0.7020	0.0000	0.0039	0.0670
Salesgrowth	957	0.1501	0.8739	-0.8469	6.2843	-0.2364	0.0151	0.2293

Table 1: Descriptive Statistics

9.1.2 Explanation of variable transformation

All tables visualize the statistics of all the winsorized variables at the 1% level, except for the variable for firm size and the indicator variables for ERM, Dividends, BigFour audit, and Diversified int. The reason for this is two-fold: first, “Size” already has undergone a log transformation, and second, it naturally makes little sense to winsorize indicator variables as they either take the value 0 or 1. Moreover, the motivation behind winsorizing variables is to remove the impact of extreme observations since the OLS estimator is sensitive to outliers, making the regression model less accurate (Stock & Watson, 2020, pp. 159, 225, 375). As such, these observations will influence the distributions of the mean, making it less representative of the average of the sample. Additionally, outliers can also significantly increase variability, which impairs the ability of the regression model to detect underlying patterns and relationships in the data, reducing the power of statistical tests. More specifically, a sharp increase in the standard deviation leads to a larger standard error of the mean, leading to a smaller t-statistic for the liquidity coefficient. A smaller t-statistic translates to a higher p-value, which entails less significant coefficient estimate results (Stock & Watson, 2020, p. 113). Accordingly, by winsorizing the data and thus reducing the impact of outliers, we increase the likelihood of finding significant effects if they

exist. A log transformation essentially provides the same outcome by pulling in the tails of the sample distribution, reducing a potential skewness, thus making it more normalized. In practice, the process of winsorization at the 1% level translates to a transformation of observations in the upper 99th percentile and lower 1st percentile to the largest and smallest value, respectively, that were not transformed when the winsorization at the 1% level was computed (Wilcox, 2017).

9.1.3 Observations and key findings from Table 1

The statistics in Table 1 provide a good overview of the general characteristics of the variables in our dataset. Our final sample consists of 113 companies and corresponding 957 observations for all variables, suggesting that the dataset does not suffer from missing values. The mean value of Tobin's Q, our proxy for firm value, is 1.3667. Moreover, there is substantial variation in firm value within our sample, as highlighted by the standard deviation of 0.9394 and a range from 0.1890 to 6.8967.

Concerning the key findings from Table 1, it is worthwhile to consider the mean value of our independent variable of interest, ERM. Since ERM is a dummy variable equal to 0 or 1, the mean thus provides an understanding of the proportion of companies that have implemented ERM within the sample. More specifically, the number 0.3406 indicates that 34.06% of the companies in our sample have implemented ERM during the period under observation (2010-2020). Applying the same process to the other dummy variables entails that 50% of the companies in our sample pay a dividend, 55.17% operate internationally, and 76.07% are audited by one of the big four accounting firms.

Moreover, the other control variables also exhibit interesting patterns. The mean Size, computed as the natural logarithm of total assets, is 21.33, and the observations range from the smallest company in the sample measured at 14.77 to the largest measured at 26.74. On average, the sample companies have a Liquidity ratio of 2.4686 which implies that, on average, the companies have about 2.46 times as much cash, cash equivalents, and short-term investments as they have in current liabilities. This ratio reflects the volatile nature of the oil and gas industry and underscores the importance of having cash at hand in the event of something

unexpected. Interestingly, the average ROA is negative (-0.08%), which suggests that, on average, companies are not making a profit from their assets. While this could be a cause for concern for the industry, the relatively high standard deviation of 0.3127 reflects a substantial degree of variation between the companies, indicating that some companies are a lot more profitable than others. More specifically, the oil and gas industry is a significantly capital-intensive industry that creates huge entry barriers for competitors, effectively solidifying the position of incumbents. We can easily find support for this argument by reviewing the return on assets for some of the largest companies in our sample. For instance, Equinor and Shell plc recorded positive ROAs for almost every year during the sampling period.

The average leverage ratio in the sample is 1.2005, which suggests that, on average, companies have slightly more liabilities than shareholder's equity. The mean value of Growth opp. is 0.6355. Given that this ratio is computed as capital expenditure divided by revenue, it implies that firms are investing in growth opportunities. The average sales growth is 15%, which is positive, signaling that firms in the sample are, on average, growing.

All the variables exhibit considerable standard deviations, advocating for substantial variation across the sample. From a research perspective, variation is important for three reasons. First, if there is no variability in, for instance, Size, it would be impossible to identify any relationship between Size and firm value since there is no variation to explain. Second, with relatively higher variation, the chances of missing relationships that truly exist decrease. As such, statistical tests would be better equipped to detect an effect with higher variation in the sample. The third concerns generalizability of the results. While this could be an ambiguous interpretation, high variation could make the findings more generalizable. If, for instance, the sample comprises a broad range of firms, the results may apply to companies of different sizes, provided that all the firms are similar in other aspects such as industry and country of operations.

