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A control perspective

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CAPITAL BUDGETING AND STRATEGIC INVESTMENTS

A CONTROL PERSPECTIVE

BY
CLAUS HØJMARK JENSEN

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Abstract

Capital budgeting refers to decision-making related to a firm's long-term investments, which represent important organizational processes as uneconomical allocation of scarce resources stands the chance of destroying value (Arnold and Hatzopoulos, 2000; Jensen and Kristensen, 2021). Effective economic management is a critical factor in achieving long-term success and survival. Therefore, allocation or distribution of firm resources to capital investments is one of the top strategic priorities for top management (Bowman and Hurry, 1993a; McGrath *et al.*, 2004; Bennouna *et al.*, 2010; Jensen and Kristensen, 2021). For a long time, academics have promoted the use of theory consistent appraisal techniques such as net present value, and while the adoption of such techniques has been confirmed, capital budgeting has many facets, and any one technique provides no role for the policies and processes that appear to be critical for an organization's investment outcomes (Haka, 2006). Capital budgeting also includes various processes and procedures aimed at managing a firm's capital investment projects. This dissertation contributes with insights on capital budgeting processes related to investment reviews, also termed post-decision controls, and real options reasoning (ROR).

One of the scarcely researched processes of capital budgeting are those processes that occur after the investment selection decision. The academic literature in this area has documented various types of such post-decision controls. Relatedly, extant literature is ambiguous about whether different investment types require different control mechanisms. This dissertation takes a closer look at these processes and contributes with a survey study, which examines how capital budgeting post-decision controls may help or hinder translating investments in exploration and exploitation into performance. The results further our understanding of how management controls can contribute to managing innovation investments by showing a positive relation to performance when formal post-decision control is used in connection with exploration investments, and when informal post-decision control is used in connection with exploitation investments.

In innovative firms where environmental uncertainty is a key driver of expected future returns, the design of effective organizational control forms to support decision-making under uncertainty may be particularly challenging. A scarcely researched area within ROR relates to how firms implement ROR. This dissertation contributes with the development of a multidimensional survey construct measuring three individual dimensions of ROR. The results indicate that environmental uncertainty is an important contingency to consider when studying ROR. The findings show that the conditional correlations between the ROR constructs are only significant in a context of high environmental uncertainty, meaning that in such context firms prefer a joint implementation of ROR. Further, one of the main benefits of ROR is the theorized relation to lower levels of downside risk. Empirical research in this area has largely been limited to studies of multinational corporations (MNC). This dissertation contributes with results showing

that the relationship between ROR and lower levels of downside risk extends beyond the context of MNCs.

Resumé

Kapitalbudgettering refererer til beslutningstagning relateret til en virksomheds langsigtede investeringer og repræsenterer vigtige organisatoriske processer, da ineffektiv fordeling af knappe ressourcer sandsynligvis vil føre til værdidestruktion (Arnold and Hatzopoulos, 2000). Stærk økonomisk forvaltning er af afgørende betydning for en virksomheds langsigtede succes og overlevelse (Bennouna *et al.*, 2010), og fordelingen af ressourcer mellem alternative investeringsprojekter er en af de mest presserende prioriteter for topledelsen (Bowman and Hurry, 1993; McGrath *et al.*, 2004). I lang tid har akademikere søgt at fremme brugen af teknikker indenfor investeringskalkyler så som net present value (nutidsværdi), og på trods af at indførelsen af sådanne teknikker er blevet bekræftet, så har kapitalbudgettering mange facetter, og ingen enkelt teknik kan omfatte de processer der synes at være kritiske for en organisations investeringsresultater (Haka, 2006). Kapitalbudgettering inkluderer også forskellige processer og procedurer, der sigter mod at styre et firmas kapitalinvesteringsprojekter. Denne afhandling bidrager med indsigt i kapitalbudgetteringsprocesser i forbindelse med investeringsevalueringer, også betegnet post-decision controls, og real option reasoning (ROR).

En af de lidet efterforskede kapitalbudgetteringprocesser er processer der anvendes efter beslutningen om at investere er taget. Den akademiske litteratur på dette område har dokumenteret forskellige typer af sådanne kontroller. Relateret hertil er at eksisterende litteratur er tvetydig om, hvorvidt forskellige investeringstyper kræver forskellige kontrolmekanismer. Denne afhandling ser nærmere på disse processer og bidrager med en spørgeskemaundersøgelse, der undersøger hvordan post-decison control inden for kapitalbudgettering kan hjælpe eller hindre resultaterne af investeringer i exploration og exploitation. Resultaterne fremmer vores forståelse af, hvordan kontrolmekanismer kan bidrage til styring af innovationsinvesteringer. De viser en positiv relation til finansielle resultater, når formel post-decision control anvendes i forbindelse med investeringer i exploration, og når uformel post-decision control anvendes i forbindelse med investeringer i exploitation.

I innovative virksomheder kan omverdenusikkerhed være en drivkraft til forventet fremtidigt afkast. Her kan det være særligt udfordrende at designe effektive organisatoriske kontrolmekanismer som støtter beslutningstagning under usikkerhed. Et område inden for ROR som kun har modtaget begrænset interesse for forskning vedrører, hvordan virksomheder implementerer ROR. Denne afhandling bidrager med udviklingen af et flerdimensionelt spørgeskemainstrument, der måler tre individuelle dimensioner af ROR. Resultaterne indikerer, at omverdenusikkerhed er en vigtig faktor at overveje når man studerer ROR. Resultaterne viser, at korrelationer mellem ROR-instrumenterne kun er signifikante i sammenhæng med høj omverdenusikkerhed. Det

betyder, at i en sådan kontekst foretrækker virksomheder en simultan implementering af ROR. En af de mest promoverede fordele ved ROR den teoretiske relation til lavere niveauer af nedadgående risiko. Empirisk forskning på dette område har stort set været begrænset til undersøgelser af multinationale selskaber. Denne afhandling bidrager med resultater, der viser, at forholdet mellem ROR og lavere niveauer af nedadgående risiko strækker sig ud over en multinational kontekst.

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Chapter 1. Introduction

This dissertation revolves around the topic of capital budgeting, which refers to decision-making related to a firm's investments, specifically a firm's long-term investments which are meant to create value for its owners (Haka, 2006). Haka (2006) notes that such investments are expected to create returns over multiple future periods and include for example machines, buildings, advertising campaigns, options to lease or buy, acquisitions of other businesses, expenditures on employee training, alliances, and joint ventures, etc. As such, a firm's capital investments may take different forms, some of which may be present on a firms' balance sheet and while others are expensed immediately. What is important is that they are expected to create long-term value. For this dissertation, I apply a similar definition, inspired by Haka (2006). The definition used in this dissertation is *the use of the organization's capital to acquire assets that the organization controls, and is expected to create long-term (more than one year) value. Depending on the specific organization, investments/investment projects can include fixed assets (buildings, machinery, production equipment, computer systems, M&A, etc.), intangible assets (research and development, product development, goodwill, etc.), as well as non-capitalized expenditures for activities related to e.g., research or marketing.* While capital budgeting may often be associated with the evaluation of the investment decision through financial techniques such as a discounted cash flow analysis (DCF), capital budgeting may also be seen as a process (Haka, 2006; Lefley, 2016). Capital budgeting processes may include processes related to investment decision-making well beyond that of appraisals. According to Haka (2006), capital budgeting processes may include conception, formalization, coordination, evaluation, request, capital budget formation, capital budget approval, project justification, authorization, project performance, and abandonment. Lefley (2016), however, notes that the capital budgeting process includes project proposal, appraisal, selection, implementation, completion, and at last, the post-completion audit (PCA). There is no one agreed-upon definition of what is included in capital budgeting processes, and therefore not one clear definition of *the* capital budgeting process. Further, capital budgeting processes are not limited to computational practices with the aim of arriving at a number from which decision-makers can base their choice. The human element in capital budgeting is also of much importance, and investment decisions continue to rely on business experience and intuition (Bower, 1970; Haka, 2006). The reason being that a simple focus on any one technique provides no role for the policies and processes that appear to be critical for an organization's investment outcomes (Haka, 2006). Therefore, in this dissertation, I consider capital budgeting processes from the broader perspective that can be inferred from prior research, that capital budgeting processes are those processes and procedures that firms apply with the purpose of managing their capital investment projects. Specifically, this dissertation considers two such processes which are investment reviews, also known as post-decision controls, and real options reasoning (ROR).

The initial motivation for this dissertation was an interest to work with ROR. During my master's program in Finance at Aarhus University, I was introduced to real options and

was intrigued by the idea of incorporating the value of managerial flexibility into the capital budgeting appraisal exercise, and by the notion that failure to consider real options value may create downward bias on the perceived capital investment value (Phelan, 1997). However, diving into research on the adoption of capital budgeting appraisal techniques revealed a poor adoption of this otherwise praised technique. Adoption rates, albeit different geographies, differed in the lower ranges from 32% (Truong et al., 2008) to as low as 14.3% and even 8.1% (Bennouna *et al.*, 2010; Block, 2007; Graham and Harvey, 2001). In a subsequent chapter in this dissertation, I confirm, through a survey study, that adoption rates are comparatively low in Denmark. This dissertation does not consider why adoption rates of real options are so seemingly low, but other researchers have considered that it may be due to the complexity of the technique (Block, 2007; Cotter *et al.*, 2003). Real options values may be difficult to compute in practice, and as an appraisal technique, it seems to have failed to achieve high adoption. Nevertheless, researchers have found that firms find alternative ways of benefitting from the principles of real options. Such alternative ways are often referred to as real options reasoning and refer to a managerial practice which compared to static resource allocation regimes such as net present value (NPV), managers consider the value of managerial flexibility as an investment project develops (Bowman and Hurry, 1993). Finding this approach particularly interesting, I decided to commit to this topic, which has resulted in two of the papers in this dissertation, one of which has been published in the academic journal; European Business Review. While diving into the literature of ROR, I discovered that there may be much value to add to a capital investment project after the selection stage, and hence after the initial capital commitment has been made. Therefore, I sought out research on other managerial practices with the purpose of managing capital investment projects, which resulted in a review of practices related to capital investment reviews, also referred to as post-decision control, which also inspired one of the papers in this dissertation.

The two topics that I mention above are the two overall areas that I study in this thesis. However, the research has been greatly inspired by the extant research on management control in the accounting literature. In particular, I find inspiration in research on the adoption of management control in the context of different environmental variables or in interdependence with other choice variables (Bedford, 2015; Bedford *et al.*, 2019; Chenhall, 2003). Given that capital budgeting is concerned with the firm's investment processes, I find it interesting to study the effects of capital budgeting processes in different investment contexts. As such, for two of the papers in this dissertation, I have chosen to characterize different types of investments based on March's (1991) theory of exploration and exploitation which has received extensive attention in accounting and management literature.

As such, this dissertation is concerned with the processes, which firms use to influence managers' decision-making for the purpose of optimizing the outcome of its capital investment projects. Therefore, this dissertation's point of departure was asking the research question: How do managers exert control over their capital investment projects?

Such question is of course too broad to answer in this dissertation, but in the following, I will narrow this down to the specific questions asked in the individual papers, and also presented in subsection 1.3. Sub-section 1.1. present the contents of this thesis, followed by sub-section 1.2., an introduction to the key themes used in this dissertation. Sub-section 1.3. introduces complementarity theory, which is the main theoretical underpinning used in this dissertation. In the same sub-section, I motivate the research questions from the individual papers and outlines how complementarity theory is used to answer these questions. Subsection 1.4. outlines the overall contribution of this dissertation.

1.1. Contents of the thesis

This dissertation is based on articles and consists of three individual articles, which are presented in chapters 6, 7, and 8. The articles are self-contained, and inevitably, there will be some overlap between the articles and this introduction, as well as the background information for the dissertation. The papers are all primarily based on data that I collected through a questionnaire from Danish companies with more than 100 employees. The data is collected based on the questionnaire sent out to the sample of companies across different sectors with the main purpose of collecting data on firm behavior related to capital budgeting processes, as well as perceived contextual factors and indicators of organizational performance.

In chapter 2, I present Danish and English summaries of the scientific results from the three articles and how these results contribute to the extant literature. Chapter 3 presents the questionnaire, describes the data collection, and discusses the methodological considerations of conducting this dissertation with the use of survey data. In Chapter 4, I present some descriptive findings based on the questionnaire. Here I intend to present the current state-of-the-art use of capital budgeting practices in Danish companies. Chapter 5 is a literature review of research on investment review practices intended to establish a base of knowledge for the purpose of conducting research in the area of post-decision control. I chose to make a literature review of research on investment review practices rather than on ROR, because Ipsmiller *et al.* (2019) and Trigeorgis and Reuer (2017) have provided recent reviews on ROR, and as such a new ROR review would not provide a contribution.

Chapter 6 presents paper 1: Capital budgeting post-decision control: Performance implications for innovation investments. This paper examines how the performance effect of investments in exploration and exploitation is affected by post-decision controls in capital budgeting. The findings show that formal post-decision controls moderate the effect of exploration on financial performance. On the other hand, the paper shows that informal post-decision controls moderate the effect of exploitation on financial performance.

Chapter 7 presents paper 2: Implementation of a real options reasoning design as a response to environmental uncertainty. This paper suggests that organizations implement real options reasoning as a set of interdependent control forms as a response to environmental uncertainty. In the paper, real options reasoning is measured by three distinct survey constructs. We suggest that the three control forms may not be optimally effective when implemented in isolation and show that these controls are complements in a setting of high environmental uncertainty.

Chapter 8 presents paper 3: Relative exploration orientation and real options reasoning: Survey evidence from Denmark. This paper studies the effect of real options reasoning on downside risk. We hypothesize that real options reasoning is negatively associated with downside risk and that the effect will be stronger for firms with a high extent of relative exploration orientation. The findings confirm our expectations. Relative exploration orientation is a term used to define the percentage amount of exploration activities relative to the total amount of exploration and exploitation activity.

1.2. Key themes

1.2.1. Types of strategic investments: A note on exploration and exploitation

Papers 1 and 3 in this thesis apply measures of exploration and exploitation to assess various contingent effects of choice variables related to investment strategy. I chose to limit the studies to investments with some relation to innovation, and for that purpose, exploration and exploitation is a prime candidate. The notion of exploration and exploitation was developed by March (1991), who defined exploitation as activities related to e.g., refinement, production, efficiency, implementation, and execution, whereas exploration activities capture e.g., search, variation, experimentation, discovery, and innovation. As such, exploration and exploitation offer a method to distinguish incremental (exploitation) and radical (exploration) innovations (Ylinen and Gullkvist, 2014). Researchers have already allocated much attention to studying exploration and exploitation. Findings of particular interest to studies on capital budgeting include that investments in exploration have a greater variance of payoffs attached to them in comparison to investments in exploitation (Raisch and Birkinshaw, 2008). The two activities have different relations to environmental dynamism, which measures predictability of outcomes, and while exploitation suffers in the presence of environmental dynamism, exploration yields higher performance effects in contexts of high environmental dynamism (Raisch and Birkinshaw, 2008). On the other hand, under highly competitive conditions, performance from exploration erodes, while exploitation is associated with higher performance in competitive contexts. However, while research shows that firms increase performance from exploration and exploitation under different conditions, extant empirical studies have also highlighted that the performance implications of exploration and exploitation are established from the simultaneous pursuit of the two activities (Raisch and Birkinshaw, 2008). In fact, both the combined

effect and the act of balancing the two activities have implications for performance (Cao *et al.*, 2009; He and Wong, 2004).

Studies of exploration and exploitation in accounting have been popular in recent years (e.g., Bedford, 2015; Bedford *et al.*, 2019), and empirical studies have shown that there is merit in considering the types of control that firms apply in different settings of exploration and exploitation. Bedford (2015), for example, showed through the levers of control framework (Simons, 1995) that diagnostic controls were associated with enhanced performance for firms specializing in exploitation, while interactive controls were associated with enhanced performance for firms specializing in exploration. This line of research has inspired the use of exploration and exploitation in this dissertation.

1.2.2. Pre- and post-decision controls in capital budgeting

Paper 1 in this dissertation considers firms' use of post-decision controls in capital budgeting. According to Huikku *et al.* (2018), the management controls for capital budgeting can be divided into only two main groups: pre-decision and post-decision controls. Pre-decision controls pertain to the control mechanisms used up until the selection/investment decision, whereas post-decision controls are the control mechanisms used after the selection of a capital investment project. There is a fair amount of research on traditional capital budgeting methods used in pre-decision control. Researchers have portrayed popular methods such as e.g., net present value, internal rate of return, payback period, adjusted payback period, profitability rate, etc. (Alkaraan and Northcott, 2006; Arnold and Hatzopoulos, 2000; Carr and Tomkins, 1998; Haka, 2006; Pike, 1996; Pike and Sharp, 1989; Verbeeten, 2006). To set the scene for research on post-decision control, Chapter 5 present a review of literature relevant to this topic and is primarily concerned with processes related to investment reviews. While many of the papers in the review use a definition of a formal review procedure, the papers also reveal the use of less formal practices, from which firms seem to benefit (Huikku, 2007). This is the focus of this dissertation, which therefore concerns formal and informal behaviors, routines, and ways of working that are directed at learning from or managing the outcome, trajectory, or otherwise faith of a capital investment project after the capital budgeting selection phase and after initial capital commitment.

1.2.3. Real options reasoning

Papers 2 and 3 study the use of real options reasoning (ROR). The use of real options is a capital budgeting process, which involves the recognition that managerial flexibility has value, and that this flexibility can be exercised over the lifetime of a project. Such flexibility exists when managers can abandon a project early on or rapidly expand after initial milestones (Denison, 2009). As stated in Jensen and Kristensen (2021), "*Real options resemble financial options in that the underlying asset's volatility positively relates to the option value, as the potential gains increase, while the costs remain constant. Potential profits, thus, increase while potential losses remain fixed to the cost of the option. The same is true for a real option, though for a real option*

it is the variance of assets' expected returns, which drives the potential for profits, thus making uncertainty an accelerator for real option value (McGrath, 1999)". McGrath (1999) argues that real options imply that investments are committed sequentially, and only when uncertainty is resolved will the investment have larger capital commitments allocated. In general terms, the motivation for implementing a ROR approach to capital investments is the promise to reduce downside risk, while maintaining upside potential (Bowman and Hurry, 1993). This implies that managers implement controls to ensure the acquisition of competencies to strategically sequence investment commitments in a forward-looking and flexible manner (Driouchi and Bennett, 2012). The research on ROR is vast, and the empirical research is dominated by scholars in strategic management (Ipsmiller *et al.*, 2019). This line of research is mostly based on the common sense thinking associated ROR, instead of the calculative practice of computing option value (Driouchi and Bennett, 2012). The research includes studies on multinationality and international joint ventures, which have ROR's negative relationship to downside risk as their focus of interest (Reuer and Leiblein, 2000; Tong and Reuer, 2007). Driouchi and Bennett (2011) found that firms that have developed strong managerial awareness of their real options were significantly better at reducing downside risk, and Tong *et al.* (2008) found a positive relation to upside potential by showing that international joint ventures enabled firms' upside growth potential through sequential expansion. Researchers in accounting have shed light on the use of real options techniques and shown that managers put more weight on standard planned path analysis such as net present value (NPV) than on real options (Denison *et al.*, 2012). However, users of real options are less reluctant to demonstrate escalation of commitment when evaluating an investment decision with real options analysis compared to NPV only analysis.

I am particularly motivated by the notion from e.g., Miller and Arikan (2004), who argue that managers may not be able to determine explicit option values through the real option pricing approach to investment appraisals but may still benefit from framing investments as real options. Further, the literature shows various calls for research that could choose to go down this path. Reuer and Tong (2007) call for research on the implementation of ROR, as this is one of the most neglected areas of empirical ROR research. They note that the organizational and managerial aspects of ROR management are among the most pressing research needs, as the implications of yielding benefits from ROR are determined by managers' devotion of time and costs to the search and development of options inside and outside the firm (Bowman and Hurry, 1993). Trigeorgis and Reuer (2017) further promote an increase in use of primary data from e.g., surveys in order to investigate ROR-based decision-making. Likewise, Ipsmiller *et al.* (2019) call for more attention to perceptual measures.