9.1.4 Table 2: Comparing firms with and without ERM

Based on the indicator variable for ERM, Table 2 splits the sample into two groups, thus providing grounds for comparing firms that have implemented ERM

(sample 2) and those that have not (sample 1). The table presents the number of observations, the mean, and the standard deviation for both groups, and the last column on the right-hand side provides the t-statistic for the difference-in-means test between the two groups. While this table enhances the understanding of our dataset, taking into account our main variable of interest, ERM, it must be stressed that no causal interpretation can be made. One should instead perceive it as a check of the relationship between ERM and the other variables. We use Table 2 in companionship with the econometric results in section 10 to discuss the implications of our study's findings.

Variables	Obs sample 1	Mean sample	Std. dev. sample	Obs sample 2	Mean sample 2	Std. dev. Sample 2	T-statistics
Tobinsq	631	1.4380	1.046	326	1.228	0.666	3.251***
Size	631	20.560	2.370	326	22.827	1.837	-15.108***
Liquidity	631	3.137	8.404	326	1.103	1.477	4.401***
ROA	631	-0.099	0.360	326	-0.043	0.184	-2.626**
Dividend	631	0.381	0.486	326	0.730	0.444	-10.873***
Leverage	631	1.226	3.735	326	1.351	2.976	-0.850*
Growth opp.	631	0.724	1.511	326	0.464	0.543	3.007***
Diversified int.	631	0.462	0.499	326	0.723	0.447	-8.015***
BigFour audit	631	0.697	0.459	326	0.883	0.321	-6.530***
Asset opacity	631	0.057	0.116	326	0.065	0.102	-1.017**
Salesgrowth	631	0.208	1.109	326	0.036	0.496	3.0556***

Note: ***. **, * denote 1%, 5% and 10% significance level respectively. N refers to the number of firms. Obs refers to the number of observations. Standard errors in parenthesis

Table 2: Difference-in-means comparison

9.2 Correlation matrix

This section presents and interprets the correlation matrix for all the variables in our study. The reason for its inclusion is, on one hand, to obtain insights into the pairwise relationships between these variables and, on the other, to perform a check for multicollinearity. The latter refers to a situation in which one of the variables is highly correlated with others, thus forming a close linear combination that could result in an inexact estimation of one or more of the regression coefficients (Stock & Watson, 2020, p. 228).

	Tobinsq	ERM	Size	Liquidity	ROA	Dividend	Leverage	Growth opp.	Diversified int.	Bigfour	Asset opacity	Salesgrowth
Tobinsq	1											
ERM	-10.45*	1										
Size	-0.183*	0.439*	1									
Liquidity	0.079*	-0.141*	-0.347*	1								
ROA	-0.034	0.085*	0.235*	-0.047	1							
Dividend	0.124*	0.331*	0.487*	-0.044	0.222*	1						
Leverage	-0.023	0.0275	0.009	-0.101*	-0.011	-0.040	1					
Growth opp.	0.158*	-0.097*	-0.169*	0.090*	-0.095*	-0.149*	-0.017	1				
Diversified int.	-0.130*	0.251*	0.338*	-0.092*	0.079*	0.166*	0.023	-0.167*	1			
Bigfour audit	-0.212	0.207*	0.601*	-0.266*	0.157*	0.307*	-0.040	-0.200*	0.386*	1		
Asset opacity	0.021	0.033	0.049	-0.100*	0.045	-0.0002	0.043	-0.102*	0.156*	0.182*	1	
Salesgrowth	0.075*	-0.098*	-0.097*	-0.031	0.105*	-0.116*	-0.038	0.080*	-0.067*	-0.088*	0.056	1

Note: * denotes 5% significance level

Table 3: Correlation matrix

9.2.1 Discussion of correlations with ERM – our independent variable of interest

Considering the main variable of interest, ERM, we observe interesting patterns. ERM has a positive and statistically significant correlation with Size (0.4387*), ROA (0.085*), Dividend (0.331*), Diversified int. (0.251*), and BigFour audit (0.207*). These relationships intuitively make sense since larger and better performing firms, as indicated by ROA, firms paying dividends, those operating internationally, and those audited by the big four are more likely to have the

resources to adopt and benefit from ERM. Furthermore, ERM has a negative and statistically significant correlation with Tobin's Q (-0.105*), Liquidity (-0.141*), Growth opp. (-0.097*), and Salesgrowth (-0.098*), indicating that companies with ERM tend to exhibit lower firm value, lower liquidity, lesser growth opportunities and lesser sales growth. There could be many explanations as to why this is the case. For example, one possible argument could be that ERM's portfolio risk management enables companies to opt for safer investment opportunities with lower returns, which may result in a lower Tobin's Q. Another one could be that sophisticated ERM systems require substantial resources and maintenance, which may decrease liquidity in the short term. Effective portfolio risk management may also facilitate more efficient use of the company's liquidity in the long term.

9.2.2 Multicollinearity check

While it is customary to check for multicollinearity in multiple regression using the so-called VIF (Variance Inflation Estimator), our type of regression model does not support its use, something we discussed in section 8. However, using the correlation matrix to identify pairwise correlations between variables can also adequately assess whether multicollinearity is present (Shrestha, 2020). Although perfect multicollinearity refers to a situation in which one of the regressors is a perfect linear function of the other regressors (100% correlation) and thus prevents estimation of the regression, imperfect multicollinearity refers to a situation of very high correlation that does not prevent regression estimation but could lead to imprecise estimations (Stock & Watson, 2020, p. 228). Moreover, the general threshold for pairwise correlation between variables that potentially may constitute issues with multicollinearity is 0.8 (Bashatweh & Ahmed, 2021).

Examining the matrix, the most substantial correlation among the variables is between Size and BigFour audit (0.601*), suggesting that larger firms are more likely to be audited by one of the big four accounting firms. This is clearly below the generally accepted threshold (0.8), which indicates that multicollinearity is not a significant issue in our regression analysis. Additionally, there are only two more pairwise correlations above 0.4, as showcased by the correlation between Size and ERM (0.439*) and Size and Dividend (0.487*), which further strengthens the argument against the presence of multicollinearity.

9.3.3 Other interesting correlations

The relatively high and statistically significant correlation between Size and Dividend (0.4871*) suggests that larger firms are more likely to pay dividends. Size also shows a significant negative correlation with Liquidity, implying that larger firms have lower liquidity. Interestingly, positive, and statistically significant correlation exists between Tobin's Q and Dividend, suggesting that firms that pay dividends may exhibit higher firm values.

10. Results and Discussion

In this section, we present the econometric results of both models (Table 4) accompanied by a difference-in-means comparison between firms with and without ERM (Table2).

Variables	Obs sample 1	Mean sample	Std. dev. sample	Obs sample 2	Mean sample 2	Std. dev. Sample 2	T-statistics
Tobinsq	631	1.4380	1.046	326	1.228	0.666	3.251***
Size	631	20.560	2.370	326	22.827	1.837	-15.108***
Liquidity	631	3.137	8.404	326	1.103	1.477	4.401***
ROA	631	-0.099	0.360	326	-0.043	0.184	-2.626**
Dividend	631	0.381	0.486	326	0.730	0.444	-10.873***
Leverage	631	1.226	3.735	326	1.351	2.976	-0.850*
Growth opp.	631	0.724	1.511	326	0.464	0.543	3.007***
Diversified int.	631	0.462	0.499	326	0.723	0.447	-8.015***
BigFour audit	631	0.697	0.459	326	0.883	0.321	-6.530***
Asset opacity	631	0.057	0.116	326	0.065	0.102	-1.017**
Salesgrowth	631	0.208	1.109	326	0.036	0.496	3.0556***

Note: ***. **, * denote 1%, 5% and 10% significance level respectively. N refers to the number of firms. Obs refers to the number of observations. Standard errors in parenthesis

Table 2: Difference-in-means comparison

Variable	Model 1: Firm specific fixed effects	Model 2: Country specific fixed effects
ERM	0.395 (0.122)***	-0.067 (0.091)
Size	-0.271 (0.092)***	-0.032 (0.026)
Liquitidy	0.035 (0.012)	0.08 (0.011)
ROA	-3.04 (0.171)*	-0.347 (0.167)**
Dividend	0.110 (0.09)	0.367 (0.116)***
Leverage	0.002 (0.006)	0.001 (0.007)
Growth opp.	0.011 (0.04)	0.109 (0.039)***
Diversified int.	0.519 (0.157)***	0.028 (0.091)
BigFour audit	-0.188 (0.109)*	-0.219 (0.134)
Asset opacity	0.588 (0.366)	0.201 (0.499)
Sales growth	0.093 (0.023)***	0.102 (0.031)***
R-squared	0.7506	0.5118
Adjusted R-squared	0.7111	0.4938
N	110	113
Obs	954	957

Note: ***. **, * denote 1%, 5% and 10% significance level respectively. N refers to the number of firms. Obs refers to the number of observations. Standard errors in parenthesis

Table 4: Regression results Model 1 & Model 2

10.1 Model 1: firm-specific fixed effects

We recall that model 1 is a panel data model with firm specific fixed effects, time fixed effects, and one-way clustered standard errors on firm level. These features ensure that our model captures both firm-specific and year-specific effects that are constant over time and provides robust standard errors, ascertaining model validity in terms of heteroskedasticity and serial correlation. We also recall that model 1 measures the change effect of ERM on firm value, i.e., the ERM effect on firm value, by changing the ERM status from 0 to 1.