1.3. Theoretical underpinnings

With the overall aim of studying the procedures and controls, which firms use to influence managers' decision-making for the purpose of optimizing the outcome of their capital investment projects, I have chosen to do so from the lens of complementarity

theory. Complementarity theory assumes that certain organizational choice variables are reinforcing each other such that doing more of one thing increases the value of doing more of the other (Ennen and Richter, 2010; Matsuyama, 1995; Roberts, 2006). This makes complementarity theory particularly interesting because it may also be a source of creating a sustainable competitive advantage. Porter (1996) notes that a key to sustainable competitive advantage is strategic fit among many of a firm's activities. When sets of activities interact in a firm's system of activities, they become harder to replicate, thus making positions built on systems far more sustainable (Porter, 1996). Complementarity theory is a particularly good fit to answer the specific research questions outlined in the papers presented in this dissertation. The reason is that while the papers revolve around different topics, they all study the firm from the perspective of the different systems or procedures which it has implemented, thus choice variables. Papers 1 and 3 both hypothesize that a type of capital investment project leads to a performance outcome and that the relationship is stronger for firms also implementing a certain control or procedure related to ROR or post-decision control. In paper 2, I am interested in studying how firms implement ROR, and here I apply complementarity theory to aid the hypothesizing on how separate parts of ROR are complements in a specific context of high environmental uncertainty.

In the following, I will introduce complementarity theory and what it means for the research in this dissertation. Following this, I introduce the papers presented in this dissertation, with the purpose of introducing the scientific debates which have inspired the specific research questions and show how the research is situated in relation to complementarity theory. I will also introduce how complementarity theory is applied to answer these questions, and outline the contributions, which are thoroughly discussed in the individual papers and summarized in Chapter 2.

1.3.1. Complementarity theory

What the above introduction to the articles in this dissertation show is that all the research questions share a common factor. They are all related to how a number of firm choice variables are related to each other. At its most basic level, this is how complementarity theory has guided the research questions in this dissertation. Complementarity theory denotes that multiple elements in a system may have beneficial interplays, such that one element increases the value of other elements (Ennen and Richter, 2010; Matsuyama, 1995). In economic terms, this means that the marginal returns from one variable increase in the level of the other variables, and as such, the total value of combining two (or more) complementary elements in a system, therefore, exceeds the value of the elements in isolation (Milgrom and Roberts, 1994). Thus, complementarities are phenomena that are specific to a system, resulting from the interaction of individual organizational characteristics, and are for practical purposes most likely to occur among multiple, heterogeneous factors in complex systems. As such, an underlying view of complementarity theory is that elements in an organization should not be studied in isolation but be perceived as being part of a larger system. The research in this

dissertation, therefore, has a relation to systems theory, which includes the study of simultaneous workings of different phenomena (Abnor and Bjerke, 2009; Burrell and Morgan, 2019, p. 57-68). Systems theory views the whole as more than the sum of its parts and thus takes a holistic perspective of the phenomena, which in this dissertation is a firm. According to Burrell and Morgan (2019, p. 57-68), a system may take the form of an open system or a closed system. Closed systems are often used in conventional physics and consider the system as isolated from its environment and characterized by equilibrium (Burrell and Morgan, 2019, p. 57-68). Examples may include controlled experiments. Open systems are connected and interdependent. They engage in import and export exchanges with their environment. Open systems may take various forms, and no general rule dictates their state (Burrell and Morgan, 2019, p. 57-68). One of the often-used purposes of open systems research includes the study of patterns of relationships in systems and relationships with the environment to understand how the system operates (Burrell and Morgan, 2019, p. 57-68). The open system approach is used in this dissertation with a focus on how practices of capital budgeting fit into a larger organizational system. In papers 1 and 3, we study how the choices of capital budgeting practices (post-decision controls and real options reasoning) interact with strategic choices of capital investment types (exploration and exploitation). This implies a system view, as we consider practices of capital budgeting to have different effects on performance based on the contingent setup of capital investment strategy. In paper 2, we study a capital budgeting practice (real options reasoning) as a set of interdependent choice variables, whose interdependency is contingent on external factors (environmental uncertainty). The basic premise for all these papers is that the output of one element in the system may be changed contingent on the other elements in the system, whether this contingent factor is other choice variables (Ennen and Richter, 2010; Roberts, 2006) or external factors (Donaldson, 2001). Although being the overall underpinning used across all three papers in this dissertation, complementarity theory does not provide any predictions about the interactions or relationships between any specific elements in an organizational system (Ennen and Richter, 2010). Rather, these specific relationships are predicted by various micro-level theories, which are used to develop the hypotheses in the individual papers and will therefore not be treated here. However, working with complementarity as the underlying theory lens does imply working with a specific set of assumptions that impact the empirical strategy. I will treat these considerations in Chapter 3, which covers the methodology used in this dissertation.

1.3.2. Post-decision controls and investments in innovation

There is an ongoing debate about whether exploration and exploitation investments require different control mechanisms (Jansen *et al.*, 2006; Ylinen and Gullkvist, 2014). Prior research on this topic has produced mixed results and used numerous types of control conceptualizations. Examples include Cardinal (2001) who studied firms' use of input and output controls and concluded that exploitation and exploration should not be managed differently. On the contrary, in a study of centralization and formalization, Jansen *et al.* (2006) concluded that centralization harmed exploratory innovation, whereas

formalization positively influenced exploitation investments. Further, Ylinen and Gullkvist (2014) show that the direct positive effect of organic controls on project performance is stronger for exploitative innovations than for exploratory. They also find a direct positive relation between mechanistic controls and project performance for firms scoring high on exploratory innovations. As this debate considers whether exploration and exploitation require different control mechanisms, this area of research considers the firm as consisting of various elements. The overall question of whether these investment types require different control mechanisms implies that the extant literature has perceived exploration and exploitation activities as organizational elements whose outcome may be influenced by other organizational elements, here control mechanisms. Hence, the extant literature views the firm from a systems perspective where individual sets of elements can interact and therefore has a direct link to complementarity theory.

This lively debate has inspired one of the papers in this dissertation (Paper 1). I find the debate both interesting and important because exploration and exploitation represent investments of strategic importance, and to ensure long-term survival, firms should engage in both activities simultaneously (March, 1991). Further, as effective financial management is a critical factor for a firm's long-term success and survival (Bennouna *et al.*, 2010) I found it relevant to explore whether investments in exploration and exploitation require different uses of post-decision controls. As such, I ask the following research question in paper 1:

Research question: Do investments in exploration and exploitation require different uses of post-decision controls?

To answer this question, I hypothesize on the performance effects of applying post-decision control in combination with exploration and exploitation. According to complementarity theory, I, therefore, assume that certain organizational choice variables – in this case, post-decision control and exploration/exploitation – are reinforcing each other such that doing more of one thing increases the value of doing more of the other (Ennen and Richter, 2010; Matsuyama, 1995; Roberts, 2006).

With the results showing that firms should indeed apply different control mechanisms to exert influence on the outcome of exploration and exploitation, the paper contributes to the debate of whether exploration and exploitation require different control mechanisms. Scattered as the debate may be, these results support recent challenging findings from Holahan et al. (2014), by showing that formal (informal) control is more important for exploration (exploitation).

1.3.3. ROR and environmental uncertainty

Relationships between real options investing and the predicted outcomes such as decreased downside risk and increased upside potential are already well documented in the literature (Andersen, 2011, 2012; Belderbos *et al.*, 2014; Driouchi and Bennett, 2011;

Elango, 2010; Tong *et al.*, 2008; Tong and Reuer, 2007). However, insights may also be drawn from researchers who failed to document such relationships (Reuer and Leiblein, 2000). Reuer and Leiblein (2000) argue that failure to find significant results when studying firms' possession of real option-like assets may stem from a lack of knowledge of whether firms' managers are actually aware of and manage their option-like assets in a manner consistent with ROR. From a complementarity theory perspective, what Reuer and Leiblein (2000) here argue is that researchers should expand their focus and study this phenomenon from the perspective of a system, thus including additional elements as these may be interdependent. Later research has shown this to be an important factor, and Driouchi and Bennett (2011) and Ioulianou *et al.* (2020), found that the level of knowledge about real options is an important factor to consider. As such, the extant literature has considered that real option-like investments lead to some performance outcome, but also that this relationship may be dependent on firms' choices to implement procedures consistent with ROR theory. That situates the literature in relation to complementarity theory in that it assumes one element will increase the value of other elements.

Nevertheless, the attention attributed to how ROR is implemented in organizations continues to be relatively scarce, but researchers such as Klingebiel and Adner (2015) have considered its implementation from the perspective of ROR as a multidimensional construct. This means that ROR is viewed as a set of individual procedures and Klingebiel and Adner (2015) found that a fit between two of such procedures led to increased innovation performance. As such, the relation to complementarity theory from the literature on ROR implementation is that it considers how the joint implementation of multiple elements related to ROR interacts in order to create a performance.

I am particularly inspired by this topic on how organizations implement ROR and believe it presents a good opportunity for a contribution to the ROR literature. In paper 2, I follow the idea of treating ROR as a multidimensional construct, breaking it into three separate parts. Inspired by environmental uncertainty being an important antecedent of ROR, as mentioned in Section 1.2.3., I examine the importance of a joint implementation of ROR by studying how the individual ROR measures covary as a result of environmental uncertainty. As such, I ask the following research question in paper 2:

Research question: Do ROR firms select a joint implementation when environmental uncertainty is high?

To answer this question, I hypothesize on how environmental uncertainty determines the joint use ROR. According to complementarity theory, I, therefore, assume that certain configurations of organizational controls – in this case, ROR – are more suited to certain environmental contexts and that managers will adjust their use of ROR in accordance with the environmental context to achieve fit and enhanced performance (Chenhall, 2003). While there is no one optimal firm structure, managers can adapt the firm structure to fit the environmental contingencies (Chenhall, 2003; Gerdin and Greve, 2004).

The results showed that in a context of high uncertainty, all pairs of ROR constructs are complements. Those results contribute to the literature on ROR in important ways. First, it addresses a scarcely researched area within ROR, which relates to how firms implement ROR. The results show that when firms operate under high environmental uncertainty, a joint implementation of the separate ROR parts is preferred. Further, because the paper is concerned with managers taking an active role in resolving uncertainty, the paper also contributes to the debate of whether ROR is appropriate when uncertainty is endogenous (Adner, 2007; Adner and Levinthal, 2004). The paper supports recent findings by Klingebiel and Adner (2015), by showing that under high environmental uncertainty, firms prefer to take an active part in resolving uncertainty.

1.3.4. ROR and investments in innovation

The field of real options reasoning (ROR) research which focuses on the association with downside risk and portfolio subadditivity has mainly been conducted within the lens of multinationality. As stated in Jensen and Kristensen (2021) *"Formally, downside risk is a probability-weighted function of below-target performance outcomes (Reuer and Leiblein, 2000), and for the purpose of this study, it is considered as failure to meet an aspired to level of performance. Subadditivity considers the effectiveness of ROR when investment activities have correlated uncertainty profiles (Belderbos et al., 2014, 2019; Belderbos and Zou, 2009; Ioulianou et al., 2020; Li and Chi, 2013; McGrath, 1997; McGrath and Nerkar, 2004; Vassolo et al., 2004)".* As mentioned in the previous sub-section, the relationships between real options investing and decreased downside risk is already well documented in the literature (Andersen, 2011, 2012; Belderbos *et al.*, 2014; Driouchi and Bennett, 2011; Elango, 2010; Reuer and Leiblein, 2000; Tong *et al.*, 2008; Tong and Reuer, 2007). Some recent studies show that this relationship is contingent on low correlation between a firms' real options (Belderbos *et al.*, 2014; Ioulianou *et al.*, 2020). As such, this literature is situated in relation to complementarity theory in that it assumes that the effect of ROR increases as a result of choosing to construct a portfolio of investment activities with low correlation in uncertainty profiles.

These literatures inspired the third paper in this dissertation, which has been published in the European Business Review. The paper was inspired by prior research largely being limited to the context of multinational corporations (MNCs). As such, I found an interesting opportunity to contribute to the literature by asking if the relationship between ROR and downside risk, and the importance of portfolio sub-additivity would extend into other contexts than MNCs. As such, the third paper considers the following research questions:

Research questions:

1) Does the relationship between higher levels of ROR and lower levels of downside risk extend outside the context of MNCs?

2) Does the negative moderating effect of correlation in the options portfolio extend into the context of product/service innovation?

To answer these questions, I hypothesize on the outcome of applying ROR in combination with exploration and exploitation. According to complementarity theory, I, therefore, assume that certain organizational choice variables – in this case, ROR and exploration/exploitation – are reinforcing each other such that doing more of one thing increases the value of doing more of the other (Ennen and Richter, 2010; Matsuyama, 1995; Roberts, 2006).

The results of the study show that a high level of ROR is associated with a low level of downside risk for firms in our sample. The results also show that level of relative exploration orientation moderates the association between ROR and a lower level of downside risk in a negative direction. As such the results contribute to the existing literature. As described in Jensen and Kristensen (2021) the results *"extends the literature on ROR and downside risk outside the context of MNEs and into the literature of ROR as a multidimensional construct. Extending findings on the relationship between ROR and downside risk outside the scope of MNEs is important as it addresses the distinguishment of two separate ROR approaches to managing uncertainty. The two ROR approaches pertain to "wait and see" and "act and see" (Adner and Levinthal, 2004a; Barnett, 2008)."* And further that the results *"also extend the literature on the role of option portfolio correlation and its moderating effect on ROR's relation to downside risk (Belderbos et al., 2014; Ioulianou et al., 2020), into the context of product/service innovation by applying March's (1991) framework of exploitation and exploration activities. Extending the literature into the context of product/service innovation further strengthens the contribution of showing ROR's impact on downside risk in an "act-and-see" regime because product/service innovation explicitly represents an "act-and-see" option (Cuypers and Martin, 2010)."*

1.4. Contributions of the dissertation

While the overall topic of this dissertation is capital budgeting, the main purpose has been to shed light on the overall research question with which this dissertation initiated. How do managers exert control over their capital investment projects? Of course, this question can only be partially answered, and as such, this dissertation has sought to focus on some specific types of controls, which firms use to manage their capital investment projects. The specific controls which are considered in this dissertation are real options reasoning, and post-decision controls, where the latter may also be recognized as practices for investment project reviews. This has resulted in a range of specific research questions and scientific contributions, which will be summarized in the next chapter and elaborated on in the individual papers. Here, I will synthesize the overall contributions, both scientific and practical. Overall, this dissertation contributes to two main areas.

1. The link between innovation investments and post-decision controls
2. Adoption and use of real options reasoning

1.4.1. The link between innovation investments and post-decision controls

From the literature review presented in Chapter 5, some general observations can be made about the current state of research on this topic. Specifically, two of those observations inspired ways for this dissertation to contribute to this area. Those two observations were.

1. While many of the papers in the review use a definition of a formal review procedure, the papers also reveal the use of less formal practices, from which firms seem to benefit
2. There are only a few papers published which are focused on the outcomes of post-decision controls

In Paper 1, we develop a new scale for the purpose of measuring the extent to which firms use formal post-decision controls and informal post-decision controls. This contributes to the literature on management control and capital budgeting with the development of a scale for post-decision control, by extending the breadth of post-decision control measures to, in our assessment, better reflect the full use of post-decision control. Secondly, this dissertation contributes with additional research on the outcomes of post-decision control. As mentioned in the previous section, the debate of whether exploration and exploitation investments require different control mechanisms provided a good opportunity to research the use of formal and informal post-decision controls in different contexts. As such, the dissertation contributes to this debate by showing that the joint implementation of exploration (exploitation) and formal (informal) post-decision control leads to increased performance. Those results contribute to the debate (e.g., Bedford, 2015; Bedford *et al.*, 2019; Cardinal, 2001; Holahan *et al.*, 2014; Jansen *et al.*, 2006; Ylinen and Gullkvist, 2014) by supporting the view that exploitation and exploration investments should indeed be managed differently when considering post-decision control. More generally, those findings support the view of other researchers such as Holahan *et al.* (2014), with the view that exploration investments are more likely to benefit from formal controls than are exploitation investments. Thirdly, this dissertation also contributes with practical implications for managers as it informs managers not only about the different uses of post-decision control but also its applicability in the context of different types of investments. This is important as prior researchers have identified post-decision controls as the least important part of capital budgeting (Batra and Verma, 2014), and neglecting these processes gives away great potential for competence building (Von Zedtwitz, 2002).

1.4.2. Adoption and use of real options reasoning

The adoption of the real options appraisal technique has achieved low adoption rates (Bennouna *et al.*, 2010; Block, 2007; Graham and Harvey, 2001; Truong *et al.*, 2008), and in the sample of Danish firms used in this dissertation, 62% never considers the technique as will be presented in Chapter 4. This is interesting because failure to consider

the value of managerial flexibility may create downward bias on the perceived capital investment value (Phelan, 1997). As such, Danish firms may be missing out on value in their capital investment projects. However, the benefits of real options may also be achieved through other means of managerial practices such as real options reasoning (Barnett, 2008). While prior research has indeed confirmed this (Andersen, 2011, 2012; Belderbos *et al.*, 2014; Driouchi and Bennett, 2011; Elango, 2010; Reuer and Leiblein, 2000; Tong *et al.*, 2008; Tong and Reuer, 2007), the research has primarily been limited to a setting of MNCs, and more research is needed to confirm that the value of ROR extends outside of the context of MNCs. Further, we know very little about how firms implement ROR in practice.

In Paper 2, this dissertation addresses how ROR is implemented in practice. Based on an unstructured review of ROR literature, the paper breaks down ROR into a number of managerial practices. The paper shows that firms operating under a high level of environmental uncertainty, prefer a joint implementation of all ROR practices. Therefore the dissertation contributes with important findings, showing the importance of a complete joint implementation of ROR, and also how the context of high environmental uncertainty is an important determinant of choosing to implement ROR. This is a contribution because much of the ROR literature has focused on the extent to which firms are in possession of real option-like assets, but not the managerial implementation. Failure to find significant results when studying firms' possession of real option-like assets may stem from a lack of knowledge of whether firms' managers are actually aware of and manage their option-like assets in a manner consistent with ROR (Reuer and Leiblein, 2000). This is confirmed in the extant literature by e.g., Driouchi and Bennett (2011) and Ioulianou *et al.* (2020), but still only a few studies comprehends the broader dimensionality of implementing ROR (e.g., Klingebiel and Adner, 2015). On a practical level, these findings may be important for the adoption of ROR and therefore contributes by informing managers about the implications of implementing such practice. While Paper 2 contributes knowledge about the implementation of ROR, Paper 3 shows that ROR is indeed applicable outside the scope of MNCs. Paper 3 shows that ROR is associated with lower levels of downside risk and that the relationship is moderated by the level of relative exploration orientation, meaning that ROR is increasingly important for firms investing in exploration well beyond the level of exploitation. These findings are important for the adoption of ROR, as it confirms that the benefits of ROR are not limited to firms in a multinational context. As such, the results inform firms or managers that they may find value in ROR even though their context differs from that of MNCs. This is an important contribution as the literature has been ambiguous about the appropriateness of ROR outside a context of exogenous uncertainty.

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Chapter 2. Summary of scientific results

2.1. Dansk resumé (Danish summary)

For alle danske resuméer, som præsenteres herunder, gælder at de er danske oversættelser af de engelske resuméer, som er præsenteret i afsnit 2.2.

2.1.1. Artikel 1: Capital budgeting post-decision control: Performance implications for innovation investments

Forfattere: Claus Højmark Jensen og Thomas Borup Kristensen

Status: Artiklen har været indsendt til International Journal of Innovation Management. Vi har modtaget editor og reviewers anbefalinger til revidering af artiklen forud for genindsendelse.

Data: Artiklens benyttede data er en kombination mellem et dataudtræk fra virksomhedernes årsopgørelser, samt data fra et spørgeskema der bygger på svar fra 98 virksomheder, hvor respondenten hovedsageligt er virksomhedens økonomidirektør.

Videnskabelige resultater: I artikel 1 tilstræber vi at bidrage til forskning som omhandler virksomheders anvendelse af kontrolmekanismer med henblik på at påvirke resultatet af investeringer i exploration og exploitation (f.eks., Bedford, 2015; Bedford *et al.*, 2019; Benner and Tushman, 2003; Davila *et al.*, 2009; Hill and Rothaermel, 2003; Ylinen and Gullkvist, 2014). Der eksisterer en debat om hvorvidt investeringer i exploration og exploitation har brug for forskellige kontrolmekanismer (Jansen *et al.*, 2006; Ylinen and Gullkvist, 2014). Denne artikel er især motiveret af nylige resultater fra Holahan *et al.* (2014), som afviger fra den almene holdning til styring af radikal (exploration) og inkrementel (exploitation) innovation. Vi tilstræber at bidrage med viden til denne litteratur ved at studere dette spørgsmål i kontekst af post-decision control som er kendt fra kapitalbudgeteringslitteraturen (Huikku, 2008, 2011; Lefley, 2016, 2019; Neale, 1991; Neale and Buckley, 1992). Vi gør dette ved at udvikle et spørgeskemainstrument til at måle hhv. formel og uformel post-decision control.