While the results indicate that four variable coefficients are statistically insignificant, two coefficients are significant at the 10% level and five are highly significant at the 1% level.

The main variable of interest, ERM, is highly statistically significant (p-value: 0.002) and is estimated to have a positive coefficient of 0.395, suggesting an economically significant effect. Economic significance translates to whether the coefficient estimate is relatively large and thus has a meaningful impact on the dependent variable. Given that the mean Tobin's Q for the entire sample is 1.3667 (see Table 1) and the ERM coefficient is 0.395 (29% of 1.3667), the ERM coefficient is economically significant. In other words, the model estimates that the ERM effect on firm value is 0.395 when the firm goes from not having ERM, to having ERM.

Other highly significant coefficients correspond to the variable for Size, Liquidity, Diversified int., and Salesgrowth. Specifically, the Size coefficient has a p-value of 0.004 and is estimated to impact Tobin's Q by -0.271 for a unit increase in Size. The Liquidity coefficient has a p-value of 0.007 and is estimated to impact Tobin' Q by 0.035 for a unit increase in Liquidity. Surprisingly, the coefficient for ROA has a negative effect (-0.3) on Tobin's Q, but the result is only significant at the 10% level. Furthermore, another surprising result is that neither Leverage, nor Growth opp. are estimated to have statistically significant effects on Tobin's Q. On the contrary, Salesgrowth has the most statistically significant coefficient with a p-value of 0.0 and is estimated to impact Tobin's Q with 0.09 for a unit increase in Salesgrowth.

10.2 Model 2: country-specific fixed effects

The regression results from Model 2, which includes country-specific fixed effects and one-way clustered standard errors on firm level, exhibit notable differences from Model 1. As explained in section 8, this model aims to measure the effect of ERM on firm value by controlling for different sets of time-invariant country-specific effects. Hence, it seeks to capture the firm value effect of ERM, irrespective of when the related activities were initiated.

Contrary to Model 1, the results of Model 2 indicate that the ERM coefficient is neither statistically, nor economically significant. In fact, the coefficient is estimated to be -0.067, entailing that implementing ERM would potentially only reduce firm value by 0,067. Moreover, the estimated effect is negative, in stark contrast to model 1.

Out of the eleven variables, model 2 estimated statistically significant effects on Tobin's Q for only four variables; Dividend, Growth opp., Salesgrowth, and ROA. The first three are positively significant at the 1% level, while return on assets has a statistically significant inverse association with Tobin's Q, at the 5% level.

It is also worth noting that the coefficient sizes in this model vary substantially, implying varying degrees of impact on Tobin's Q. Furthermore, not all variables are statistically significant in the model, which is to be expected as not all factors can exert significant influence at the country level.

10.3 Model selection

When choosing which model to employ in our analysis, there are three aspects to consider. First, concerning the significance and impact of the ERM variable. While model 1 estimates a highly significant result for the ERM coefficient, model 2 estimates an effect that is not significant on any level. Additionally, there is a considerable discrepancy between estimated effects, in which model 1 estimated a substantial positive effect of ERM on Tobin's Q and model 2 estimated a relatively low negative effect. Furthermore, contrary to model 2, model 1 provided a coefficient estimate for the ERM variable that was both

statistically and economically significant. Considering the corresponding t-statistics, which translates into a p-value in model 1 at 0.002 and a p-value in model 2 at 0.461, there is little doubt that model 1 is the better fit.

Second, while model 2 only estimates four statistically significant coefficients, model 1 estimates seven, out of which five are significant at the 1% level. This suggests that model 1 delivers more significant results and thus facilitates more robust inference.

Third, the R-squared for Model 1 is 0.7506, indicating that 75.06% of the variation in Tobin's Q is explained by the variation in the independent variables. On the contrary, the variation in the independent variables in Model 2 only explains 51.18%. Accordingly, Model 1 thus has a better explaining ability, enhancing the ability to detect relationships if they exist.

In sum, model 1 is the preferred model, allowing us to discuss the ERM effect on Tobin's Q when companies change their ERM status, i.e., choose to implement an ERM system.

10.4 Discussion of results

In examining the impact of various factors on firm value, as measured by Tobin's Q, our firm-specific fixed effects model showed several notable findings. Three elements – ERM, Diversified int., and Salesgrowth – significantly increased firm value, while other factors like Size, ROA, and BigFour audit appeared to decrease firm value.

In our regression model, the variable of interest, ERM emerged with a positive and statistically significant coefficient (0.395), providing an empirical indication that the adoption of ERM does enhance firm value. Since our model measures the change effect, a positive ERM coefficient entails that a firm transitioning from not having ERM (ERM=0), to adopting ERM, is associated with an increase in firm value of 0.395, which aligns with our expectations. This relationship was, however, not consistent with Table 2, which divides the sample into two groups, facilitating a difference-of-means comparison between firms that had ERM (ERM=1) and firms that did not (ERM=0). Specifically, Table 2 displays that

firms that implemented ERM tend to be associated with lower firm value and that this difference in the mean value of Tobin's Q is statistically significant at the 1% level. However, we underscore that this observation cannot be interpreted causally, suggesting that there may be several explanations for the discrepancy between the results of Table 2 and Table 4. One explanation could be that resources spent on implementing and maintaining ERM systems could have been used for other profit-generating opportunities that the market perceived as a suboptimal allocation of resources. However, given that our econometric model estimated a highly statistically significant ERM coefficient with corresponding economic significance, this seems unlikely.

Alongside ERM, Diversified int. (0.519), Salesgrowth (0.093), and Liquidity (0.035) were similarly significant (1% level) and positively related to Tobin's Q, reinforcing their perceived benefits for the firm's value. The findings on Diversified int. in Table 2 also postulated that firms with ERM showed a higher mean value (0.7239) than those without ERM (0.4628). Implicitly, this suggests that firms with more sophisticated risk management practices tend to have more internationally diversified operations, which could stem from the fact that ERM encourages a broader perspective of risk, including those arising from concentrated geographic locations, as stated by Lin (2011) and Farrell & Gallagher (2015). This in line with the ERM philosophy, firms may diversify their operations across different regions to mitigate this risk.

Looking at the correlation matrix, we observe a statistically negative correlation between Salesgrowth and ERM (-0.0982). This suggests that firms with ERM tend to have lower sales growth, aligning with the difference-in-means comparison in Table 2. However, Salesgrowth seems to increase Tobin's Q. As firms with ERM tend to have lower sales growth, it could be inferred that firms with a comprehensive risk management framework might exhibit slower sales growth due to more cautious business strategies (P. Kapstad, personal communication, June 1, 2023), which raises questions about the trade-off between risk management and growth. Regarding Liquidity, our findings may seem counterintuitive. Although it shows a statistically significant and positive impact, albeit not economically significant, on Tobin's Q, Table 2 reveals that firms without ERM have a higher liquidity mean (3.174) than those with ERM (1.104). This can be explained by the plausible argument that firms with ERM could be

more likely to focus on long-term financial stability, which might involve retaining fewer liquid assets for strategic investments. Moreover, given the volatile and uncertain nature of the oil and gas industry, which may increase the need for liquidity in the event of something unexpected, ERM could be argued to moderate these needs by providing more efficiency in terms of, for instance, resource allocation, thus reducing the need for liquidity. Alternatively, it could be the case that highly liquid firms possess greater opportunities to undertake certain investments, such as implementing ERM, as discussed in the works of Anton & Nucu (2020) and Lechner & Gatzert (2018). As a result, they may experience reduced liquidity post-ERM implementation.

On the other hand, and contrary to our expectations, firm Size demonstrated a significant negative relationship with Tobin's Q with an economically significant coefficient of -0.271, which is consistent with Lechner & Gatzert, but contradictory to Aldoseri's (2022) and Kinyar's (2020) findings. However, Table 2 shows that firms with ERM are larger on average (22.83) than firms without ERM (20.56). One explanation could be that larger firms benefit from greater assets such as financial, technological, and human resources (Lechner & Gatzert, 2018). Additionally, it could suggest that relatively large firms are more inclined to implement ERM, potentially due to increased complexity and risk in their operations. We are, in other words talking about the concept of endogeneity, i.e., that firms do not randomly adopt ERM, which is one of the main weaknesses of ERM studies. As such, although our model estimated a negative effect, one could still argue that there is a positive relationship between size and firm value since size seems to moderate whether ERM should be implemented, and ERM has a strong statistically and economically significant effect on firm value. The relatively large statistically significant correlation between Size and ERM in Table 3 (0.4387*) supports this argument. This aligns with the statements of Petter Kapstad, who explained that, since ERM is a considerable investment, larger firms are typically better positioned financially to adopt.