Eksisterende litteratur omhandlende kontrolmekanismers påvirkning af exploration og exploitation har historisk vist tvetydige resultater. Cardinal (2001) konkluderede for eksempel, at inkrementelle (exploitation) og radikale (exploration) innovationsprojekter ikke skulle styres forskelligt. I modsætning til dette fandt Jansen *et al.* (2006), at centralisering havde en negativ indvirkning på exploration, mens formalisering havde en positiv indflydelse på exploitation. Ylinen and Gullkvist (2014) viste at organisk og mekanistisk kontrol havde forskellige virkninger på exploration og exploitation. Holahan *et al.* (2014) viste at virksomheder i deres studie havde tendens til at styre projekter i exploration mindre fleksibelt end projekter i exploitation. Yderligere at frem for at blive

uformelt introduceret er projekter i exploration resultat af formel planlægning. Disse sidstnævnte resultater er i modsætning til resultaterne i Jansen *et al.* (2006), og i øvrigt tidligere gængse overbevisninger om, hvordan projekter indenfor exploration bør styres (Holahan *et al.*, 2014; Leifer *et al.*, 2000; Veryzer, 1998).

Spørgsmålet om hvorvidt projekter indenfor exploration og exploitation kræver forskellige kontrolmekanismer er altså relativt uafklaret. Hertil foreslår vi to hypoteser: 1) effekten af exploration på finansiel præstation modereres positivt af niveauet for formel post-decision control, og 2) effekten af exploitation på finansiel præstation modereres positivt af niveauet for uformel post-decision control.

Vores empiriske resultater viser, at formel (uformel) post-decision control modererer effekten af exploration (exploitation) på finansiel præstation. Ylinen and Gullkvist (2014) resultater er til dels understøttende af vores resultater. De viste, at den direkte positive effekt af organisk kontrol på et projekts præstation er stærkere for exploitation innovationer end for exploration. Derudover fandt de en direkte positiv sammenhæng mellem mekaniske kontroller og projektpræstation for virksomheder, der scorede højt på exploration innovationer. Andre undersøgelser viser imidlertid modstridende resultater. På trods af at det primære forskningsområde er Levers of Control (LoC) og PMS, så fortæller resultaterne fra et nyligt spørgeskemastudie foretaget af Bedford (2015) en anden historie. For virksomheder som scorer højt på exploitation, finder han en positiv relation mellem virksomheders præstation og diagnostiske kontroller. Han finder til gengæld ingen relation for virksomheder som scorer højt på exploration. Sådan stærkt fokus på output har tidligere været forventet at flytte fokus til kortere sigt, mere forudsigelige og inkrementelle innovationer, da det er vanskeligt at bestemme ex-ante-resultater af radikale innovationer (Cardinal, 2001). Dette synes ikke nødvendigvis at være tilfældet i praksis, som vist i denne artikel såvel som i Cardinal (2001) og Holahan *et al.* (2014). Dermed bidrager vores undersøgelse til debatten om, hvorvidt exploration og exploitation skal styres med forskellige kontrolmekanismer (f.eks., Bedford, 2015; Bedford *et al.*, 2019; Cardinal, 2001; Holahan *et al.*, 2014; Jansen *et al.*, 2006; Ylinen and Gullkvist, 2014). Vores resultater understøtter den opfattelse, at de skal styres forskelligt og understøtter nylige udfordrende resultater fra Holahan *et al.* (2014). Artiklen bidrager dermed med support til nyere resultater fra litteraturen (Holahan *et al.*, 2014) ved at udvide undersøgelsesområdet til en kontekst indenfor post-decision control.

2.1.2. Artikel 2: Implementation of a real options reasoning design as a response to environmental uncertainty

Forfattere: Claus Højmark Jensen og Thomas Borup Kristensen

Status: Artiklen er endnu ikke indsendt til et tidsskrift.

Data: Artiklens benyttede data er en kombination mellem et dataudtræk fra virksomhedernes årsopgørelser, samt data fra et spørgeskema der bygger på svar fra 95 virksomheder, hvor respondenten hovedsageligt er virksomhedens økonomidirektør.

Videnskabelige resultater: I artikel 2 tilstræber vi at fremme forståelsen for hvordan virksomheder implementerer real option reasoning (ROR). Artiklen er motiveret af debatten om anvendelsen af ROR til strategiske investeringer, hvor ledere aktivt deltager i at forløse den underliggende usikkerhed i modsætning til en vent-og-se-strategi (Adner, 2007; Adner and Levinthal, 2004; Barnett, 2008; Cuypers and Martin, 2010; Klingebiel and Adner, 2015). Der eksisterer meget begrænset empirisk litteratur om hvordan ROR implementeres i organisationer. I denne artikel anvender vi et flerdimensionelt spørgeskemainstrument til at måle ROR for at undersøge, hvordan virksomheder implementerer ROR for at styre investeringsadfærden, når usikkerheden forløses endogent. For det første investerer virksomheder, der bruger ROR, sekventielt og ved kun at lave indledende forpligtelser (sequential low commitment) (Bowman and Hurry, 1993), hvilket indebærer en ressourcetildelingsstrategi med flere trin. For det andet indebærer ROR at forløse usikkerheden omkring investeringen. Denne kan karakteriseres som værende enten eksogen eller endogen (Adner and Levinthal, 2004; Cuypers and Martin, 2010). Vi er interesseret i endogent forløst usikkerhed og de potentielle problemer dette medfører i en flertrins investeringsproces (endogenous uncertainty resolution). ROR-litteraturen har identificeret problemer forbundet med tabt fokus, hvilket kan resultere i overdreven udnyttelse af sunk cost fænomenet samt escallation of commitment (Adner and Levinthal, 2004). Dermed introduceres et tredje element, som omhandler omfordeling af ressourcer (reallocation), for at undersøge, hvordan virksomheder sætter grænser for den sekventielle investering for at sikre, at mislykkede projekter afvikles rettidigt, og kun succesrige projekter modtager yderligere finansiering. Der har været meget diskussion om vigtigheden af omfordeling såvel som dens anvendelighed, når usikkerhed forløses endogent (Adner and Levinthal, 2004). Eksisterende empirisk litteratur på dette område er ikke ligefrem utvetydig (Cuypers and Martin, 2010; Klingebiel and Adner, 2015), så vi forsøger at adressere dette. På grund af denne tvetydighed mener vi, at det er vigtigt at overveje de contingency faktorer, der kan føre til forskellige resultater. Verdu *et al.* (2012) fandt for eksempel, at omverdenusikkerhed modererede effekten af ROR på produkt-/procesinnovation. Denne artikel adresserer den litteratur, der behandler ROR som en flerdimensionel faktor (Klingebiel and Adner, 2015), og vi finder det både interessant og vigtigt at overveje de kendte contingency faktorer, når man studerer tilpasningen mellem individuelle ROR-faktorer. Derfor omhandler artiklen også spørgsmålet om, hvorvidt omverdenusikkerhed er en vigtig contingency faktor, der skal overvejes, når man undersøger fit mellem ROR-faktorer.

I artiklen fremstiller vi fire hypoteser: 1) at sequential low commitment og endogenous uncertainty resolution er komplementerende i kontekst af høj omverdenusikkerhed, 2) at sequential low commitment og reallocation er komplementerende i kontekst af høj omverdenusikkerhed, 3) endogenous uncertainty resolution og reallocation er

komplementerende i kontekst af høj omverdenusikkerhed, og 4) at virksomheder i en kontekst af høj omverdenusikkerhed er mere tilbøjelige til at implementere alle tre ROR-faktorer samtidigt.

I artiklen finder vi support for alle hypoteser og viser, at virksomheder, der opererer i kontekst af høj omverdenusikkerhed, foretrækker en simultan implementering af alle tre ROR-faktorer. Vi argumenter for at ROR-faktorerne er komplementære, således at en stigning i niveauet for én variabel reducerer omkostningerne forbundet med en anden. Vi viser, at den simultane implementering af sequential low commitment, endogenous uncertainty resolution og reallocation vælges i kontekst med høj omverdenusikkerhed.

Artiklen bidrager til debatten om hvordan ROR kan anvendes under usikkerhed. Da vi benytter os af nyudviklede spørgeskemainstrumenter, bekræfter vi noget eksisterende viden om ROR for at øge validiteten af artiklen. For det første viste (Driouchi and Bennett, 2011), at man bør kontrollere for ledelsens bevidsthed om ROR, og at dette var en vigtig faktor for statistisk at kunne vise effekten af ROR. Vi bekræfter vigtigheden af dette ved at vise, at ledelsens bevidsthed herom er stærkt korreleret med implementering af alle ROR-faktorer. For det andet undersøgte Klingebiel and Adner (2015) også ROR ved hjælp af separate faktorer. De anvendte separate faktorer til at måle sekventiel investering og lav initial forpligtelse og de fandt ud af, at kun sekventiel investering havde en direkte effekt på præstation for projekter hvor usikkerhed forløses endogent. Derudover fandt Cuypers and Martin (2010) ingen indikation på at JVs hvor usikkerhed forløses endogent ville investere med lave initiale forpligtelser. I modsætning hertil finder vi, at sekventiel investering og lav initial forpligtelse loader på en enkelt faktor, dermed sekventiel lav forpligtelse (sequential low commitment), og at denne faktor er komplementær med endogen forløsning af usikkerhed (endogenous uncertainty resolution) i en kontekst med høj omverdenusikkerhed. Vi anerkender at sammenligningsgrundlaget er begrænset på grund af de forskellige konceptualiseringer, og at vi kan miste en vis informationsværdi ved at måle sekventiel investering og lav initial forpligtelse som en enkelt faktor. I modsætning til de eksisterende undersøgelser finder vi dog, at der er et positivt statistisk forhold mellem de to, og at denne er betinget af høj omverdenusikkerhed og dermed bidrager med viden om at omverdenusikkerhed kan være en vigtig contingency faktor, som bør overvejes når man studerer forholdet mellem individuelle ROR-faktorer. For det tredje viste Klingebiel and Adner (2015), at et fit mellem lav initial forpligtelse og omfordeling (reallocation) øgede innovationspræstationen. Vi finder lignende resultater og viser, at sequential low commitment og reallocation er komplementære i en kontekst med høj omverdenusikkerhed. For det fjerde fandt Klingebiel and Adner (2015), at reallocation ikke havde nogen direkte effekt på innovationspræstation for projekter med tilbøjelighed for endogen forløsning af usikkerhed. Det er her vigtigt at tage konceptualiseringen af reallocation i Klingebiel and Adner (2015) i betragtning. Dette blev i deres studies målt ved procenten for afviklede projekter, og adresserer dermed ikke virksomhedernes politikker for afvikling. I denne artikel behandles reallocation som en streng politik for at specificere investeringsomfanget på tidspunktet for den første investering. Vi finder ud

af, at endogenous uncertainty resolution og reallocation er komplementære i en kontekst med høj omverdenusikkerhed. Vi bidrager dermed med vigtig indsigt i hvordan virksomheder sætter interne rammer for at begrænse omfanget af investeringer. Sådanne rammer har i forbindelse med endogen usikkerhedsforløsning været stærkt diskuteret i litteraturen (Adner, 2007; Adner and Levinthal, 2004; Cuypers and Martin, 2010; Klingebiel and Adner, 2015). Der er blevet stillet spørgsmålstegn ved, om endogen usikkerhedsforløsning overhovedet er passende for ROR på grund af potentielle omkostninger ved at specificere omfanget af investeringen forud (Adner and Levinthal, 2004). Denne artikel viser at fordelene ved at specificere strenge regler for investeringsomfanget i en kontekst med høj omverdenusikkerhed faktisk opvejer omkostningerne, når usikkerheden forløses endogent. Slutteligt - vi allerede ved, at omverdenusikkerhed er en vigtig faktor når der forskes i ROR (Verdu *et al.*, 2012). Denne artikel bidrager hertil med indsigt i vigtigheden af omverdenusikkerhed som en betinget faktor, når man studerer interdependens mellem ROR-faktorer. Hvor andre undersøgelser allerede har studeret ROR som en multidimensionel konstruktion (Klingebiel and Adner, 2015), mener vi, at dette er den første artikel, der viser, at faktorerne kun er interdependente i en kontekst med høj omverdenusikkerhed.

2.1.3. Artikel 3: Relative exploration orientation and real options reasoning: Survey evidence from Denmark

Forfattere: Claus Højmark Jensen og Thomas Borup Kristensen

Status: Denne artikel er publiceret i European Business Review

Data: Artiklen benytter en kombination mellem et dataudtræk fra virksomhedernes årsopgørelser, samt data fra et spørgeskema der bygger på svar fra 94 virksomheder, hvor respondenten hovedsageligt er virksomhedens økonomidirektør.

Videnskabelige resultater: I artikel 3 tilstræber vi at bidrage til forståelsen af hvordan ROR er forbundet med nedadgående risiko (downside risk), og hvordan en virksomheds portefølje af investeringsaktiviteter påvirker ledernes mulighed for effektivt at anvende ROR. Artiklen er motiveret af litteraturen om downside risk og sub-additivity. Formelt er downside risk en sandsynlighedsvægtet funktion af lavere end målsat opnåede resultater (Reuer and Leiblein, 2000), og med henblik på denne undersøgelse betragtes det som manglende opnåelse af et ønsket niveau af præstation. Sub-additivity relaterer sig til effektiviteten af ROR når investeringsaktiviteter har korrelerede usikkerhedsprofiler (Belderbos *et al.*, 2014, 2019; Belderbos and Zou, 2009; Ioulianou *et al.*, 2020; Li and Chi, 2013; McGrath, 1997a; McGrath and Nerkar, 2004; Vassolo *et al.*, 2004). Den eksisterende empiriske ROR-litteratur har lagt stor vægt på at teste forholdet mellem ROR og downside risk, hvor forholdet for det meste blevet undersøgt i kontekst af multinationale selskaber (MNS) baseret på den forudsætning, at MNSer er i besiddelse af 'real switching options', som for eksempel tillader dem til at skifte produktion mellem lokationer for at optimere skiftende makroøkonomiske forhold og derved reducere

downside risk (Reuer and Leiblein, 2000). Dette forhold er blevet undersøgt og bekræftet i forskellige sammenhænge (f.eks., Andersen, 2011, 2012; Driouchi and Bennett, 2011; Reuer and Tong, 2007), og nyere undersøgelser har vist, at forholdet er betinget af lav korrelation mellem MNSers 'switching options' (Belderbos *et al.*, 2014; Ioulianou *et al.*, 2020). Dermed er tidligere forskning omhandlende ROR og downside risk stort set begrænset til konteksten med MNSer. Nylige resultater antyder også, at hvis flere optioner i en portefølje er korreleret, så kan de interagere negativt, hvilket får porteføljen til at blive betragtet som subadditiv, hvilket betyder at optionernes værdi i porteføljen er mindre end summen af de individuelle optioner (Belderbos *et al.*, 2014; Girotra *et al.*, 2007; McGrath, 1997a; Vassolo *et al.*, 2004).

Mens forholdet mellem ROR og downside risk hovedsageligt har været undersøgt af MNS-forskere, så har andre ROR-forskere studeret de individuelle faktorer som udgør ROR, såsom lav initial forpligtelse, sekventielle investeringer og omfordelingspolitikker i sammenhæng med andre strategiske investeringer såsom produkt-/serviceinnovation (Cuypers and Martin, 2010; Klingebiel and Adner, 2015). I denne artikel er vi interesseret i at undersøge om de forhold, der er etableret i MNS-litteraturen, også gør sig gældende i denne sammenhæng. Vi fremstiller to hypoteser: 1) et højere niveau af ROR er forbundet med lavere niveauer af downside risk, og 2) ROR's forhold til lavere niveauer af downside risk modereres af niveauet for 'relative exploration orientation' i negativ retning. I artiklen anvendes et lavt niveau af relative exploration orientation som mål for høj korrelation i optionsporteføljen. Et nøglespørgsmål i denne artikel er derfor, om forholdet mellem højere niveauer af ROR og lavere niveauer af downside risk også gør sig gældende uden for MNS-konteksten. Endvidere om den negative modererende effekt af korrelation i optionsporteføljen gør sig gældende i kontekst af produkt-/serviceinnovation.

Vores empiriske analyser supporter begge vores hypoteser. Vi viser, at virksomheder med en høj grad af ROR oplever lavere niveauer af downside risk. Vi viser også at den negative sammenhæng mellem ROR og downside risk modereres af niveauet for relative exploration orientation. Dermed bidrager denne artikel til litteraturen om ROR og downside risk uden for MNS-konteksten. Det er vigtigt undersøge forholdet mellem ROR og downside risk uden for MNS-konteksten, da dette adresserer skelnen mellem to separate ROR-tilgange til håndtering af usikkerhed. De to ROR-tilgange vedrører 'vent og se' og 'handl og se' (Adner and Levinthal, 2004; Barnett, 2008). I forbindelse med MNSer repræsenterer ROR en 'vent og se'-strategi, hvilket indebærer en totrinstilgang til 1) at få en optionsposition i en periode og 2) udøve eller opgive positionen (Barnett, 2008; Bowman and Moskowitz, 2001). Specifikt ville et MNS vente og se, om de makroøkonomiske forhold ændrede sig på en måde, der ville gøre det fordelagtigt at skifte produktionssted. Da makroøkonomiske udsving ligger uden for et firmas indflydelse, vil der ikke blive taget nogen aktiv handling for at fremme optionens udnyttelse. Vi modellerer specifikt ind i vores spørgeskemainstrument en 'handl og se' tilgang til ROR. Dette betyder, at ledelsen tager en aktiv rolle for at øge sandsynligheden for et projekts succes (Barnett, 2008; McGrath, 1997). Vi bidrager således med empiriske

resultater der viser, at forholdet mellem ROR og lavere niveauer af downside risk også gør sig gældende i et 'handl-og-se' ROR-regime. Vi bidrager også til litteraturen om sammenhængen mellem optionsporteføljer og den modererende virkning på RORs forhold til downside risk (Belderbos *et al.*, 2014; Ioulianou *et al.*, 2020) i kontekst af produkt-/serviceinnovation. Dette gør vi ved at anvende March' (1991) rammeværktøj for exploration og exploitation. Bidraget til litteraturen i kontekst af produkt-/serviceinnovation styrker yderligere bidraget til at vise ROR's indvirkning på downside risk i et 'handl-og-se'-regime, fordi produkt-/serviceinnovation specifikt repræsenterer en 'handl og se'-option (Cuypers and Martin, 2010). Vores artikel bidrager også til området ROR-forskning i kontekst af produkt-/serviceinnovation (Cuypers and Martin, 2010; Klingebiel and Adner, 2015; Verdu *et al.*, 2012), men som endnu ikke har undersøgt effekten af ROR på downside risk.

2.2. English summaries

2.2.1. Paper 1: Capital budgeting post-decision control: Performance implications for innovation investments

Authors: Claus Højmark Jensen and Thomas Borup Kristensen

Status: This paper has been submitted to International Journal of Innovation Management. We have received the comments from the editor and the reviewers, and the paper is currently advised for revision and re-submission.

Data: The paper applies a combination of financial statement data and data from a questionnaire. The data is based on 98 Danish firms with more than 100 employees, and the respondents of the questionnaire are primarily the firms' CFO's.

The summary below is a reproduction of the summary given in the introduction of paper 1 (Chapter 6)

Summary of scientific results: A summary of the scientific results of paper 1 is also presented in the introductory and concluding sections of Chapter 6 in this thesis (Jensen, 2021, p. 151), and therefore this summary is presented as sections of citations from chapter 6.

In paper 1, we (Jensen, 2021, p. 151) aim to *"extend the research on how firms apply control mechanisms to exert influence on the outcome of exploratory and exploitative innovations (e.g. Bedford (2015), Bedford et al. (2019), Benner and Tushman (2003), Davila et al. (2009), Hill and Rothaermel (2003), Ylinen and Gullkvist (2014)). We are motivated by the debate of whether exploratory and exploitative investments require different control mechanisms (Jansen et al., 2006; Ylinen and Gullkvist, 2014), and are especially motivated by the recent results of Holahan et al. (2014), which diverge from commonly held beliefs about the management of radical (exploration) and incremental (exploitation) innovation. We aim to extend the literature into the context of post-decision controls as*

known from the capital budgeting literature (Huikku, 2008, 2011; Lefley, 2016, 2019; Neale, 1991; Neale and Buckley, 1992), by introducing measures of formal and informal post-decision control.

The extant literature on how control mechanism influence outcomes of exploration and exploitation have produced mixed results and are relatively scattered with the use of various conceptualizations of control. In a study of input and output control, Cardinal (2001) for example concluded that incremental (exploitation) and radical (exploitation) innovations should not be managed differently. Jansen et al. (2006) on the other hand, showed that centralization had a negative impact on exploratory innovation, whereas formalization positively influenced exploitation investments.". "Holahan et al. (2014) find that firms in their sample tend to manage exploratory activities less flexibly than exploitative ones, and rather than being informally introduced, exploration activities are the result of formal planning. These latter results are in opposition to the results of Jansen et al. (2006), and to previously held beliefs about how radical (exploration) projects should be managed (Holahan et al., 2014; Leifer et al., 2000; Veryzer, 1998)." - (Jensen, 2021, p. 152).