Furthermore, ROA exhibits a negative, economically significant impact on Tobin's Q (-0.304). However, this result is only significant at the 10% level, which is also contrary to our expectations, as well as to previous literature (Aldoseri, 2022; Bertinetti et al., 2013; Lechner & Gatzert, 2018). This result suggests that the value of upstream oil and gas sector firms in our sample might

not primarily depend on their short-term profitability, as measured by ROA. The mean value of ROA for the entire sample is -0.0804, providing support for this argument. It could be argued that the firm values of these firms are influenced by other factors such as long-term growth prospects, risk management practices, and industry-specific dynamics (P. Kapstad, personal communication, June 1, 2023). For instance, upstream firms often require significant capital investments and face high risks, which may overshadow short-term profitability's influence on their valuation. Furthermore, while the mean value of ROA is negative for both firms with ERM (-0.0493) and without ERM (-0.099) (see Table 2), it is substantially higher for firms with ERM. The corresponding t-statistic of -2.6 advocates for a statistically significant difference at the 1% level between the two groups, indicating that ERM companies are more efficient and profitable, aligning with previous studies (Aldoseri, 2022; Hoyt & Liebenberg, 2011; M. McShane, 2018).

Another finding that contradicts our expectations concerns the BigFour audit variable. Model 1 displays that this variable negatively influences Tobin's Q, with a coefficient of -0.188, statistically significant at the 10% level. However, not surprisingly, and in accordance with previous literature (M. S. Beasley et al., 2005; Gatzert & Martin, 2015; Lechner & Gatzert, 2018), our findings from Table 2 show that firms being audited by one of the Big Four are more likely to have implemented ERM compared to those who are not audited by one of the Big Four.

The findings on Asset opacity, Dividend, Leverage, and Growth opp. were all positive but not statistically significant, indicating that these variables may not be crucial determinants of firm value in the oil and gas sector within our sample. Moreover, the estimated coefficient of Asset opacity is 0.588, which coincides with Gatzert & Martin and Lechner & Gatzert. This implies that there is not a solid empirical basis to assert a relationship between asset opacity and Tobin's Q for the upstream oil and gas sector firms in our sample. The effect of financial Leverage on firm value has been subject to ambiguous results according to prior research (Gatzert & Martin, 2015; Hoyt & Liebenberg, 2011). Our model estimated a statistically insignificant Leverage coefficient of only 0.002, indicating a minimal insignificant economic effect. Table 2 shows a slight increase in Leverage for firms with ERM (1.35) compared to those without ERM (1.12). Since ERM is significantly related to higher Tobin's Q in our study, it could be that ERM implementation helps firms manage the risks associated with

higher leverage (Kinyar, 2020; Pagach & Warr, 2011), thus reducing the potential negative impact on firm value. The lack of a significant relationship between Dividend and firm value might be due to the specific characteristics of the oil and gas sector, in which companies often need to retain earnings for future investments in exploration and development activities. Therefore, contrary to other industries, the payment of dividends might not be seen as a strong signal of firm value. Looking at Table 2, we can see that 73% of firms with ERM pay dividends, whereas only 38,2% of the firms without ERM pay dividends. This might suggest, as previously explained, that ERM implementation can allow more predictable cash flows and increased confidence in the ability to maintain dividend payments.

In further consideration of Table 2, the average level of Growth opp. for firms without ERM is slightly higher (0.7240) than for firms with ERM (0.4642). The t-statistics for the difference in means is 3.0079, indicating that the difference is statistically significant. This may suggest that companies implementing ERM are more conservative and prefer to limit their exposure to high-risk growth opportunities (P. Kapstad, personal communication, June 1, 2023). However, given the insignificant result in our regression model, we cannot definitively conclude that Growth opp. have an impact on Tobin's Q. While Table 2 suggests a relationship between ERM and growth opportunities, this relationship does not translate into a significant effect on Tobin's Q according to our model.

In sum, as displayed in Table 5, we choose to reject H1, H4 and H10 and accept H6, H7 and H9. Concerning H2, H3, H5 and H8, none of the corresponding coefficients are significant which suggests that there is not enough evidence to neither reject, nor accept them. Both H2 on asset opacity and H3 on financial leverage has been included to a large extent in previous studies, but the results are ambiguous. While H5 on dividend payments is positively related to firm value in our model and has been consistently found to influence firm performance-related dependent variables in prior literature, the corresponding coefficient is far from statistically significant, suggesting that the result could be random.

Hypothesis	Description	Findings	Significance	Results
H1	Firm size positively affects Tobin's Q	Negative (-)	0.004	Reject H1
H2	Asset opacity negatively affects Tobin's Q	Positive (+)	0.110	Ambiguous
H3	Increased financial leverage increases Tobin's Q	Positive (+)	0.663	Ambiguous
H4	Increased ROA increases Tobin's Q	Negative (-)	0.079	Reject H4
H5	Dividend payment increases Tobin's Q	Positive (+)	0.222	Ambiguous
H6	Increased liquidity increases Tobin's Q	Positive (+)	0.007	Accept H6
H7	International diversification increases Tobin's Q	Positive (+)	0.001	Accept H7
H8	Growth opportunities reduce Tobin's Q	Positive (+)	0.778	Ambiguous
H9	Sales growth increases Tobin's Q	Positive (+)	0.000	Accept H9
H10	Being audited by one of the Big Four auditors increases Tobin's Q	Negative (-)	0.089	Reject H10

Table 5: Hypotheses results

10.5 Conclusion

This study aimed to investigate the effect of Enterprise Risk Management (ERM) on firm value in the oil and gas upstream sector. Utilizing a panel data fixed effects model spanning the years 2010 to 2020 on 113 companies in North America and Europe, we processed 957 firm-year observations to examine the relationship. Our empirical findings indicate that the implementation of ERM is positively associated with firm value. Specifically, the regression results show a positive and statistically significant coefficient on the ERM variable, implying that the change effect on firm value of implementing ERM is positive. Beyond the primary ERM variable, several control variables also revealed interesting findings. Firm size exhibited a statistically negative influence on firm value. Conversely,

increased liquidity, international diversification, and sales growth presented a statistically significant positive influence. These findings contribute to the literature on ERM and firm value by providing empirical evidence from decade-long panel data. They provide supportive evidence that ERM implementation can be beneficial to firms in the North American and European oil and gas sectors, offering valuable insights for firms contemplating such risk management practices.

However, while our study provides meaningful insights, it has various drawbacks. The following paragraphs cover certain limitations the reader should be aware of. First, the reader should be aware that there is no possibility of claiming causality based on this study. Our research design, while robust, is essentially correlational, meaning that it is structured to find relationships between variables, but not to determine the direction of cause and effect definitively. While we found that ERM implementation and firm value are related in our sample, we cannot decisively conclude that implementing ERM directly leads to higher firm value. It could be the case that firms with a higher value are simply likely to adopt ERM, or an unobserved third variable may influence both. In other words, correlation does not imply causation.

Second, and related to the issue of causality, endogeneity refers to a situation where an explanatory variable is correlated with the error term. In our context, endogeneity could arise if firms that are naturally more likely to have higher value – for instance, larger or more complex – are also more likely to implement ERM. In other words, there is no reason to believe that firms randomly adopt ERM. Such a scenario could lead us to mistakenly attribute the higher value to the implementation of ERM, while in fact, it is these other inherent characteristics that are driving value.

Third, this study may not be free of measurement errors. Our study manually measures ERM using annual reports as the source of information, which could introduce errors or inconsistencies classifying firms as having or not having ERM. ERM in reality, is not a binary ‘yes or no’ entity (P. Kapstad, personal communication, June 1, 2023), and our operationalization of it could oversimplify the reality. Additionally, displacement of risk management practices in annual

reports is not mandatory, suggesting that our data collection method may not fully illustrate how risk management is conducted in a given company.

Furthermore, the data for European companies were manually collected, potentially leading to human errors in the dataset and thereby skewing our measurements and, consequently the findings. It is also worth mentioning some limitations that could arise from our selected timeframe of 2010 to 2020. This period contains market conditions and global events that may not be representative of other time periods. For example, the economic recovery following the 2008 financial crisis, the Eurozone crisis, Brexit, or the Covid-19 pandemic.

Fourth, as briefly described in section 8, our study does not include potentially essential variables such as governance variables and indicators of management of quality, primarily due to the challenges in accurately obtaining this information from annual reports. This omission could bias our results if these excluded variables are indeed significant predictors of firm value or ERM implementation. Governance variables, for instance, can influence both risk management practices and firm value, while management quality, even though not typically disclosed in annual reports, could significantly affect a firm's performance and, thus, its value.

In conclusion, while our study provides valuable insights into the relationship between ERM and firm value, it is subject to certain limitations, as outlined above. However, these limitations offer opportunities for further research to build on our work and continue advancing our understanding of this area.

Indeed, future research avenues present themselves as we consider the scope of our study. A notable area of focus could be the examination of different methodologies to assess ERM, particularly in the same sector as this study. A more comprehensive methodology, such as questionnaires, could complement the information gathered from annual reports, allowing for a more complete and nuanced understanding of ERM within individual companies. In addition, these potential questionnaires could be structured such that the researcher would obtain a deeper knowledge of contextual factors such as industry characteristics and regulatory aspects, enabling him/her to tailor the study.

Finally, the research could also beneficially explore the impact of ERM on firm value in various sectors outside the oil and gas sector. Every industry carries unique characteristics and risk profiles, so ERM's effectiveness may vary across sectors. Additionally, on request, we are inclined to share our findings with interested parties.

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Appendix

Appendix A: Guiding questions for the conversation with P. Kapstad 01.06.2023

How does Equinor utilize ERM to gain a competitive advantage?

What are the key benefits of portfolio risk management?

Elaborate on the top-down process at Equinor. To what extent does the board involve in risk oversight?

How is ERM rooted in Equinor's strategies?