As such Jensen (2021, p. 153) notes that *"the question of whether exploitative and exploratory innovations require different control mechanisms remains relatively unresolved.".* And therefore, proposes two hypotheses: *"1) the effect of exploration on performance is positively moderated by the level of formal post-decision control, and 2) the effect of exploitation on performance is positively moderated by the level of informal post-decision control."*

Our empirical findings show that formal (informal) post-decision control positively moderates the effect of exploration (exploitation) on performance. *"In partial support of our findings is Ylinen and Gullkvist (2014). They showed that the direct positive effect of organic controls on project performance is stronger for exploitative innovations than for exploratory. Additionally, they found a direct positive relation between mechanistic controls and project performance for firms scoring high on exploratory innovations." -* (Jensen, 2021, p. 170). Other studies, however, show contradicting results. *"While primarily studying the use of levers of control (LoC) and PMS, a recent survey study by Bedford (2015) provides results showing a positive performance relation with diagnostic controls for high exploitation firms but no relation for high exploration firms. Such a strong focus on output has previously been expected to shift the focus to shorter-term, more predictable, and incremental innovations, as ex-ante outcomes of radical innovations are difficult to determine (Cardinal, 2001). This does not necessarily appear to be the case in practice, as shown in this paper as well as in Cardinal (2001) and Holahan et al. (2014)." -* (Jensen, 2021, p. 170).

As such, *"our study contributes to the debate of whether exploration and exploitation should be managed with different control mechanisms (e.g., Bedford, 2015; Bedford et al., 2019; Cardinal, 2001; Holahan et al., 2014; Jansen et al., 2006; Ylinen and Gullkvist, 2014). Our results are in support of the view that they should indeed be managed differently and support recent challenging findings from Holahan et al. (2014). As such, we contribute by extending recent findings from the literature into the context of post-decision control." -* (Jensen, 2021, p. 171).

2.2.2. Paper 2: Implementation of a real options reasoning design as a response to environmental uncertainty

Authors: Claus Højmark Jensen and Thomas Borup Kristensen

Status: This paper has not yet been submitted to a journal

Data: The paper applies a combination of financial statement data and data from a questionnaire. The data is based on 95 Danish firms with more than 100 employees, and the respondents of the questionnaire are primarily the firms' CFO's.

The summary below is a reproduction of the summary given in the introduction of paper 2 (Chapter 7)

Summary of scientific results: A summary of the scientific results of paper 1 is also presented in the introductory and concluding sections of Chapter 7 in this thesis (Jensen, 2021, p. 185), and therefore this summary is presented as sections of citations from chapter 7.

In paper 2, we *"aim to advance the understanding of how firms implement real options reasoning (ROR). We are motivated by the debate of the applicability of ROR for strategic investment where managers actively participate in resolving the underlying uncertainty in contrast to a wait and see strategy (Adner, 2007; Adner and Levinthal, 2004; Barnett, 2008; Cuypers and Martin, 2010; Klingebiel and Adner, 2015)"* - (Jensen, 2021, p. 185). Only limited attention has been attributed to how ROR is implemented in organizations. Therefore *"we apply a multidimensional construct of ROR to examine how firms set behavioral boundaries to guide investment behavior when uncertainty is resolved endogenously. First, firms using ROR invest sequentially and with low initial commitments (Bowman and Hurry, 1993), which entails a resource allocation strategy with multiple steps. Second, ROR entails resolving the uncertainty surrounding the investment, which may be characterized as either exogenous or endogenous (Adner and Levinthal, 2004; Cuypers and Martin, 2010). We are interested in endogenously resolved uncertainty, and the potential problems this entails when engaging in a multi-step investment process. The ROR literature has identified problems associated with lost course of action resulting in exaggerating the sunk costs fallacy and escalation of commitment (Adner and Levinthal, 2004). As such, a third element, reallocation, is introduced to examine how firms set boundaries for the sequential investment behavior to ensure that failing projects are abandoned timely and only successful ones receive additional funding. There has been much discussion about the importance of reallocation as well as its usefulness when uncertainty is resolved endogenously (Adner and Levinthal, 2004). Existing empirical literature in this area is not exactly unequivocal (Cuypers and Martin, 2010; Klingebiel and Adner, 2015), so we seek to address this gap."* - (Jensen, 2021, p. 187). *"Because of the unequivocal result, we believe it is important to consider the contingent factors that may lead to different results. Verdu et al. (2012) for example found that environmental uncertainty moderated the effect of ROR on product/process innovation. This paper addresses the literature that treats ROR as a multidimensional construct (Klingebiel and Adner, 2015), and we find it both interesting and important to consider the known contingency factors when studying the fit between individual constructs of ROR. As such, the*

paper also addresses the question of whether environmental uncertainty is an important contingency factor to consider when examining fit between ROR constructs." (Jensen, 2021, p. 185).

The paper proposes four hypotheses: *"1) that sequential low commitment and endogenous uncertainty resolution are complements in a context of high environmental uncertainty, 2) that sequential low commitment and reallocation are complements in a context of high environmental uncertainty, 3) that endogenous uncertainty resolution and reallocation are complements in a context of high environmental uncertainty, and 4) that in a context of high environmental uncertainty, firms are more likely to implement all three ROR constructs simultaneously."* - (Jensen, 2021, p. 185).

In the paper, we find support for all hypotheses and *"show that firms operating in a context of high environmental uncertainty have a preference for implementing ROR choice variables. We argue that the choice variables of ROR are complementary, such that an increase in the level of one choice variable will decrease the costs associated with another. We show that the joint implementation of sequential low commitment, endogenous uncertainty resolution, and reallocation is selected in a context of high environmental uncertainty. We identify conditions under which the ROR choice variables are complementary, and thereby contribute to the understanding of the costs associated with ROR implementation in an uncertain context."* - (Jensen, 2021, p. 185).

The paper contributes to *"the debate of how ROR may be appropriately used under uncertainty. As our study relies on newly developed survey items, we confirm some existing knowledge about ROR to increase the validity of our paper. First, Driouchi and Bennett (2011) showed that controlling for managerial awareness of real options were an important factor to statistically show the effect of ROR. We confirm the importance of option awareness by showing that it is an important predictor of implementing the ROR constructs used in this paper. Second, Klingebiel and Adner (2015) also researched ROR using separate constructs. They applied separate constructs for sequential investment and low initial commitment and find that only sequential investment had a direct impact on increased innovation performance for projects prone to endogenous uncertainty resolution. Further, Cuypers and Martin (2010) found no indication that JV's prone to endogenous uncertainty resolution were likely to invest with low initial commitments. In contrast, we find that sequential investment and low initial commitment loads on a single construct, thus sequential low commitment, and that this construct is complementary with endogenous uncertainty resolution in a context of high environmental uncertainty. We acknowledge that the basis for comparison is limited due to the different conceptualization, and that we may lose some informational value by measuring sequential investment and low initial commitment as a single construct. However, in contrast to the existing studies, we find that there is a positive statistical relationship between the two, and that it is contingent on high environmental uncertainty, and thus contributes, at least with the interesting observation that environmental uncertainty may be an important contingency factor to consider when studying the relationship between individual ROR constructs. Third, Klingebiel and Adner (2015) showed that a fit between low initial commitment and reallocation increased innovation performance."* - (Jensen, 2021, p. 188). *"We find similar results by showing that sequential low commitment and reallocation are complements in a context of high environmental uncertainty. Fourth, Klingebiel and Adner (2015) found that reallocation had no direct effect on innovation performance for projects prone to endogenous uncertainty resolution. It is here important to consider the conceptualization of reallocation in Klingebiel and Adner's (2015) study, which was*

measured by the project abandonment rate, and thus not addressing the firms' policies for abandonment. We treat reallocation as a strict policy of specifying the investment scope at the time of initial investment and find that endogenous uncertainty resolution and reallocation are complements in a context of high uncertainty. As such, we contribute with important insights into ROR firms' internal policy setting for limiting the scope of investments. Such policy setting in connection with endogenous uncertainty resolution has been heavily discussed in the literature (Adner, 2007; Adner and Levinthal, 2004; Cuypers and Martin, 2010; Klingebiel and Adner, 2015), and it has been questioned whether endogenous uncertainty resolution is appropriate for ROR investing due to potential cost of specifying the scope of the investment ex-ante (Adner and Levinthal, 2004). As such, our findings indicate that in a context of high environmental uncertainty, the benefits of specifying strict ex-ante rules for the investment scope do indeed outweigh the costs when uncertainty is resolved endogenously. Sixth and last, while we already know that environmental uncertainty is an important factor to consider when researching ROR (Verdu et al., 2012), our study contributes with insights into the importance of considering the environmental uncertainty as a contingent factor when studying the interdependence of ROR constructs. While other studies have already studied ROR as a multidimensional construct (Klingebiel and Adner, 2015), we believe that this is the first to show that the constructs are interdependent, only in the context of high environmental uncertainty." - (Jensen, 2021, p. 189).

2.2.3. Paper 3: Relative exploration orientation and real options reasoning: Survey evidence from Denmark

Authors: Claus Højmark Jensen and Thomas Borup Kristensen

Status: This paper is published in European Business Review

Data: The paper applies a combination of financial statement data and data from a questionnaire. The data is based on 94 Danish firms with more than 100 employees, and the respondents of the questionnaire are primarily the firms' CFO's.

The summary below is a reproduction of the summary given in the introduction of paper 3 (Chapter 8 / Jensen and Kristensen 2021)

Summary of scientific results: A summary of the scientific results of paper 3 is also presented in the introductory section of Jensen and Kristensen (2021), and therefore this summary is presented as sections of citations from Jensen and Kristensen (2021).

As noted in Jensen and Kristensen (2021), we *"extend the understanding of how real options reasoning (ROR) is associated with downside risk and how a firm's portfolio of investment activities affects managers' ability to effectively apply ROR. We are motivated by the literature on downside risk and subadditivity. Formally, the downside risk is a probability-weighted function of below-target performance outcomes (Reuer and Leiblein, 2000) and for the purpose of this study, it is considered as a failure to meet an aspired to the level of performance. Subadditivity considers the effectiveness of ROR when investment activities have correlated uncertainty profiles (Belderbos et al., 2014, 2019; Belderbos*

and Zou, 2009; Ioulianou et al., 2020; Li and Chi, 2013; McGrath, 1997; McGrath and Nerkar, 2004; Vassolo et al., 2004)."

In positioning the research, Jensen and Kristensen (2021) notes *"extant empirical ROR literature has paid substantial attention to testing the relationship between ROR and downside risk. This relationship has mostly been studied in the context of multinational enterprises (MNE) based on the premise that MNEs possess real switching options, which, for example, allows them to shift production between sites to optimize changing macroeconomic conditions and thereby reduce downside risk (Reuer and Leiblein, 2000). This relationship has been studied and confirmed in various contexts (Reuer and Tong, 2007; Andersen, 2011, 2012; Driouchi and Bennett, 2011) and more recent studies have shown that the relationship is contingent on the low correlation between MNE's switching options (Belderbos et al., 2014; Ioulianou et al., 2020)."*. Further that, *"prior research on ROR and downside risk is largely limited to the context of MNEs. Recent results also suggest that if multiple options in a portfolio are correlated, they may interact negatively, causing the portfolio to be considered subadditive, which means that the option value of the portfolio is smaller than the sum of the options considered individually (Belderbos et al., 2014; Girotra et al., 2007; McGrath, 1997; Vassolo et al., 2004)."*

Jensen and Kristensen (2021) notes that *"While RORs relation to downside risk has been mainly occupied by MNE researchers, other ROR scholars have studied the individual constructs of ROR such as low initial commitment, sequential investments and reallocation policies in the context of other strategic investments such as product/service innovation (Cuypers and Martin, 2010; Klingebiel and Adner, 2015)."* Jensen and Kristensen (2021) subsequently presents the following hypotheses and research questions. *"(1) a higher level of ROR is associated with lower levels of downside risk; and (2) ROR's association with lower levels of the downside risk is moderated by the level of relative exploration orientation in a negative direction. A key question in this paper is whether the relationship between higher levels of ROR and lower levels of downside risk extends outside the context of MNEs and into the context of ROR as a multidimensional construct, where companies¨ simultaneous use of these constructs is required to produce the expected benefits. Further, whether the negative moderating effect of correlation in the options portfolio extends into the context of product/service innovation."*

In the paper, we find support for both of the hypotheses and Jensen and Kristensen (2021) notes that *"we show that firms with a high degree of ROR experience lower levels of downside risk. We also studied how this relationship is affected by other choice variables related to the characteristics of the capital investment portfolio, as measured by relative exploration orientation. We show that the negative association between ROR and downside risk is moderated by the level of relative exploration orientation."*. These results contribute to the extant literature in various ways. Jensen and Kristensen notes *"this paper extends the literature on ROR and downside risk outside the context of MNEs and into the literature of ROR as a multidimensional construct. Extending findings on the relationship between ROR and downside risk outside the scope of MNEs is important as it addresses the distinguishment of two separate ROR approaches to managing uncertainty. The two ROR approaches pertain to "wait and see" and "act and see" (Adner and Levinthal, 2004a; "Barnett, 2008). ROR in the context of MNEs represents a "wait and see" strategy, meaning a two-step approach to: (1) obtain an option position for a period of time; and (2) exercise or abandon the position (Barnett, 2008; Bowman and Moskowitz, 2001). Specifically, an MNE would wait and see if the macroeconomic conditions*

changed in a way that would make it preferable to switch production sites. As macroeconomic fluctuations are outside the scope of a firm's influence, no active action would be taken to further the exercisability of the option. We specifically model into our measure the "act and see" approach to ROR. This means that management takes an active effort to increase the likelihood of a project's success (Barnett, 2008; McGrath, 1997). We, thus, contribute with empirical findings showing that the relationship between ROR and lower levels of downside risk extends from a "wait-and-see" to an "act-and-see" ROR regime. We also extend the literature on the role of option portfolio correlation and its moderating effect on ROR's relation to downside risk (Belderbos et al., 2014; Ioulianou et al., 2020), into the context of product/service innovation by applying March's (1991) framework of exploitation and exploration activities. Extending the literature into the context of product/service innovation further strengthens the contribution of showing ROR's impact on downside risk in an "act-and-see" regime because product/service innovation explicitly represents an "act-and-see" option (Cuypers and Martin, 2010). Our paper also contributes to the area of ROR research in the context of product/service innovation (Cuypers and Martin, 2010; Klingebiel and Adner, 2015; Verdu et al., 2012), which has not yet studied the effect of ROR on downside risk."

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Chapter 3. Methodology

This dissertation presents empirical research, where the main source of data is based on a questionnaire. In this chapter, I discuss the methodological considerations that led to the decision of collecting survey data for the purpose of answering the research questions set forth in the individual papers. The chapter also presents the questionnaire.

3.1. Methodological considerations

As described in Chapter 1, the overall theoretical underpinning of this dissertation is based on complementarity theory. As complementarities are system-specific phenomena, which result from the interaction of individual elements in the organization (Ennen and Richter, 2010), its underlying assumptions have consequences for the empirical strategy. One of the underlying assumptions is that the organization is viewed as a system, and it is the interdependencies between different practices that form a system (Grabner and Moers, 2013; Milgrom and Roberts, 1995). When considering how to assess the interdependencies in such a system, it is useful to consider different variables' embeddedness from the perspective of fit. According to Gerdin and Greve (2004), fit may, on a top-level, be distinguished between Cartesian and Configuration forms of fit, and the difference between them stems from their dominant modes of inquiry. The Configuration form takes a holistic view, while the Cartesian takes a reductionist view, and the latter, the Cartesian, is the fit to which research in this dissertation belongs. Common for all research questions in this dissertation is that they lead to hypotheses about how pairs of organizational factors interact. The Cartesian approach focuses on how single pairs of factors affect each other and how these pairs affect performance (Drazin and Van de Ven, 1985; Gerdin and Greve, 2004). As such, this assumes that a limited number of factors can generate explanations of organizational structure (Gerdin and Greve, 2004). The two most common ways to test for complementarities in such a setting are via a performance specification or a demand specification (Grabner and Moers, 2013; Masschelein and Moers, 2020). A performance specification is a test of whether an interaction between two practices correlates with performance (Athey and Stern, 1998; Carree *et al.*, 2011; Grabner and Moers, 2013; Masschelein and Moers, 2020). Papers 1 and 3 in this dissertation hypothesizes on such a test. To answer the research question in paper 1, it is hypothesized that an interaction between formal post-decision control and exploration positively correlates with performance. In paper 3 it is hypothesized that an interaction between ROR and relative exploration orientation negatively correlates with downside risk. The underlying assumption of the performance specification is that a sufficiently large number of firms deviate from the optimal level for the practices studied, which allows the researcher to observe differences in performance between optimal and suboptimal systems (Masschelein and Moers, 2020). As such, it is assumed that organizations have variations in their degree of fit, making it the researcher's task to observe that higher levels of performance are associated with higher levels of fit (Gerdin and Greve, 2004). A demand specification tests whether two

practices are positively correlated after controlling for environmental factors (Arora, 1996; Grabner and Moers, 2013; Masschelein and Moers, 2020). Paper 2 seeks to answer the question of whether firms prefer a joint implementation of three ROR factors when environmental uncertainty is high. To answer this question, the paper hypothesizes on the pair-wise correlation between two ROR factors when controlling for environmental uncertainty. The underlying assumption is that a sufficient number of firms have chosen this optimal level of practice when accounting for the environment (Masschelein and Moers, 2020). As such, the researcher's task is to explore the nature of the relationship between context and structure, leaving out the effect on performance, which is unnecessary as it is assumed that only the best performing organizations survive (Gerdin and Greve, 2004).

The challenges of empirically studying the types of fit discussed above are not unique to the papers presented in this dissertation. Speklé and Widener (2020) note that a growing literature is studying the interrelationships between organizational variables, many of which with the use of survey methods (e.g., Abernethy *et al.*, 2015; Bedford *et al.*, 2016; Bedford and Malmi, 2015; Grabner, 2014). A survey is also the method of choice for this dissertation. In terms of data, examining interrelationships between organizational practices is very demanding as it requires access to detailed information on various managerial practices, contextual factors, and outcomes (Speklé and Widener, 2020). As a solution to these demands, survey research has some unique advantages. Surveys allow researchers to examine relatively complex questions, describe aspects of the natural setting to support external validity, and obtain enough observations to perform statistical analysis to conclude from (Speklé and Widener, 2018). In particular, the survey method is a good fit for the research in this dissertation, because the survey allows modeling of both the demand and performance specification (Grabner and Moers, 2013). Further, this dissertation considers organizational practices from the perspective of such practices being part of a system, and for organizational practices to form a system, they must covary (Speklé and Widener, 2020). If one is to observe covariation empirically, variation has to be present among firms' adoption of interdependent practices, either in a cross-section or over time (Grabner and Moers, 2013). For the purpose of the research in this dissertation, a cross-sectional sample is chosen as it is also assumed that some firms will not always have adopted optimal fit.

3.2. Data collection

All papers in this dissertation use the same data source. Therefore, the following presentation of the data collection has substantial overlaps with papers 1, 2, and 3, as the data collection is also presented in the individual papers, hereunder Jensen and Kristensen (2021).

As may be inferred from the research questions and hypotheses put forth in this dissertation, the purpose of the survey is to test theories, which predict relationships between two or more variables. For such a purpose, it is necessary to obtain a sample

from a group of subjects relevant to the proposed theories, which puts less pressure on the response rate (Speklé and Widener, 2018). So, for the data collection, I managed an online questionnaire addressed to CFOs in Danish companies with more than 100 employees. CFOs were chosen as the target respondent, assuming that the CFO has exhaustive knowledge about the firm's capital budgeting processes. I sent out the questionnaire throughout the fall of 2018. I chose firms with more than 100 employees in order to improve the chances of getting data from firms with formalized policies regarding investments. I identified the population of such firms using the Navne og Numre Erhverv database and excluded state-owned and financial firms. The survey was sent to 1056 organizations, and based on Dillman *et al.'s*, (2014) recommendations for survey research. By the end of the survey, to encourage participation, I offered the respondents an opt-in choice to receive a summary of the findings. The survey was distributed through an e-mail targeted at the CFO, where the e-mail contained a link to the questionnaire. After three weeks, I sent out an e-mail reminder, accompanied by a physically signed letter. After an additional three weeks, I sent out a second e-mail reminder. The respondents received a third and final e-mail reminder after an additional three weeks. The data collection resulted in an average response rate of 8.9%[1]. The average tenure of the respondents was 10.6 years in the firm, and 7.2 years in their position. The questionnaire included a question about involvement in the organization's investment decisions as a way of confirming that the responses came from suitable sources. The involvement was assessed on a scale from 1-7 (1 = no involvement at all, 7 = extremely high involvement), and I obtained a satisfactory average score of 6.0.