How does the "green transition" affect Equinor?

Elaborate on how ERM is a vital part of Equinor's corporate and business management.

What does the "ERM-landscape" look like in 5-10-15-20 years?

What firm characteristics is the most prevalent for ERM implementation?

Appendix B: List of Companies

Company name	Company name	Company name
Abraxas Petroleum Corp	Gulfport Energy Corp	PJSC Tatneft
Altex Industries Inc	Gail Gas Ltd	Primeenergy Resources Corp
APA Corp	Halliburton CO	Panoro
Aker BP	Helix Energy Solutions Group	Petro Matad
Archer	Helmerich & Payne	Petrolia
Atlantic Petroleum	Hess Corp	Petronor E&P ASA
Awilco Drilling	Highpoint Resources Corp	Prosafe
Barnwell Industries	Houston Armen Energy Corp	QEP Resources Inc
Basic Energy Services Inc	Harbour Energy	Questerre Energy Corp
Battalion Oil Corp	Hurricane Energy Plc	Range Resources Corp
BP Plc	International Petroleum Corp	Ranger Oil Corporation
Block Energy Plc	Key Energy Services Inc	Reserve Petroleum CO
Borr Drilling	Kosmos Energy	Ring Energy Inc
Callon Petroleum CO/DE	Marathon Oil Corp	Royale Energy Inc
Camber Energy Inc	Mexco Energy Corp	RPC Inc
Cheniere Energy Inc	Minerals Technologies Inc	Romgaz
Chesapeake Energy Corp	Murphy Oil Corp	Schlumberger Ltd
Chord Energy Corp	Maha Energy	Silverbow Resources Inc
Cimarex Energy CO	Nabors Industries Ltd	SM Energy CO
ConocoPhillips	Noble Energy Inc	Superior Energy Services Inc
Contango Oil & Gas CO	Northern Oil & Gas Inc	Seadrill Ltd
Core Laboratories Inc	Nuverra Environmental Solutn	Serica Energy
Coterra Energy Inc	Noble Corp Plc	Shelf Drilling
Capricorn Energy Inc	Northern Drilling	Shell Plc
Dawson Geophysical CO	Occidental Petroleum Corp	Tengasco Inc
Deep Well Oil & Gas	Oceaneering International	Tetra Technologies Inc/DE
Denbury Inc	OGDCL Ltd	Torchlight Energy Resources
Devon Energy Corp	OKEA	Transatlantic Petroleum Ltd
Diamond Offshore Drilling Inc	OMV Petrom	Transglobe Energy Corp
DNO	Ovintiv Inc	Transocean Ltd
Diversified Energy	Odfjell Group	Tethys Oil
Enservo Corp	Parker Drilling CO	TotalEnergies
EOG Resources Inc	Patterson-Uti Energy Inc	Tullow Oil Plc
Evolution Petroleum Corp	PDC Energy Inc	Ultra Petroleum Corp
Energean Plc	PHX Minerals Inc	Vaalco Energy Inc
Eni	Pioneer Energy Services Corp	Valaris Ltd
Enquest Plc	Pioneer Natural Resources CO	Vital Engy Inc
Equinor		W&T Offshore Inc
Gran Tierra Energy Inc		Whiting Petroleum Corp

Appendix C: Examples of ERM

1: Capricorn Energy

Annual report 2020, p. 31:

"As in previous years, Capricorn's risk management process is based on a *holistic approach* and provides a systematic process for the identification and management of key risks and opportunities that may impact the delivery of the Group's strategic objectives. *KPIs* are set annually and determining the level of risk the Group is willing to accept in the pursuit of these objectives is a fundamental component of Capricorn's risk management framework."

2: Tullow Oil

Annual report 2020, p. 31:

"Our risk management framework takes a '*top down, bottom up' approach to risk*, ensuring that ownership and responsibility for identification, assessment and management of key risks and opportunities is embedded throughout the business. The Board sets the context for risk management through defining the strategic direction and risk appetite for the organization."

3: Eni

Annual report 2020, p. 26:

"The *Integrated Risk Management Model* is characterized by a structured approach, based on international best practices and considering the guidelines of the Internal Control and Risk Management System, that is structured on three control levels. Risk governance attributes a central role to the Board of Directors, which defines the nature and level of risk in line with strategic targets, including

in evaluation process all those risks that could be consistent for the sustainability of the business in the medium-long term".

4: Noble Corp Plc

Proxy Statement 2020, p. 17:

"We have not concentrated responsibility for all risk management in a single risk management officer within our executive management, but rather we rely on a management steering committee to administer an *enterprise risk management ("ERM") system* that is designed to ensure that the most significant risks to the Company, on a *consolidated basis*, are being identified, managed and monitored appropriately, and that due care is exercised in considering such risks in the management of the Company".