Table 3-1: Industry classification

DB07* industry classification	Frequency	%
Administrative services	6	6%
Construction and civil engineering	8	8%
Wholesale and retail	13	13%
Real estate	2	2%
Manufacturing	35	36%
Liberal, scientific and technical services	7	7%
Accommodation facilities and restaurants	5	5%
Transportation and freight handling	7	7%
Other	15	15%
Total sample	98	100%

Note:
[i] *DB07 - Danish standard industry classification

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[1] Small variations occur between the papers, as some observations has been removed from some papers due to missing measures. Table 3 is the distribution from paper 1.

Common method bias may a problem in singly method studies like the one presented in this dissertation (Speklé and Widener, 2018). I made several preparations to protect against it, and introduced temporal separation, meaning a time lag between questions used as dependent and independent variables respectively. This ought to reduce saliency of contextually provided retrieval cues (Podsakoff et al., 2003). I also ensured to protect respondents' anonymity, which according to Podsakoff et al. (2003) should decrease the apprehension toward more socially desirable, lenient, acquiescent, and consistent answers. At last, bivariate correlations are especially prone to common method bias (Speklé and Widener, 2018), and although all three paper are indeed concerned with bivariate correlations, all regression models are specified as multivariate, which should have a mitigating effect as long as additional variables shows correlation less than or equal to 0.30 with the existing variables (Speklé and Widener, 2018). This is addressed in the individual papers. A χ^2-test is used to assess sample representativeness. I compare the sample with that of full list of firms and find insignificant differences ($\chi^2 = 11.73$, degrees of freedom $= 8$, p > 0.10). The sample industry classifications are presented in Table 3-1. T-tests are used to assess mean firm size differences and mean differences in all variables. Comparing this sample ($\bar{X} = 392$) compared to the full sample ($\bar{X} = 406$) with the t-test shows no significant differences (t $= 0.58$, p > 0.10). The late response bias test, comparing scores of the variables between the 25% first and last responses showed no significant differences.

3.3. Survey item scales

In the following subsections, I describe all the constructs and associated measures used in the papers presented in this dissertation. Since all articles must be self-contained, there will be substantial overlap between the introduction to the survey items as presented in this chapter and the presentation hereof in the individual papers. All survey items used in this dissertation are measured on a seven-point Likert scale, where labels are provided for each point on the scale to reduce measurement error and response bias. I chose to use the seven-point Likert scale because Eutsler and Lang (2015) conclude that this approach is superior to five- or nine-point Likert scales. Their findings showed that the seven-point scale maximized the variance, and further scale points did not increase variance, while fewer points reduced variance. Further, labeling is superior to scales that only label at the ends because it reduces extreme response and central tendency bias (Dillman *et al.*, 2014). To improve the general understanding of the questionnaire, I informed the respondents that the questionnaire was part of a larger research project on investment decisions, and thus sent out the questionnaire including a cover letter with the following wording:

Cover letter

Dear Finance Manager,

You and your company have been selected for this study at Aalborg University, which deals with investment behavior in private Danish companies. We, therefore, ask for your help in answering the attached questionnaire.

The purpose of the questionnaire is to collect data for use in research at Aalborg University with a view to publication in scientific journals. You will contribute to creating knowledge about how Danish companies can make better investment decisions. The results will also be used in teaching at the MSc, MBA, and HD.

The questionnaire is sent to a sample of private companies with more than 100 employees and is addressed to the finance manager (CFO or similar), as this person is presumed to have extensive knowledge of the organization's investment decisions. As a representative of your organization, we kindly ask you to answer the questionnaire. Your participation is of great importance, as the theoretical part of the research is tested on the basis of your answers.

The questionnaire is estimated to take approx. 25 minutes to answer. Your answers will of course be treated with confidentiality, and the results of the research will not be traceable to any individual organization, nor which organizations have participated in the survey.

You have the option to leave and access the questionnaire along the way, as long as you remember to use the provided link. If you want the questionnaire sent to another e-mail address, please inform Claus Højmark Jensen via the contact information below.

If you have any questions, please feel free to contact Claus Højmark Jensen via the contact information below.

Your participation is especially appreciated. Thank you for your time.

Once respondents entered the survey, they arrived at an introductory page, which intended to set the scene for the survey:

Introductory page

The survey has four parts: Post evaluations of investment decisions, Processes for investment decisions, Risk and uncertainty, and Efficiency of investment decisions.

General guidelines: For multiple-choice questions, only one answer can be chosen. Chose the answer that best fits **your organization**. If the question is not relevant for your organization, then please use the option 'Don't know / not relevant'. It is important that **all questions be answered**, so even if you do not have a clear answer, please provide a realistic estimate. Answer all questions on behalf of the **organization** rather than your individual position. Throughout the survey, we use the term **'investment/investment project'** about the use of the organization's capital to acquire assets that the organization controls, and is expected to create long-term (more than one

year) value. Depending on your specific organization, investments/investment projects can include fixed assets (buildings, machinery, production equipment, computer systems, M&A, etc.), intangible assets (research and development, product development, goodwill, etc.), as well as non-capitalized expenditures for activities related to e.g., research or marketing.

3.3.1. Post-decision control

The development of items that measure post-decision control was important for this dissertation as this represents the main topic of paper 1. To develop the items, we drew on the extant literature, with the aim of identifying the different practices that researchers before us had observed and use this to develop items that represented firm practices. This resulted in the development of items intended to measure the extent to which firms engage in formal and informal post-decision control. We developed a total of 12 survey items to cover the two post-decision control dimensions. We measure the degree of formal post-decision control by the regularity of execution, standardization of processes, how quantitative the evaluation approach is, and the degree to which measures are predetermined. Informal post-decision control is measured by the arbitrariness of execution, flexibility, and absence of standardization in processes, use of non-predetermined objectives, use of personal judgment, and degree of qualitative assessment.

We sought to ensure that respondents answered questions regarding post-decision control with a distinction from a more general evaluation process. As such, we offered the following definition in the question introduction prior to answering the related questions: 'In the following, we ask you to answer a range of questions regarding your organization's processes for post-decision controls. These are post-evaluations of investment projects, meaning the evaluation and monitoring of an investment/investment project after the initial capital allocation to the investment/investment project. While the questions seem like each other's inverse, they should not be interpreted as mutually exclusive. Rather, because the type of investments/investment projects varies, we intend to measure the degree to which the processes for post evaluations also vary.

Please indicate the degree to which your organization's behavior for investment monitoring fits the following statements

Formal post-decision control

Post-evaluations are regularly executed

The post-evaluations process is clearly defined

The post-evaluations process is standardized

The post-evaluations process assesses quantitative financial goals that were determined when the investment was made (e.g. payback period, NPV, IRR, etc.)

The objectives that are evaluated in the post-evaluations process are measured in quantitative terms

The post-evaluations process is based on predetermined measures/objectives (e.g. discounted cash flows, payback period, etc.)

Informal post-decision control

Post-evaluations are arbitrarily executed

The post-evaluations process is loosely defined

The post-evaluations process is unstandardized

The post-evaluations process is based on subjective measures/objectives (e.g. objectives that were not determined at the time the investment was made)

The post-evaluations process is based on the personal judgment from the person executing the evaluation

The post-evaluations process assesses objectives/goals that depend on how the investment develops after it has been initiated*

Note:
i Scale: 1 = Very low extent; 2 = Low extent; 3 = Somewhat low extent; 4 = Neither low/high extent; 5 = Somewhat high extent; 6 = High extent; 7 = Very high extent
ii * Dropped items

In paper 1, the two dimensions of post-decision control were established through exploratory factor analysis, and satisfactory measures for reliability were obtained with Cronbach's alpha between 0.797 and 0.889 and composite reliability scores between 0.771 and 0.836.

3.3.2. Real options reasoning

The development of items that measure real options reasoning was of particular importance for this dissertation as it represents a substantial part of papers 2 and 3, and therefore deserves special attention. The literature on ROR was reviewed in order to create a base knowledge which could be used to develop a scale for ROR. I followed the methodological steps laid out in Bisbe *et al.* (2007) and Hinkin (1998) who provides guidelines for developing survey constructs. We developed 12 survey items intended to measure four constructs related to ROR. These constructs are (1) option awareness, (2) sequential low commitment, (3) active uncertainty resolution, and (4) reallocation.

Sequential low commitment, as described in Jensen and Kristensen (2021) *"refers to the resource allocation policy applied in the context of ROR. In contrast to the static assumptions used in resource allocation regimes such as NPV (Bowman and Hurry, 1993; Dixit and Pindyck, 1994), ROR firms do not assume deterministic futures, and will invest in projects sequentially and with low initial commitment which allows a firm to reduce downside risk, if the events unfold unfavorably, but maintains the option of taking advantage of future opportunities, if events unfold favorably (Ipsmiller et al., 2019; Li and Chi, 2013; Vassolo et al., 2004). As such, the theory suggests that there is value in deferring full commitment to an investment project until the underlying uncertainty is resolved (Song et al., 2015). We operationalize sequential low commitment with items intended to assess the degree to*

which management uses uncertainty to assess the size of capital commitments, as well as the effect of resolving uncertainty on exercising options."

Active uncertainty resolution, as described in Jensen and Kristensen (2021) *"refers to actions that will maintain an organization's access to opportunities, which means establishing routines that maintain and develop knowledge about an option's value (Barnett, 2008). While the NPV technique fundamentally assumes that the project will be launched and then left on its own, ROR expects managers to take an active role throughout the lifetime of the project, where managers exert an ongoing effort to respond to changing conditions to maximize the assets' potential (Barnett, 2005). If such management of options is not executed, or if management misuses its discretion over investment decisions, the theoretical value of real options may never be realized (Barnett, 2008; Coff and Laverty, 2008; Song et al., 2015). As such, a key part of ROR is to establish practices that produce the knowledge necessary to adapt to uncertainty (Driouchi and Bennett, 2012) and a flow of information that reduces uncertainty (Janney and Dess, 2004; McGrath and Nerkar, 2004). We ask about the extent to which management continuously observes the environment to make assessments of the value of the firm's options, and we assess the extent to which management puts continuous effort into creating value from its options."*

Reallocation as defined in Jensen and Kristensen (2021) *"refers to how managerial boundaries are set with regard to capital commitments after the initial investment has been made. Reallocation has especially been promoted by Adner and Levinthal (2004a), who argue that to create value from ROR, firms must restrict the area in which their real options are defined. Appropriate implementation of ROR includes explicitly defined circumstances under which an investment project is allocated further capital or is abandoned (Adner, 2007). The justification of a well-specified reallocation policy is found in the managerial biases inherent in policies of both low initial commitment and endogenous uncertainty resolution. Adner and Levinthal (2004) argue that information about the value of an investment may improve managerial decision-making, but flexibility is revealed in the abandonment decision. An option is flexible because, in the event of information about negative outcomes, it can be abandoned. However, low initial commitment often leads to escalation of commitment where there are no proper de-escalating procedures in place (Klingebiel and Adner, 2015). Reasons for such biases may be explained by a focus on sunk costs, personal interest, aversion to failure, and overconfidence (Camerer and Lovallo, 1999; Klingebiel and Adner, 2015; McGrath, 1999; Samuelson and Zeckhauser, 1988). Barnett (2008) argue that ROR firms will seek to reduce the uncertainty of a project from the time of the initial investment to the time of a potential subsequent investment, which implies a flow of information seeking to reduce adverse effects of uncertainty (Janney and Dess, 2004; McGrath and Nerkar, 2004). However, negative information about the development of an investment may not arrive all at once but be interrupted by occasional positive developments. According to Adner (2007), this escalates the chance that managers are convinced that an opportunity is worthy of continuation rather than abandonment. To mitigate such effects, ROR firms should set explicit boundaries for real options to ensure that managers abandon options that are no longer worth pursuing (Song et al., 2015). We operationalize reallocation by the extent to which management clearly specifies an asset's embedded options prior to investment in the said asset, the extent to which circumstances for abandonment, and further capital allocation, are specified ex-ante of option acquisition."*

Option awareness as defined in Jensen and Kristensen (2021) *"refers managers' awareness of opportunities to acquire option-generating resources (Barnett, 2008). Adner and Levinthal (2004b) argue that the underlying logic of real options is that future opportunities are contingent on past investments and Bowman and Hurry (1993) note that organizations develop as they pursue strategic opportunities, but that these opportunities are contingent on their resources. Bowman and Hurry (1993) argue that such opportunities for change only exist to the degree that managers recognize that investments in resources hold strategic opportunities. Driouchi and Bennett (2011) showed that managerial awareness of real options were important for MNC's ability to reduce their downside risk. They argue that shadowing is the firm's managerial aptitude to actually recognize that its assets hold embedded real options, which can be proxied by the extent to which managers pay attention to option-like opportunities (Barnett, 2005, 2008). Options awareness is operationalized with three items, covering management's consideration of an investment's options, such as abandonment, expansion, etc. We further asked about the importance of acquiring options, and the degree to which the firm recognize that future opportunities are contingent on prior investments in resources."*

The table below is reproduced from Jensen and Kristensen (2021).

Please rate the extent to which your organization's investment behavior is in accordance with the following statements
Option awareness
Prior to an investment, we consider the potential future trajectories of its inherent opportunities (e.g. deferment, expansion, flexibility, redeployment, etc.)
Future opportunities are important for the decision to make an initial investment
The firm's future opportunities are contingent on our prior investments
Active uncertainty resolution
We observe our environment on a continual basis to assess if an opportunity has become profitable
We observe our environment on a continual basis to assess if an opportunity is about to expire (e.g. patent expiration, competitive entry, etc.)
We put continual effort into creating value from the opportunities that are embedded in our investments
Sequential low commitment
When the uncertainty about an investment's outcome is resolved/low, we commit larger sums of capital
When the uncertainty about an investment's outcome is high, we commit smaller sums of capital
We realize our opportunities when we feel certain that we have resolved the uncertainty about its outcome
Reallocation
We clearly define which opportunities are inherent in an investment before committing capital to the initial investment
We clearly define under which circumstances an opportunity should be deferred or abandoned before committing capital to the initial investment
We clearly define under which circumstances an opportunity can be allocated further capital prior to the initial investment

Note:

In paper 2 and 3, the four constructs related to ROR were established through exploratory factor analysis, and satisfactory measures for reliability was obtained with Cronbach's alpha between 0.717 and 0.876 and composite reliability scores between 0.720 and 0.890.

3.3.3. Exploration and exploitation

Measures for exploration and exploitation are used in papers 1 and 3, and all items used to measure exploration and exploitation were based on Atuahene-Gima (2005). The framing of the questions was refined to fit the context investments. The table below is reproduced from Jensen and Kristensen (2021).

Please indicate the extent to which the following have been prioritized investments of the organization that you lead over the last 2 years:
Exploration
Acquiring entirely new skills that are important for product/service innovation (such as identifying emerging markets and technologies; coordinating and integrating R&D, marketing, manufacturing, and other functions; managing the product development process)
Learning product/service development skills and processes entirely new to your industry (such as product design, prototyping new products, timing of new product introductions)
Acquiring product/service technologies and skills entirely new to the organization
Learning new skills in key product/service innovation-related areas (such as funding new technology, staffing R&D function, training and development of R&D, and engineering personnel for the first time)
Strengthening product/service innovation skills in areas where it had no prior experience
Exploitation
Upgrading current knowledge and skills for familiar products/services and technologies *
Investing in enhancing skills in exploiting mature technologies in your industry that improve productivity of current product/service innovation operations
Enhancing competencies in searching for solutions to customer problems that are near to existing solutions
Upgrading skills in product/service development processes in which the firm already possesses significant experience
Strengthening knowledge and skills for projects that improve efficiency of existing product/service innovation activities.

Note:
[i] Scale: 1 = Very low extent; 2 = Low extent; 3 = Somewhat low extent; 4 = Neither low/high extent; 5 = Somewhat high extent; 6 = High extent; 7 = Very high extent
[ii] * Dropped items

In paper 1 and 3, the two constructs related to exploration and exploitation were established through exploratory factor analysis, and satisfactory measures for reliability

was obtained with Cronbach's alpha between 0.813 and 0.892 and composite reliability scores between 0.782 and 0.856.

3.3.4. Capital budgeting procedures

Data on capital budgeting procedures are used in Chapter 4 to report a state-of-art overview of the use of capital budgeting practices in Danish firms.

I collected data on capital budgeting techniques under two different categories; 1) investment evaluation procedures, and 2) techniques to address risk and uncertainties. I ask the respondents to rate on a scale from 1 to 7 (1 = never, 7 = always) their usage of specific capital budgeting techniques. For the remaining questions on investment evaluation procedures, I use questions applied in other surveys on capital budgeting practices such as Alkaraan and Northcott (2006), Chen (1995), Pike (1996), and Verbeeten (2006). Secondly, I ask the respondents to rate on a scale from 1 to 7 (1 = never, 7 = always) their usage of specific risk analysis techniques.

Please indicate how frequently your company employs the following evaluation techniques when deciding which investment projects to pursue?							
	1	**2**	**3**	**4**	**5**	**6**	**7**
Non-financial decision rules	o	o	o	o	o	o	o
Payback period	o	o	o	o	o	o	o
Accounting rate of return	o	o	o	o	o	o	o
Profitability index	o	o	o	o	o	o	o
Internal rate of return	o	o	o	o	o	o	o
Net present value	o	o	o	o	o	o	o
Economic value added	o	o	o	o	o	o	o
Real options	o	o	o	o	o	o	o
Game theory	o	o	o	o	o	o	o

Note:
[i] 1 = Never; 2 = Very rarely; 3 = Rarely; 4 = Sometimes; 5 = Often; 6 = Very often; 7 = Always

Wordlist:

Non-financial decision rules
Non-financial decision rules lead to investment decisions that are not contingent on specific financial data. Examples include decisions that lead to e.g. maximizing market share or implementation of strategy

Payback period
The time it takes a project to earn the costs of the investment

Accounting rate of return
Sum of the (yearly) expected profit divided by the investment sum

Profitability index
Net present value of the expected profit divided by the investment sum

Internal rate of return
The return on an investment's assets. The internal rate of return is calculated as the discount rate that sets the net present value of the expected cash flows equal to the investment sum

Net present value
The value of an investment, calculated as the difference between the investment sum and the discounted cash flows

Economic value added
The value of an investment, calculated as the difference between the operating profit after tax and the cost of capital multiplied with the invested capital

Real options
Computation of the net present value of an investment project as the sum of the project value itself, including the value of flexibility (e.g. flexibility of abandonment, deferral, expansion, etc.)

Game theory
Game theoretical decision rules make it possible to make a decision when objective data for profitability distributions and different scenarios are missing. Examples of game theoretical decision rules include maximax rules, minimax rules, etc.

Please indicate how frequently your company employs the following techniques to express uncertainties and analyzes risk in an investment project?							
	1	**2**	**3**	**4**	**5**	**6**	**7**
Adjusting the payback period	o	o	o	o	o	o	o
Adjusting the required return*	o	o	o	o	o	o	o
Reducing risk related to cash flows**	o	o	o	o	o	o	o
Weighting cash flows for different scenarios	o	o	o	o	o	o	o
Sensitivity / Break-even analysis	o	o	o	o	o	o	o
Scenario analysis***	o	o	o	o	o	o	o
Monte Carlo simulations****	o	o	o	o	o	o	o
CAPM / beta-analysis*****	o	o	o	o	o	o	o

Note:
[i] 1 = Never; 2 = Very rarely; 3 = Rarely; 4 = Sometimes; 5 = Often; 6 = Very often; 7 = Always
[ii] * e.g. increasing/decreasing the discount rate/hurdle rate/WACC; ** contracts such as futures/forwards/options; *** Analysis of different assumptions; **** assignment of probability distribution for assumptions; ***** analysis of risk in comparable projects, and assignment of cast of capital based on such comparison

3.3.5. Environmental hostility

Environmental hostility is used as a control variable in papers 1, 2, and 3. As defined in Jensen and Kristensen (2021) *"Environmental hostility is a measure of competitiveness and the degree of pressure for market demand, resources, and growth opportunities (Dess and Beard, 1984; Miller and Friesen, 1983). Hostility increases the attractiveness of exploitation while limiting profitability from exploration due to increased risk (Levinthal and March, 1993; Zahra, 1996). Environmental hostility may also have implications for ROR, as it may decrease the managers' focus on venturing into new areas (Wang and Dass, 2017), thus reducing the variance of expected outcomes. While firms may be encouraged to increase innovativeness to compete (Drechsler and Natter, 2012; Weerawardena et al., 2006), tense competition increases the challenges of finding unique opportunities to act on and therefore makes the search, learning, and action more costly (Wang and Dass, 2017). Based on Miller and Friesen (1983) and Tan and Litschert (1994), environmental hostility [HOST] is constructed as an index of three dimensions."*. Environmental hostility is measured as a formative construct. The table below is reproduced from Jensen and Kristensen (2021).

Over the past two years…
How intense you rate the competition for your primary products/services (1 = very low intensity, 7 = very high intensity)
How difficult has it been to acquire the necessary input for your business (1 = very low difficulty, 7 = very high difficulty)
How many strategic opportunities have been available for your business (1 = extremely few, 7 extremely many)

3.3.6. Environmental dynamism

Environmental dynamism is used in papers 1, 2, and 3. As defined in Jensen and Kristensen (2021) *"Environmental dynamism measures the predictability of the firm's environment (Dess and Beard, 1984). Dynamism is measured as an index of five dimensions, as in Chenhall and Morris (1993) and Gordon and Narayanan (1984)."*. Environmental dynamism is an important variable throughout this dissertation due to its relationship with both ROR and exploration/exploitation. Environmental uncertainty is a key concept in ROR because predictability of a firm's investment trajectory has material impact on the variance of the expected payoffs (Song *et al.*, 2015). With regard to exploration (exploitation), environmental dynamism increase (decrease) the expected payoffs. The table below is reproduced from Jensen and Kristensen (2021).

Over the past two years, how predicable or unpredictable have important changes in your external environment been with regard to the following?
Customer (e.g. demand, preferences)
Suppliers (e.g. key markets, quality of resources)
Competitors (e.g. competitors entering/exiting, tactics, strategies)
Technology (e.g. R&D, process innovations)
Regulations (e.g. economics, processes)

Note:
[i] Scale: 1 = Very predictable; 2 = Predictable; 3 = Somewhat predictable; 4 = Neither predictable/unpredictable; 5 = Somewhat unpredictable; 6 = Unpredictable; 7 = Very unpredictable

3.3.7. Strategy

We measure business strategy, as shown in the table below, as in Slater and Olson (2002), and the measure is used in paper 2. We provide respondents with five statements regarding business strategy and ask them with which type they identify. Firms are thus categorized into either prospectors, analyzers, defenders (Miles *et al.*, 1978), low-cost defenders, or differentiated defenders (Porter, 1980; Walker and Ruekert, 2006).

Please choose the company typology that best fits your organization
These businesses are frequently the first-to-market with new product or service concepts. They do not hesitate to enter new market segments where there appears to be an opportunity. These businesses concentrate on offering products that push performance boundaries. Their proposition is an offer of the most innovative product, whether based on dramatic performance improvement or cost reduction
These businesses are seldom 'first-in' with new products or services or to enter emerging market segments. However, by carefully monitoring competitors' actions and customers' responses to them, they can be 'early-followers' with a better targeting strategy, increased customer benefits, or lower total costs
These businesses attempt to maintain a relatively stable domain by aggressively protecting their product–market position. They rarely are at the forefront of product or service development; instead they focus on producing goods or services as efficiently as possible. These businesses generally focus on increasing share in existing markets by providing products at the best prices
These businesses attempt to maintain a relatively stable domain by aggressively protecting their product–market position. They rarely are at the forefront of product or service development; instead they focus on providing superior levels of service and/or product quality. Their prices are typically higher than the industry average
These businesses do not appear to have a consistent product–market orientation. They primarily act to respond to competitive or other market pressures in the short term.

3.3.8. Financial performance

Financial performance is applied in paper 1. A subject of debate in management research is the subjectivity versus objectivity of performance measures. Venkatraman and Ramanujam (1987) argue that in terms of validity and reliability, neither subjective nor objective measures can claim superiority and Chenhall (2003) has shown significant

correlations between subjective and objective performance measures in a number of studies. In this dissertation, a subjective measure of financial performance is used. It is based on a three-item reflective measure, derived from Chapman and Kihn (2009). Objectively measured performance (e.g., profitability or return on investment), may only partially reflects what the researcher wishes to measure (Speklé and Widener, 2018). We chose to rely on a subjective measure of performance because, in the case of paper 1, we wish to assess performance with the firm's competition as a reference level. While objective measures may be available through financial accounting data, a broad or even a narrower industry comparison may not reflect the actual benchmark with which the firm is competing.

Please rate your organization's performance on the following dimension compared to your competitors over the past year
Return on investment
Profit
Cash flow from operations

Note:
[i] Scale: 1 = Significantly under average; 2 = Under average; 3 = Somewhat under average; 4 = Neither under/over average; 5 = Somewhat over average; 6 = Over average; 7 = Significantly over average

In paper 1, the construct related to financial performance was established through exploratory factor analysis, and satisfactory measures for reliability were obtained with Cronbach's alpha of 0.957 and a composite reliability score of 0.959.

3.3.9. Perceived downside risk, business and financial

As defined in Jensen and Kristensen (2021) *"Reuer and Leiblein (2000) argue that "formally stated, downside risk is a probability-weighted function of below-target performance outcomes". In a review of variance-based measures of risk in finance theory, behavioral decision theory, and management research, Miller and Reuer (1996) find several rationales for moving toward a downside conceptualization of risk. Reuer and Leiblein (2000) argue that in particular, a downside conceptualization incorporates reference levels, which are identified as determinants of risk preferences in behavioral decision theory, thus indirectly controlling for risk appetite. The reason being that performance and aspiration constructs are central to managers' concept of risk (Miller and Leiblein, 1996). They reviewed past surveys of managers' perception of risk and mention studies such as March and Shapira (1987), who found that negative outcomes were the sole focus of risk consideration for 80 percent of the surveyed executives. March and Shapira (1987) argue that managers' decision-making considers risk not as variance in outcomes, but rather as negative outcomes. Further, out of seven definitions of risk, Baird and Thomas (1990) found that financial analysts considered size and probability of loss as the most important. As such, Miller and Leiblein (1996) argue that the surveys suggest that failure to meet an aspired to level of performance is the best-suited conceptualization of downside risk."*

In paper 3, we use two survey-based measures of downside risk by adaptation from other contexts. As defined in Jensen and Kristensen (2021) *"These are intended to measure downside*

risk in terms of the managerially perceived chance of obtaining below target performance outcomes on the organization's investment activities. To operationalize such perceived chances of obtaining outcomes from investments that fall below the objectives, we sought distant works of literature for items with similar intentions. We draw on Grewal et al.'s (1994) operationalization of Bauer's (1960) definition of performance risk. "Perceived performance risk refers to the possibility that the product will not function as expected and/ or will not provide the desired benefit" - (Grewal et al., 1994). We modify the measure to fit the purpose of this paper with two different conceptualizations. We term the first construct, Perceived downside risk, business, and define three items intended to assess an investment's risk in terms of the perceived chance of performing in accordance with expectations set at the time of investment. Additionally, the chance of an investment performing the expected features, and the chance of an investment performing with the expected functionality. For ease of interpretation, we reverse code the items to reflect that more downside risk corresponds to a higher score. We term the second construct, Perceived downside risk, financial, and ask the respondents to assess the perceived overall risk of allocating capital to an investment project. The risk of a capital allocation to an investment project due to events that will increase operational costs, and the perceived risk of a capital allocation to an investment project given the financial costs associated with the average investment project." The two tables below are reproduced from Jensen and Kristensen (2021).

How do you rate the chance that an average investment project will in your organization…
Reaches the performance expectations set at the time of the investment
Has the functionality expected at the time of the investment
Will overall function as expected at the time of the investment

Note:
[i] Scale: 1 = Very low chance; 2 = Low chance; 3 = Somewhat low chance; 4 = Neither low/high chance; 5 = Somewhat high chance; 6 = High chance; 7 = Very high chance
[ii] All items are reverse coded

How much overall risk is associated with allocating capital to an average investment project in your organization? (1 = very low risk, 7 = very high risk)
Please rate how likely you find the following statements (1 = very unlikely, 7 = very likely)
A capital allocation to an average investment project in your organization will lead to higher risk due to events that will lead to higher than expected operational costs?
A capital allocation to an average investment project in your organization will lead to higher risk due to events that will lead to higher than expected financial costs?

In paper 3, the two constructs related to downside risk were established through exploratory factor analysis, and satisfactory measures for reliability were obtained with Chronbach's alpha of 0.864 and a composite reliability score of 0.870.

3.3.10. Growth opportunities

A measure of growth opportunities is applied in papers 2 and 3. Growth opportunities is measured based on two survey items. It intends to evaluate the growth opportunities, as perceived by managers, for the organization and within the industry. The measure is based on Abernethy *et al.* (2004), and the table below is reproduced from Jensen and Kristensen (2021).

What are your expectations of the growth opportunities that exist in the industry that you compete in?
What are your expectations of the growth opportunities that your organization has?

Note:
i Scale: 1 = Strong decrease, 2 = Decrease, 3 = Somewhat decrease, 4 = Neither decrease/increase, 5 = Somewhat increase, 6 = Increase, 7 = Strong Increase

3.3.11. Short-term horizon

A measure of managerial short-term horizon is applied in papers 2 and 3. A short-term horizon might hinder the firm's ability to derive benefits from ROR. It directs managerial attention to viewing volatility only in terms of its downside (Wright *et al.*, 2007). The measure is based on Merchant (1990) and the table below is reproduced from Jensen and Kristensen (2021).

Please rate the percentage of time used on activities that will show in the income statement within… (Sum must be 100)
1 month or less
1 month to 1 quarter
1 quarter to 1 year
1 year to 3 years
3 years to 5 years
More than 5 years

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Chapter 4. State-of-the-art use of capital budgeting techniques in Danish firms

In this chapter, I present a descriptive evaluation of current techniques used in capital budgeting decision-making in Denmark. State of the art capital budgeting surveys has been popular over the past three decades, though Danish firms appear to have received less attention in the literature than other countries. Research in other countries has shown that discounted cash flow (DCF) has become the dominant method in e.g., Canada (Bennouna *et al.*, 2010; Jog and Srivastava, 1995; Payne *et al.*, 1999), the UK (Arnold and Hatzopoulos, 2000), and the US (Farragher *et al.*, 1999, 2001; Graham and Harvey, 2001; Ryan and Ryan, 2002). Other capital budgeting surveys have been conducted in Sweden, Central and Eastern Europe, Italy, France, Spain, China, the Netherlands, Hong Kong, Indonesia, and more (Brounen *et al.*, 2004; Daunfeldt and Hartwig, 2014; Hermes *et al.*, 2007; Holmén and Pramborg, 2009; Kester *et al.*, 1999; Maquiera *et al.*, 2012; Mendes-Da-Silva and Saito, 2014). Denmark has also been included in such studies. Brunzell *et al.* (2013) study the adoption of capital budgeting techniques in Nordic listed companies. As such, research on the adoption of capital budgeting techniques continues, and I, therefore, believe that it is justified to do so for Denmark as well. Further, as the overall topic of this dissertation is capital budgeting, I find it reasonable to start out with a presentation of the current state-of-the-art uses of capital budgeting techniques and practices in Danish firms. State-of-the-art studies on capital budgeting are important because the techniques used to decide on major financial commitments are crucial, as an inefficient application of scarce resources may likely result in value destruction (Arnold and Hatzopoulos, 2000). Therefore, this chapter investigates the extent to which Danish firms apply modern investment evaluation techniques.

In addition to showing the extent of technique application, I replicate the efforts of other scholars seeking to highlight preferences for certain capital budgeting practices. Alkaraan and Northcott (2006), for example, investigated the extent to which preferences change for strategic vs. non-strategic investments. This chapter therefore also assesses the extent to which technique preferences are related to firms' pursuit of investment strategies with regard to exploitative or explorative investments. Exploitation and exploration refer to two disparate modes of innovation (March, 1991). March (1991) defines exploitation by investments in e.g., refinement, production, efficiency, implementation, and execution, whereas exploration captures investments in e.g., search, variation, experimentation, discovery, and innovation. Exploration and exploitation can both be considered strategic investments, and to ensure long-term survival firms should become ambidextrous – that is engage in both activities simultaneously (March, 1991). I apply a measure of ambidexterity to proxy the extent to which a firm prioritizes strategic investments. As such, I take a slightly different approach, while still following the path laid out by Alkaraan and Northcott (2006) by assessing whether capital budgeting preferences change due to the emphasis on certain investment strategies. Other studies, such as

Verbeeten (2006), have assessed whether external factors such as uncertainty drives the preferences for capital budgeting practices, and specifically whether uncertainty drives capital budgeting sophistication. Rather than a replication of Verbeeten's (2006) study, I assess whether the level of exposure to environmental uncertainty is associated with preferences for capital budgeting-related procedures. This chapter addresses two basic questions:

1. What overall picture emerges from such a survey?
2. To what extent is the usage of investment evaluation procedures associated with investment strategy and environmental uncertainty?

Solid financial management and capital investment decisions are crucial for a firm's long-term success and survival (Bennouna *et al.*, 2010). Allocating resources among alternative capital investment projects is among the most pressing priorities of top management when implementing a firm's strategy (Bowman and Hurry, 1993; McGrath *et al.*, 2004). Capital budgeting is therefore an important topic, as this is the process of analyzing a firm's alternative capital investment opportunities in long-term assets that can be expected to generate benefits to the firm on a time horizon longer than one year (Bennouna *et al.*, 2010). Further, capital budgeting comprises practices to apply methods and techniques to evaluate different investment project alternatives and assist managers with information about which of the alternatives to select (Verbeeten, 2006).

4.1. A note on capital budgeting sophistication

The literature on capital budgeting has considered the idea of capital budgeting sophistication and distinguished between simple (naïve) and more advanced techniques (Haka *et al.*, 1986; Haka, 2006). The simple techniques are methods that in general do not consider cash flows or the time value of money. Neither do they incorporate risk measures to compare the investment to alternatives. More advanced techniques include discounted cash flow techniques, such as internal rate of return, net present value, and the like, which incorporate cash flow analysis and consider the time value of money (Verbeeten, 2006). Even more sophisticated are more recent developments in finance, where scholars (e.g., Dixit and Pindyck, 1994; Smit and Trigeorgis, 2004; Trigeorgis, 1993) have indicated shortcomings of discounted cash flow methods in a context of an unknown future. To address such circumstances the application of real options and game theory can be used as analytical methods (Verbeeten, 2006).

There have been various attempts to apply some techniques of dimension reduction to the use of capital budgeting techniques in order to produce factors that represent the degree of sophistication in the capital budgeting process. Pike and Sharp (1989) produced two factors in their search for sophistication which was 1) Financial techniques (IRR, NPV, Sensitivity Analysis), and 2) Management Science Techniques (Probability Analysis, Beta Analysis, Mathematical Programming, Computer Simulation, Decision Theory, and Critical Path Analysis). More recently, Verbeeten (2006) extended with a

range of risk analyses and managed to produce three factors. The factors produced were; 1) Naive capital budgeting practices (Accounting rate of return (ARR), Payback period (PB), Adaptation of required payback period), 2) NPV capital budgeting practices (Uncertainty absorption in cash flows, Net present value (NPV), Internal rate of return (IRR), Adaptation of required return/discount rate, Scenario analysis, Sensitivity/break-even analysis), and 3) Sophisticated capital budgeting practices (Adjusting expected values, CAPM analysis/beta analysis, Decision trees, Using certainty equivalents, Real options pricing (RO), Game theory decision rules (GT), Monte Carlo simulations).

The survey used in this chapter has been informed by such prior studies, and I have sought to replicate such dimension reduction (not reported here), and do not obtain results that confirm any of the earlier studies. One potential reason why I fail to reproduce such findings may be that capital budgeting sophistication as measured by the extent to which firms use the techniques is an inappropriate method for producing meaningful reflective factors. I do not find any theoretical rigor in the past studies that provide any reason to believe that a change in capital budgeting sophistication should cause variation in the use of any number of techniques. When observing the results from e.g., Pike and Sharp (1989) and Verbeeten (2006), their factor analyses produce factors where items such as CAPM analysis and NPV are part of separate factors. While it is certainly possible to conduct an NPV analysis without the use of CAPM, I find it surprising that they would not at least be categorized together, since they are conceptually related in that NPV assesses future cash flows to a required rate of return, which, in a capital budgeting context, is most likely what CAPM will be used for. Instead, I offer a logical categorization of investment evaluation procedures that assigns a technique into one of four overall types; 1) Non-financial analysis, 2) not time value of money compliant (non-DCF), 3) time value of money compliant (DCF), and 4) path dependent. I expand on this categorization in the next section.

4.2. Survey design and sample

The data collection process for the data used in this chapter is presented in Chapter 3 and will therefore not be repeated here. Rather, I briefly describe the use of survey measures in the following sub-section.

4.2.1. Survey measures

I collected data on capital budgeting techniques under two different categories; 1) investment evaluation procedures, and 2) techniques to address risk and uncertainties. Like Pike (1996), I am here interested in the developments of formal capital investment practices, as well as how the external environment affects the firms' choice of practice as in Verbeeten (2006).

Capital budgeting practices

I analyze two types of capital budgeting practices in this study - first I ask respondents to report the use of investment evaluation procedures, and second on the use of risk analysis procedures. I ask the respondents to rate on a scale from 1 to 7 (1 = never, 7 = always) their usage of specific capital budgeting techniques, starting with non-financial analysis. As such, non-financial analysis makes up the first of the above-mentioned categorizations. For the remaining questions on investment evaluation procedures, I use questions applied in other surveys on capital budgeting practices such as Alkaraan and Northcott (2006), Chen (1995), Pike (1996), and Verbeeten (2006). I thus end up with a categorization for non-time value of money compliant techniques (Non-DCF for short) as the payback period and accounting rate of return. The third categorization, time value of money compliant techniques (DCF for short), includes all discounted cash flow techniques, such as internal rate of return (IRR), net present value (NPV), profitability index (PI) and Economic value added (EVA). The last category of capital budgeting techniques is one that considers multiple future trajectories, thereby named path-dependent (PD), and includes game theory (GT) and real options (RO).

Secondly, I ask the respondents to rate on a scale from 1 to 7 (1 = never, 7 = always) their usage of specific risk analysis techniques. I asked the respondents the extent to which they apply the following techniques to address issues of risk and uncertainty in the capital investment decision-making process. The techniques in question were as follows: Adjusting the required payback period (Adj. PB), adjusting the required discount rate / required rate of return (Adj. RR), weighting expected cash flows (WCF), use futures/forwards/options, and the like (Contracts), break-even analysis (BEA), scenario analysis (SA), monte carlo simulations (MCS), and CAPM or other methods that are compliant with asset pricing models (CAPM).

Investment strategy

In order to assess if capital budgeting practices vary as a response to the firm's investment strategy, I apply a combined measure of exploration and exploitation. Ten survey items are used to measure the exploitation and exploration constructs. I treat the ten items as reflective indicators of the two constructs. Exploration and exploitation scores are computed as the average of the individual survey items. I utilize the exploration and exploitation constructs to operationalize a measure for organizational ambidexterity. Extant empirical studies on the performance implications of exploration and exploitation established that the simultaneous pursuit of the two activities contributes to the effect (Raisch and Birkinshaw, 2008). Cao *et al.* (2009) showed that it is both the combined effect as well as the act of balancing the two that yields an effect for performance. I follow this steam of literature and compute organizational ambidexterity, as a combined dimension, operationalized as exploration multiplied by exploration, and as a balanced dimension, operationalized as seven (the maximum score of the constructs) minus the absolute difference between exploration and exploitation, so that a higher score indicates a greater balance. As in Bedford *et al.* (2019), our applied measure of ambidexterity is the combined dimension multiplied by the balanced dimension.

Environmental uncertainty

I use a measure of environmental uncertainty using the environmental dynamism construct. As defined in Jensen and Kristensen (2021) *"Environmental dynamism measures the predictability of the firm's environment (Dess and Beard, 1984). Dynamism is measured as an index of five dimensions, as in Chenhall and Morris (1993) and Gordon and Narayanan (1984)."*. Because the items do not relate to one another, the construct is measured formatively, thus the construct is computed as the average of the five items.

4.3. Survey results

4.3.1. Investment evaluation procedures

Table 4-1 Panel A reports the frequency use of capital budgeting appraisal techniques. Table 4-1 Panel B aggregates the results based on the three categorizations, where 'Any' has been added to reflect the percentage of firms that use any technique to any extent. Non-DCF refers to the percentage of firms that use either the payback period or ARR. DCF refers to the percentage of firms that use either IRR, NPV, PI, or EVA. Finally, path-dependent refers to the percentage of firms that use either real options or game theory analysis.

Table 4-1: Investment evaluation procedures

	1	2	3	4	5	6	7	Some degree	Mean
Panel A									
Non-Fin	13%	7%	13%	36%	26%	2%	3%	88%	3.75
PB	6%	4%	10%	15%	23%	21%	21%	94%	4.90*
ARR	11%	5%	13%	23%	19%	21%	8%	89%	4.28
IRR	27%	15%	10%	14%	16%	9%	9%	73%	3.42*
PI	32%	15%	14%	17%	14%	6%	3%	68%	2.96
NPV	20%	17%	17%	16%	8%	8%	15%	80%	3.59*
EVA	57%	13%	7%	9%	6%	5%	2%	43%	2.19*
RO	68%	15%	10%	5%	0%	1%	1%	32%	1.62*
GT	71%	11%	10%	3%	2%	0%	2%	29%	1.62*
Panel B									
Any								98%	na.
Non-DCF								97%	na.
DCF								88%	na.
PD								35%	na.

Note:
[i] 1 = never, 2 = very rarely, 3 = rarely, 4 = sometimes, 5 = often, 6 = very often, 7 = always
[ii] * indicates that the technique is significantly correlated with size a p < 0.05

Nearly all firms (98%), apply some evaluation when making investment decisions. Despite its inferiority, the Payback approach is the most widely used technique, as 93.8% of firms report that they apply the PB to at least some extent, which compares to studies

conducted in other countries. In the UK, Abdel-Kader and Dugdale (1998) found that firms find the payback method being quite important with an average score of the importance of 3.1 out of 5. Carr and Tomkins (1996) found that 69% of UK firms and 52% of German firms rated the PB as their first choice. Including ARR shows that 96.9% of firms use at least some non-DCF compliant technique. Alkaraan and Northcott (2006) pointed out that the popularity of the Payback approach is likely because its focus on liquidity is an attractive feature.

The results show that 88% of firms use some form of DCF method, but it is surprising to find 12% still not applying DCF methods when appraising capital investment projects. I find NPV and IRR to be the most popular DCF methods, with a slight preference for NPV (80%) over IRR (73%) which is similar to results found by Bennouna *et al.* (2010) in a study of Canadian firms. They found 80.7% to be using DCF and 87.7% to be using IRR. In Australia Truong *et al.* (2008) found the adoption of NPV and IRR respectively to be 94% and 80% and in the US, Ryan and Ryan (2002) found the adoption rates at 96% and 92.1%. At last, in the UK Arnold and Hatzopoulos (2000) found 97% NPV adoption and 84% IRR adoption. Pike (1996) argued that one possible explanation for the strong use of the DCF techniques could be that modern technology makes such computation as straightforward a procedure as computing the PB – an argument that in the current year seem outdated though. However, an interesting observation about the use of DCF techniques is that prior surveys have discussed that a popular view is that academics prefer NPV, while practitioners prefer IRR (Pike, 1996). This pattern is not characteristic of DCF usage for the Danish firms in this sample as the preference is quite close. Though NPV is the first choice, a sizeable number of Danish firms still have preferences for the IRR, which Cheng *et al.* (1994) argue is a natural choice for managers as the technique appraises the capital investment projects in percentage terms, which makes for easy comparison with other projects. Despite the DCF techniques arguably being quite accessible, and though the adoption to some degree is quite high, Table 4-1 also shows that only 23% percent of firms use NPV always or very often, compared to 42% for PB. This mirrors the results obtained for Nordic companies by Brunzell *et al.* (2013). They showed that only 41% of the surveyed listed Nordic companies used NPV as their main method, which is rather low compared to the 74% which Graham and Harvey (2001) found for US firms.

In terms of more advanced techniques, only 35% use a path-dependent appraisal technique, and the average use of RO and GT across the entire sample is as low as 1.62 (out of 7) for both. The result is similar to a recent study on Australian firms where Truong *et al.* (2008) found that 32% of the firms apply real options. In contrast, Bennouna *et al.* (2010), Block (2007), and Graham and Harvey (2001) found real options usage only between 8.1% and 14.3% among firms in their samples. As such, though the average usage of more advanced techniques is very low, Danish firms seem to have welcome these techniques into their repertoire of appraisal techniques. This is good news for Danish firms in general, as failure to consider real options may create a downward bias on the capital investment value (Phelan, 1997). The low usage, however, may be due to

skepticism and complexity of the techniques and due to DCF being considered an appropriate choice for more advanced evaluation (Block, 2007; Cotter *et al.*, 2003).

While the adoption of DCF methods is relatively high, the results show that Danish firms are still to a high extent relying on simple investment appraisal techniques, like the payback period and ARR. Using multiple techniques may indicate that firms have a need for investigating various aspects of a capital investment (Bennouna *et al.*, 2010; Pike, 1996). Other possible explanations include that simultaneous use of different techniques means that managers weigh the results from a variety of formal calculations (McDonald, 2006). While the DCF may provide information regarding value added to the firm, the payback approach offers a quick insight into risk and liquidity (Sangster, 1993). Table 4-2 shows how firms combine different methods, and the results indicate that the majority of firms (96%) use multiple capital budgeting techniques for investment appraisal. Only 2% say that they do not use any technique, and as many as 66% states that they apply 6 techniques or more. Although, as shown in Table 4-2, only 34% have expanded to use all four categories of techniques. This means that while firms expand the number of techniques, they tend to use multiple techniques in the same category, in fact, 71% of the firms in this survey respond that they use more than one NPV technique. However, while there may be a preference for using multiple techniques within the same group, the largest group of firms (44%) apply a mix of non-financial, non-DCF, and DCF methods, which indicate a thorough appraisal of capital investment projects.

Table 4-2: Combined evaluation techniques

	Percentage of firms
No methods	2%
A single type of technique	
Non-DCF	2%
Subtotal	2%
Two types on techniques	
NF/Non-DCF	8%
Non-DCF/DCF	8%
Subtotal	17%
Three types of techniques	
NF/Non-DCF/DCF	44%
NF/DCF/PD	1%
Subtotal	45%
Four types of techniques	
NF/Non-DCF/DCF/PD	34%
Subtotal	34%
Total	100%

4.3.2. Investment evaluation procedures and strategic investments

In Table 4-3, I present a range of t-tests to assess potential differences in the preference for appraisal techniques across groups that have been split based on the firms' extent of strategic investment as measured by the level of ambidexterity, as well as levels of exploitation and exploration, respectively.

Table 4-3 reveals that the average use of investment appraisal techniques is higher for all techniques for firms that score high on strategic investments. The payback period, followed by ARR, are the most frequently used techniques across all groups. The results of the t-tests do reveal that a strong focus on pursuing specific types of investments affects the preferences for using certain appraisal techniques. The results show that firms in the high strategic investment sample have significantly higher use of ARR, EVA, and game-theoretical techniques. However, the main conclusion is that the payback period, ARR, non-financial, and DCF are the most used techniques for both the low and high strategic investment group. I include results for the difference between the groups of exploitation and exploration only for completion. These results should be considered with much caution because most firms are quite ambidextrous, which means that firms in e.g., the high exploitation group will also to a certain extent engage in exploration investments, which are not controlled for in these simple t-test analyses. While PB and ARR are the most popular techniques in all groups, the difference between the exploitation groups is highly significant for the non-DCF consistent techniques. One possible explanation for this result may be that improving the quality of existing operations can be well worth it even though the exact contribution to firm value is unknown (Cole, 1998). As such, a firm may find financial evaluation with greater sophistication unnecessary. The picture is less clear for exploration groups. I do observe a statistically significant difference between the means for EVA use between the exploration groups. However, though the difference is statistically significant, the mean score reveals that EVA is only rarely used.

Table 4-3: Investment evaluation and strategic investments

	Ambidexterity				Exploitation		Exploration	
	Low mean	High mean	Diff mean	t-value	Diff mean	t-value	Diff mean	t-value
Panel A								
NF	3.51	3.98	0.47	1.58	0.55	1.88*	0.44	1.48
PB	4.66	5.12	0.46	1.31	0.8	2.29**	0.15	0.43
ARR	3.91	4.63	0.72	2.03**	0.97	2.79***	0.5	1.36
IRR	3.32	3.51	0.19	0.46	0.23	0.55	-0.19	-0.45
PI	2.66	3.24	0.58	1.61	0.67	1.85*	0.52	1.44
NPV	3.47	3.71	0.24	0.58	0.24	0.58	0.08	0.19
EVA	1.77	2.59	0.82	2.44**	0.29	0.81	0.85	2.55**
RO	1.47	1.78	0.31	1.34	0.22	0.97	0.31	1.36
GT	1.4	1.84	0.44	1.75*	0.35	1.41	0.31	1.24

Panel B								
Non-DCF	4.29	4.88	0.59	2.07**	0.88	3.18***	0.33	1.13
DCF	2.8	3.27	0.47	1.38	0.35	0.82	0.32	0.81
PD	1.44	1.81	0.37	1.63	0.29	1.26	0.31	1.36

Note:
i * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

4.3.3. Investment evaluation procedures and environmental uncertainty

In Table 4-4, I present t-tests to assess potential differences in the preference for appraisal techniques across groups that have been split based on the firms' level of environmental uncertainty as measured by environmental dynamism, which assesses the perceived unpredictability in a firm's environment (Dess and Beard, 1984; Gordon and Narayanan, 1984). Uncertainty is an interesting topic in the context of capital budgeting, because complete information about future events is not available, and as such investment decisions involve uncertainty about the outcomes that in the future will have an impact on the firm's survival (Smit and Ankum, 1993; Verbeeten, 2006).

Table 4-4: Investment evaluation and environmental uncertainty

	Environmental uncertainty			
	Low mean	High mean	Diff mean	t-value
Panel A				
NF	3.49	3.93	0.44	1.47
PB	4.92	4.88	-0.04	0.13
ARR	3.87	4.56	0.69	1.87*
IRR	2.97	3.72	0.75	1.75*
PI	2.56	3.23	0.67	1.80*
NPV	3.51	3.65	0.14	0.31
EVA	1.77	2.47	0.7	2.10**
RO	1.33	1.82	0.49	2.34**
GT	1.21	1.91	0.7	3.32***
Panel B				
Non-DCF	4.4	4.72	0.32	1.09
DCF	2.75	3.28	0.53	1.70*
PD	1.27	1.87	0.60	3.02***

Note:
i * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

The results show that the payback period continues to be the most widely used technique across both high and low levels of uncertainty. While the payback period is the most frequently used technique, the t-tests reveal that firms that are more exposed to environmental uncertainty tend to have a stronger preference for more advanced techniques in both the DCF and path-dependent group of appraisal techniques. As such, the results indicate that environmental uncertainty is a driver of sophistication in the choice of appraisal techniques. A stronger preference for path-dependent techniques is

consistent with the theory that assumes real options are more valuable under uncertain conditions (McGrath *et al.*, 2004). As more sophisticated techniques are also more costly to implement (Verbeeten, 2006), it seems reasonable that the preference for them increases when their benefits are more likely to outweigh their costs.

4.3.4. Risk analysis

Table 4-5 reports the frequency of use of capital budgeting risk techniques. I find that the majority of Danish firms use some form of risk analysis tool. The main choice for risk analysis is the break-even analysis (84%), followed by scenario analysis (74%) and adjusting the required payback period (73%).

The least used risk analyses techniques are more advanced techniques, such as monte carlo simulation (30%), and techniques that express risk consistent with asset pricing models, such as the Capital Asset Pricing Model (CAPM) (30%). The low adoption of CAPM is consistent with Abdel-Kader and Dugdale's (1998) findings that note that while CAPM is theoretically preferable, it is perceived as less useful in practice, even for highly risky projects. On a score of 1-5, they found that UK firms rated its importance at 2.06. The low CAPM usage among the firms in this sample compares well with the conclusions drawn by Brunzell *et al.* (2013), that Nordic firms are lagging on the use of CAPM. However, it is still surprising to find such a low degree of CAPM consistent risk assessment given the emphasis on the method in standard corporate finance textbooks in both undergraduate and graduate coursework. While CAPM usage is limited, Danish firms do adjust the required rate of return (63%) for different projects. While 63% make adjustments to some degree, only 16% report that they adjust the rate between often and always. This finding mirrors that of Brunzell *et al.* (2013), who concluded that Nordic firms rarely take project-specific risk into consideration, but rather uses the same discount rate for most projects. Adjusting the required rate of return is certainly advisable, as using the same required return would indicate that the risk of any capital investment is reflected by the same level of risk as the firm's existing assets (Bennouna *et al.*, 2010). Therefore, it is advisable that firms adjust the required return either up or down depending on the risk of the individual project.

Table 4-5: Risk analysis procedures

	1	2	3	4	5	6	7	Some degree	Mean
Adj. PB	27%	18%	16%	27%	9%	1%	2%	73%	2.85
Adj. RR	38%	16%	17%	14%	10%	3%	3%	63%	2.66*
Contracts	46%	18%	9%	14%	11%	1%	1%	54%	2.34
W.CF	51%	18%	11%	10%	6%	2%	1%	49%	2.14*
BEA	16%	4%	9%	32%	22%	8%	8%	84%	3.99*
SA	26%	6%	11%	23%	21%	8%	4%	74%	3.48
MCS	70%	14%	10%	5%	0%	0%	1%	30%	1.56

| CAPM | 66% | 14% | 13% | 4% | 3% | 1% | 0% | 34% | 1.69* |

4.3.5. Risk analysis and strategic investments

In Table 4-6, I present a range of t-tests to assess potential differences in the preference for risk analysis techniques across groups that have been split based on the level of strategic investments. Nearly all techniques are applied to a larger extent in the high scoring groups with the exception of adjusting the required return and monte carlo simulations in the exploration sample, where the difference is negligible, though. The picture of firms' preferences for risk analyses techniques is unchanged and the most popular technique continues to be the break-even analysis, followed by scenario analysis and adjusting required payback period and return. While the average use continues to be low, the results do show an increased preference for using contracts and the CAPM in the sample that scores high on strategic investments. Contracts may be effective instruments to stabilize cash flow, which may provide a valuable tool for firms having a strong emphasis on venturing into new business areas where future cash flows are less predictable. While the low use of CAPM is surprising, the preference for the tool increases with the level of strategic investments. Firms that score high on the level of strategic investments have a portfolio with a strong emphasis on both exploration and exploitation. Therefore, the projects in such a portfolio will likely have very different risk profiles (March, 1991). Therefore, any given project is unlikely to reflect the risk of the firms' existing assets (Bennouna *et al.*, 2010), and the result, therefore, indicates some acknowledgment that the risk profile of individual projects in a portfolio of capital investment projects should be assessed individually. As in the above section on appraisal techniques, the results for exploitation and exploration sample are included for completion only.

Table 4-6: Risk analysis and strategic investments

	Ambidexterity				Exploitation		Exploration	
	Low mean	High mean	Diff mean	t-value	Diff mean	t-value	Diff mean	t-value
Adj. PB	2.6	3.1	0.5	1.64	0.42	1.36	0.08	0.24
Adj. RR	2.51	2.8	0.29	0.82	0.33	0.94	-0.02	0.05
Contracts	1.98	2.69	0.71	2.28**	0.50	1.6	0.70	2.22**
W.CF	1.91	2.35	0.44	1.43	0.48	1.58	0.41	1.36
BEA	3.77	4.2	0.43	1.24	1.15	3.41***	0.23	0.66
SA	3.17	3.78	0.61	1.62	1.23	3.47***	0.18	0.46

MCS	1.53	1.59	0.06	0.28	0.35	1.68*	-0.06	0.26
CAPM	1.49	1.88	0.39	1.68*	0.14	0.59	0.33	1.46

Note:
i * p < 0.10; ** p < 0.05; *** p < 0.01.

4.3.6. Risk analysis and environmental uncertainty

Table 4-7 presents t-tests to assess potential differences in the preference for risk analysis techniques across groups that have been split based on the firms' level of environmental uncertainty.

The results show that break-even analysis and scenario analysis continue to be the most popular risk analysis techniques for firms operating under both low and high uncertainty. The t-tests, however, show that firms are more likely to allow for adjustments to the payback period and adjustments to the required return when operating under unpredictable conditions. Risk analysis is crucial for effective capital investment decision-making (Alkaraan and Northcott, 2006, 2013; Bennouna *et al.*, 2010), and uncertainty tends to affect most of the parameters used in capital investment decisions (Bennouna *et al.*, 2010). The increased preference for making input adjustments indicates that Danish firms do consider the uncertainty when making capital investment decisions. Further, while the average use of CAPM is very low, results do indicate that firms operating in environments that are more dynamic are significantly more likely to use CAPM, which is consistent with firms using more advanced appraisal techniques under greater uncertainty.

Table 4-7: Risk analysis and environmental uncertainty

	Environmental uncertainty			
	Low mean	High mean	Diff mean	t-value
Adj. PB	2.41	3.16	0.75	2.47**
Adj. RR	2.26	2.93	0.67	1.93*
Contracts	2.03	2.56	0.53	1.69*
W.CF	2.00	2.23	0.23	0.73
BEA	3.67	4.21	0.54	1.48
SA	3.33	3.58	0.25	0.63
MCS	1.36	1.70	0.34	1.70*
CAPM	1.38	1.89	0.51	2.27**

Note:
i * p < 0.10; ** p < 0.05; *** p < 0.01.

4.3.7. Decision-making rules

I asked the respondents to report some rules that they apply in their investment decision-making. I asked respondents to report the average payback period and required return

that their organization applies when making decisions about initiating projects. The results are reported in Table 4-8 and 4-9, respectively.

Table 4-8: Average required payback period

< 1 year	1-2 years	2-3 years	3-4 years	4-5 years	5-6 years	> 6 years	N/A
2%	11%	19%	21%	10%	9%	14%	14%

Note:
[i] The table shows the percentage of firms that selected a given bracket for the average required payback period

Table 4-9: Average required discount rate

< 5%	5%-7%	8%-10%	11%-13%	14%-16%	17%-19%	> 19%	N/A
8%	15%	34%	3%	2%	1%	2%	34%

Note:
[i] The table shows the percentage of firms that selected a given bracket for the average required discount rate

The result shows that most firms (20.83%) have an average required payback period between 3 and 4 years, closely followed by an average required payback period between 2 and 3 years (18.75%). Table 4-9 shows that the largest group of firms (34.38%) uses an average required return between 8% and 10%, followed by 14.58% that reported an average required return between 5% and 7%.

4.4. Conclusion

In this chapter, I have used survey data to present the current state of affairs regarding the use of capital budgeting practices in a sample of Danish firms. Over the years, the DCF method has gained status as the golden standard for evaluating capital investment alternatives (Bennouna *et al.*, 2010). This has generated interest from researchers to assess if companies do in fact apply this method to make efficient capital investment decisions on behalf of the firm. Confirmation of high rate of adoption has as such been confirmed in a range of countries, such as Canada (Bennouna *et al.*, 2010; Jog and Srivastava, 1995; Payne *et al.*, 1999), the UK (Arnold and Hatzopoulos, 2000), and the US (Farragher *et al.*, 1999; Graham and Harvey, 2001; Ryan and Ryan, 2002). The findings of this study confirm that the majority of firms, to some extent, do adopt DCF techniques in their capital budgeting practices. Past studies on capital budgeting techniques have shown that the adoption of - and increase in - the use of DCF has come at the expense of more simple techniques (Bennouna *et al.*, 2010). This, however, is not confirmed in this study, where I find the payback period to still be the dominant choice of appraisal technique in Danish firms. Further, the use of more sophisticated methods is still very limited in Danish firms. While around one-third of the respondents answer that they apply path-dependent methods to some degree, the usage score for these firms reveals that the practice is only seldom used. While the use is limited, the study confirms that more

sophisticated methods have a higher adoption rate in a context of high environmental uncertainty, as predicted by theory and confirmed in prior studies on capital budgeting (Bowman and Hurry, 1993; McGrath *et al.*, 2004; Verbeeten, 2006). As such, the adoption of both DCF and more sophisticated path-dependent methods appear to augment rather than replace the more simple techniques such as PB and ARR.

The study presented in this chapter has a range of limitations. The generalizability is limited as the sample includes only Danish firms, and the literature is generally cautious about generalizing to other populations and cultures (Bennouna *et al.*, 2010). The study is also conducted on larger firms with more than 100 employees, as these were deemed more likely to employ capital budgeting procedures, and the results, therefore, do not necessarily compare to smaller Danish companies.

4.5. References

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Chapter 5. Literature review

5.1. Introduction

In this chapter, I aim to develop an overview of empirical research related to capital investment reviews, in order to explore the status of research within this topic. I use here a broad term to define the topic because various research traditions have used their own field-specific terms to define the practice of reviewing capital investment projects. The purpose of this chapter is to map the field of research and synthesize the state of knowledge, ultimately to contribute with a status on the research and an agenda for future research on this topic. Since the topic has been conceptualized and studied by different groups of researchers with different methodological approaches, it is simply not feasible to perform a review that comprehends all relevant research (Snyder, 2019). For this reason, I chose a semi-systematic review approach of literature according to a rigorous and transparent methodology.

Research on investment reviews is an important topic as ineffective resource allocation may lead to loss of value (Arnold and Hatzopoulos, 2000). This provides a solid argument for implementing strong financial management in order to secure firms´ long-term success and survival (Bennouna *et al.*, 2010). Further, the distribution of a firms' capital to alternative investment projects is among the top strategic management priorities (Bowman and Hurry, 1993; McGrath *et al.*, 2004). Therefore, I chose a definition that is explicit, yet broad enough to encompass the importance of this topic, and defined c*apital investment reviews* as a set of behaviors, routines, and ways of working that are directed at learning from or managing the outcome, trajectory, or otherwise faith of a capital investment project after the capital budgeting selection phase and after initial capital commitment.

5.2. Review protocol

When identifying relevant articles for a review, the choice of keywords is critical for locating relevant works (Massaro *et al.,* 2016; Cronin *et al.,* 2008). I initiated the search strategy with an ad-hoc approach to identify research on the topic of interest with the purpose of 1) identifying field-specific search terms, and 2) research areas engaged in research on the specific topic, because according to Massaro *et al.* (2008), a review should be narrowed down to a group of journals. Through this strategy, I identified the search terms: *post completion audits, post completion reviews, post project reviews, post investment reviews, project reviews, investment reviews.* Further, I identified that research on these topics primarily occurred in business journals. Specifically, and based on the Association of Business Schools' (ABS) journal categorization methodology, the business research fields that I have identified to have published research on this topic pertains to *Accounting (ACCOUNT), General Management, Ethics, Gender and Social Responsibility (ETHICS-CSR-*

MAN), International Business and Area Studies (IB&AREA), Innovation (INNOV), Operations and Technology Management (OPS&TECH).

To identify research articles for this review, I used the ProQuest database to identify research published in journals, identified by ABS to be within the research fields outlined above. The ProQuest database is used as it allows a specific search for the chosen search terms in the abstract, title, and keywords for papers published in the journals chosen for the review. Further, ProQuest represents the most comprehensive database which for all practical purposes has been available for this review. As other reviews relying only on the ProQuest database (e.g., Durst and Edvardsson, 2012), this method has its limitations, as it may not have allowed complete coverage of all empirical articles in this field but should be reliable for providing a valuable understanding of the current situation in the field (Durst and Edvardsson, 2012). For completion, I also chose to include the field of *Finance* in the structured search process. My search included a total of 423 journals. To identify relevant articles in these journals I applied the search terms identified in the above. Specifically, I identified all articles, which in their abstract, title, or keywords (as recommended by Massaro *et al.* (2016)) included any combination of following pairs of words with up to a one-word distance between them, and with flexible word endings: post / review, investment / review, investment / audit, post / review, post / audit, project / reveiw. This yielded a result of 283 articles across the six fields of research. To further delimitate the search, I read through all article abstracts, to ensure that the topic of the papers was aligned with the above-stated definition. This selection reduced the sample to 22 papers across five research areas. Further, through my initial ad-hoc search, I identified relevant papers outside the scope of business research. Specifically, one particular journal seems to have embraced this topic. Including relevant research from this journal, using the same method as described above, yielded an additional 3 papers, and thus increasing the total number of papers in this review to 25. The results are summarized in Table 5-1. The process is carefully documented in Appendix B, which provides a table of all journals included in the search as well as the number of hits and number of useful articles.

Table 5-1

Field	Total no of journals	Total articles found	Usable articles
ACCOUNT	88	84	7
ETHICS-CSR-MAN	76	39	4
IB&AREA	53	29	1
INNOV	33	28	8
OPS&TECH	63	77	2
FINANCE	109	26	0
OTHER	1	3	3
Total	**423**	**286**	**25**

5.3. Articles published on investment reviews

5.3.1. Citation classics

I start by reviewing 'citation classics'. Authors cite articles based on their quality, and these papers may provide an understanding of how the field has developed (Massaro *et al.*, 2016). I follow the guidelines of Massaro *et al.* (2016) and use Google Scholar to identify the number of citations and use a cut-off citation count of 100 to identify the citation classics in the sample. The citation classics are summarized in Table 5-2 and include five papers published in the fields of Accounting, Innovation, and Others. Table 5-3 provides a snapshot of the citation classics, where the findings are summarized. Further, the definitions, purpose, and benefits of investment reviews are stated to provide a base knowledge of the field, and the type of investment in question is also stated.

Table 5-2

Years	1995-1999	2000-2004	2005-2009	2010-2014	2015-2021
ACCOUNT					
(Arnold and Hatzopoulos, 2000)		423			
INNOV					
(Goffin and Koners, 2011)				375	
(Von Zedtwitz, 2002)		310			
(Goffin *et al.*, 2010)				116	
OTHER					
(Farragher *et al.*, 1999)	131				

Arnold and Hatzopoulos (2000) show evidence of a fairly high adoption of investment reviews, with only 12% of the surveyed firms never or rarely performing investment reviews. However, while Farragher *et al.* (1999) find similar adoption rates (88% performing investment reviews regularly), they also find a fairly poor implementation of the practice. An interesting point is what Farragher *et al.* (1999) use to argue for a poor implementation, which is the fact that 74% of the reviews were conducted by the project team and not a neutral third party. This is interesting because all three articles in the Innovation field of research conduct research in a context where it is indeed the

Table 5-3

Reference	Findings	Definition	Purpose	Benefits	Investment
(Arnold and Hatzopoulos, 2000)	Only 12% of the firms surveyed never or rarely undertake postauditing. The vast majority always or sometimes post-audit projects	None	na.	na.	Capital investments (general)
(Von Zedwitz, 2002)	Findings show that companies give away great potential for competence building by neglecting post-project reviews as a tool for systematic inter project learning	A formal review of the project examining the lessons that may be learned and used to the benefit of future projects	Systematically improve performance in subsequent projects. Post-project reviews should aim at capturing process knowledge for enhancement of future project work	Capturing learning for the benefit of future projects	R&D
(Goffin and Koners, 2011)	Eight lessons learned were identified. Three of the key lessons learnt from NPD—dealing with project budgets, problem solving, and changing product specifications—appear to be closely linked to tacit knowledge. Lessons for tacit knowledge are typically communicated through metaphors.	Formal meetings of the project team to discuss what can be learnt for the future	Stimulate NPD learning for future projects	Capturing tacit knowledge and lessons learnt may be challenging, but it offers R&D managers a key opportunity to make new product development teams more effective.	NPD
(Goffin et al., 2010)	Knowing what experienced NPD personnel perceive as the most important lessons they have learned and which of these lessons are most closely associated with tacit knowledge gives managers new possibilities for disseminating learning throughout the organization	A formal review of the project examining the lessons that may be learned and used to the benefit t of future projects	Stimulate NPD learning for future projects	Improve performance of NPD teams	NPD
(Farragher et al., 1999)	Findings show a high adoption of post-completion audits but poor implementation	A report by individuals not associated with the investment, reporting whether variances between forecasted and actual outcomes are due to forecasting or operating errors	Foster unbiased forecasting by making forecasters aware that their efforts will be reviewed	allow forecasters to learn from and improve upon their earlier efforts	Capital investments (general)

purpose that the project team itself conducts the review (Goffin *et al.*, 2010; Goffin and Koners, 2011; Von Zedtwitz, 2002). The reason for this discrepancy may be found in the difference in definition and purpose of the investment reviews. Farragher *et al.* (1999) defines the investment review as

"a report by individuals not associated with the investment, reporting whether variances between forecasted and actual outcomes are due to forecasting or operating errors."

While the definition from the innovation journals (Goffin *et al.*, 2010; Goffin and Koners, 2011; Von Zedtwitz, 2002) may be summarized as

"a formal review of the project examining the lessons that may be learned and used to the benefits of future projects."

Logically, with such differing definitions, the purposes also differ. Farragher *et al.* (1999) notes that the purpose is

"to foster unbiased forecasting by making forecasters aware that their efforts will be reviewed."

In contrast, Goffin *et al.* (2010), Goffin and Koners (2011), and Von Zedtwitz (2002) notes purposes relating to

"capturing and stimulating knowledge with the purpose of enhancing future projects."

This quick glance at the most cited papers serves the dual purpose of 1) intents to provide the reader with a snapshot of the research agendas in this field as presented in Table 5-3 prior to diving into the full review, and 2) to quickly spot any major tensions in the literature which may inform about methodological choices for the full review. As to the latter point, Table 5-3 provides information on practices of investment reviews which differs considerably. For this reason, I map the definition and stated purpose of investment reviews for all articles in order to further consider the context when synthesizing the results.

In Table 5-4, I present the full frequency distribution of articles based on the journals where these are published. The review includes 25 articles published across 20 different journals, and the research is thus relatively dispersed across different journals. Of the six research areas included, the dominant areas, based on the number of papers published are Innovation (32%) and Accounting (28%), followed by General Management, Ethics, Gender and Social Responsibility (16%), Others (12%), Operations and Technology Management (8%), and International Business and Area Studies (4%). The largest number of papers published in a single journal is tied between Research Technology Management and The Engineering Economist (3), followed by International Journal of Managing Projects in Business (2). The remaining journals all feature one paper. With the exception of a small peak in the 2005-2009 period and a drop in the 1995-1999 period, papers are relatively evenly distributed over the period studied in this review.

In the remaining part of this review I follow a framework previously used by e.g., Shields (1997) and Hoque (2014), which classify the articles under review by topics, settings, theories, and research methods. Following, I summarize the state of research from the major topics identified. The last sections provide a discussion of the results, proposals for future research, and concludes the paper.

5.3.2. Topics

Table 5-5 presents the frequency distribution of the research topics of the articles. I identified five topics for the 25 articles – the most frequent being adoption (12), followed by knowledge transfer (7), outcomes (3), best practices (2), and persuasiveness (1). As such, there is a large representation of articles on the adoption of investment review procedures. Here, there is a large representation of survey-based articles on state-of-the-art use of investment review procedures in different periods and geographers (Arnold and Hatzopoulos, 2000; Morgan and Tang, 1993; Pierce and Tsay, 1992), but also includes deeper dives into the reasons for low adoption (Lefley, 2016), perceived importance (Batra and Verma, 2014; Lefley, 2019), and flawed practices (Farragher *et al.*, 1999; Lefley, 2013). Knowledge transfer studies consider how tacit knowledge is transferred through metaphors (Goffin and Koners, 2008; Von Zedtwitz, 2002), how perceived importance of lessons learned influences dissemination of tacit knowledge (Goffin *et al.*, 2010), and how perceived personal responsibility influences managers to withhold information (Cheng *et al.*, 2009). Articles on outcomes have researched the outcomes on learning (Chenhall and Morris, 1993), effects of personal incentives (Turner and Coote, 2018), and forecasting accuracy (Soares *et al.*, 2007). Articles on best practices study the practices of companies in order to conclude what works best. The study on persuasiveness considers what practices make an investment review report believable (Huikku and Lukka, 2016).

5.3.3. Settings

In Table 5-6, I provide the frequency distribution of the research settings of the articles. Here setting refers to the type of investment project which is being studied in the articles. The most frequent setting is general capital expenditure (13), which represents more than half the papers included in this review. Next are NPD (5) and R&D (3), which represent very similar types of studies. The remaining settings: ICT/non-ICT, IT, marketing campaign, and strategic investments all have only one paper included. The general capital expenditures studies are heavily represented by survey-based articles studying adoption and outcomes.

Table 5-4

Years	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	2020-	Total	Total (%)
ACCOUNT	2		1	2		2		7	28.0%
Accounting and Business Research						1		1	4.0%
Accounting and Finance				1				1	4.0%
Behavioral Research in Accounting	1							1	4.0%
European Accounting Review				1				1	4.0%
Journal of Business Finance & Accounting			1					1	4.0%
Journal of Management Accounting Research	1							1	4.0%
Meditari Accountancy Research						1		1	4.0%
ETHICS-CSR-MAN					2	1	1	4	16.0%
Global Business Review					1			1	4.0%
International Journal of Managing Projects in Business					1		1	2	8.0%
Management Decision						1		1	4.0%
IB&AREA	1							1	4.0%
Journal of International Business Studies	1							1	4.0%
INNOV			3	3	2			8	32.0%
Creativity and Innovation Management				1				1	4.0%
European Journal of Innovation Management			1					1	4.0%
International Journal of Technology				1				1	4.0%
Journal of Product Innovation Management					1			1	4.0%
R&D Management			1					1	4.0%
Research Technology Management			1	1	1			3	12.0%
OPS&TECH	1			1				2	8.0%
International Journal of Operations & Production Management				1				1	4.0%
International Journal of Production Economics	1							1	4.0%
OTHER		1		1		1		3	12.0%
The Engineering Economist		1		1		1		3	12.0%
Total	**4**	**1**	**4**	**7**	**4**	**4**	**1**	**25**	**100.0%**

Table 5-6

Years	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	2020-	Total	Total (%)
Adoption	3	1	3	1	2	2		12	48.0%
Best practices			1	1				2	8.0%
Knowledge transfer				4	2		1	7	28.0%
Outcomes	1			1		1		3	12.0%
Persuasiveness						1		1	4.0%
Grand Total	**4**	**1**	**4**	**7**	**4**	**4**	**1**	**25**	**100.0%**

Table 5-5

Years	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	2020-	Total	Total (%)
Capital expenditure (general)	4	1	2	2	1	3		13	52.0%
ICT/non-ICT					1			1	4.0%
IT							1	1	4.0%
Marketing campaign				1				1	4.0%
NPD				3	2			5	20.0%
R&D			2	1				3	12.0%
Strategic investments						1		1	4.0%
Total	**4**	**1**	**4**	**7**	**4**	**4**	**1**	**25**	**100.0%**

Table 5-7

Years	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	2020-	Total	Total (%)
Agency				1		1		2	8.0%
ANT						1		1	4.0%
None/None stated	3	1	4	3	2		1	14	56.0%
Organization	1			2		2		5	20.0%
Psychology				1	2			3	12.0%
Total	**4**	**1**	**4**	**7**	**4**	**4**	**1**	**25**	**100.0%**

Table 5-8

Years	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	2020-	Total	Total (%)
Archival				1				1	4.0%
Case study				5	2	1	1	9	36.0%
Experiment				1		1		2	8.0%
Mixed methods	1		1			1		3	12.0%
Survey	3	1	3		2	1		10	40.0%
Total	**4**	**1**	**4**	**7**	**4**	**4**	**1**	**25**	**100.0%**

5.3.4. Theories

Table 5-7 reports the frequency distribution of theories used. Of the 25 articles published, 56% (14) were silent about their theoretical orientation. The use of organizational theory is well represented in the sample (5), followed by a psychological theory lens (3), agency theory (2), and actor-network theory (1). Further analysis shows that the first two-thirds of the review period (1990-2009) include most papers without an explicit theoretical standpoint. Many of these articles intersect with the state-of-the-art type of articles, researching adoption.

5.3.5. Research methods

The data presented in Table 5-8 reveal that the survey method is the most used (10). This is closely followed by case study methods (9), mixed methods (3), experimental design (2), and archival studies (1).

5.4. Results

This section discusses the two major topics identified in this review. In Appendix A, I provide an exhaustive list of the articles present in this review with summary information, whereas the forthcoming discussion is illustrative of the research themes and current tensions.

5.4.1. Adoption

The articles reviewed here reveal quite some variety in the perceived importance and hence rate of adoption of investment reviews. In a study of Indian companies, Batra and Verma (2014) find that the investment review is perceived as the least important part of capital budgeting. However, the articles show proof of high adoption rates in other geographical areas. The UK represents the area, most researched with regard to adoption rates, but also here, the results differ between articles. Arnold and Hatzopoulos (2000) showed data of very high adoption rates, where 88% of the studied companies undertook investment reviews, at least to some extent. Lefley (2013), found this figure to be only 66.2%. Even lower adoption rates were found by Von Zedtwitz (2002), who in a comparison of adoption rates between US and UK firms found UK adoption rates at 43%, which were significantly different from US firm's adoption rate of 68%. These studies were all based on firms from multiple industries with general capital expenditures as the study setting. However, there is roughly a decade between these studies, so here the comparison serves mainly to inform on the findings, but also to highlight that while the adoption rates differ, these studies clearly show proof that investment reviews are prioritized and used in practice.

The articles reveal additional insight than the mere binary fact that organizations do or do not adopt investment reviews. In a study of investment review practices in R&D

projects, Von Zedtwitz (2002) revealed that practices of investment reviews vary with regard to the formality of the process. Von Zedtwitz (2002) found that investment reviews were mostly conducted on an ad hoc basis or on particularly large projects. In fact, 55.6% of their respondent companies had no formally established guides on how to perform investment reviews. In fact, the most common mean of knowledge dissemination was found to be through individuals moving to new projects. As also mentioned in the citation classics section above, Farragher *et al.* (1999), found a fairly poor implementation of the investment reviews using the point that 74% of the reviews were conducted by the project team and not a neutral third party. Similarly, Morgan and Tang (1993) finds that investment reviews are most often performed by people involved in the planning, evaluation or implementation of the project under review, and not by independent staff.

The research on adoption has also studied reasons for not adopting investment review practices. Lefley (2019) assesses the perceived importance of a range of factors related to investment reviews and finds significant differences in the perceived level of importance when comparing the results of organizations that undertake investment reviews with those that do not. Huikku (2007) uses the following definition of investment reviews: "*a formal review of a completed investment project fulfilling the following criteria: (1) it takes place after an investment has been completed (commissioned) and has begun to generate cash flows (or savings); (2) reporting is at least partly focused on a comparison between the pre-investment estimates of an investment project and the actual figures/achievements after completion; and (3) PCA is systematic and regular, and there are instructions for it.*". Huikku (2007) studies the uses of alternative investment review practices and finds that non-adopters of the formal structure above, do not necessarily jeopardize their capital investment projects. The findings show that while alternative practices are not exactly pure tradeoff substitutes, firms with alternative practices achieve equal or sufficiently close to the performance by implementing alternative investment review practices related to performance measurement and organizational learning.

5.4.2. Knowledge transfer

The articles in this review on knowledge transfer reveal interesting findings about the knowledge dissemination and transfer of lessons learned into future projects. Goffin *et al.* (2010) study explicit and tacit knowledge and the difficulties associated with transferring tacit knowledge, which is difficult to articulate, hard to record, and based on experience. A study of investment reviews by NPD (new product development) teams, revealed that participants used metaphors and stories to communicate lessons learned that were linked to tacit knowledge (Goffin *et al.*, 2010). As such, social interactions amongst the project team members seem to be an important part of stimulating the creation and exchange of tacit knowledge (Koners and Goffin, 2007). Goffin *et al.* (2010), finds that what is important for improving this process of transferring tacit knowledge, is knowing what managers perceive as the most important lessons learned, and knowing which of these are closely linked to tacit knowledge. They map a range of categories linked to tacit knowledge, which include budgets, costs, product specifications, etc.

5.5. Discussion and remarks on future research

What is evident from the summary of the two major topics is that investment reviews are indeed used in practice. However, the articles under review show that investment reviews differ quite a lot based on their purpose and hence in the way they are executed. The articles can, in large, be divided into two camps, as also portrayed in the brief summary of citation classics. These two camps are represented by those performing investment reviews for 1) control, and 2) learning. While both camps share the objective of benefitting future projects, their purpose seems to have influenced the execution and definition of investment reviews. Definitions and purposes are listed for all articles in this paper in Appendix A. When comparing results from the articles presented in this review, some tension seems to exist, which may represent interesting paths for future research.

One such tension refers to the use of external personnel to execute the investment review, which is noted in several papers. Morgan and Tang (1993) refer to poor implementation of investment reviews when reports are not executed by independent staff. Also, Huikku and Lukka (2016) note that the absence of independent review staff may be problematic as self-reported reviews are viewed as having low objectivity. What these articles also share is a very control-oriented approach to investment reviews, which focuses on comparing forecasted figures with actual figures. On the other hand, the practice observed in the articles on knowledge transfer seems to present a practice where a successful review is much dependent on the staff involved in the project. For example, Cheng *et al.* (2009) note that project managers themselves (self-report) may report lessons learned which can be used in future projects. Similarly, the summary provided above about articles on knowledge transfer shows that the personnel involved in the projects play a key role in the dissemination of knowledge and lessons learned because tacit knowledge is transferred through metaphors in social interactions (Goffin *et al.*, 2010; Koners and Goffin, 2007). What the practice in these articles share is an objective to generate knowledge and lessons learned which can be used in future projects. Huikku and Lukka (2016), refer to this particular tension, noting that when investment reviews are primarily used for accountability purposes rather than learning purposes, the involved managers are significantly less willing to share unfavorable project information. What is interesting about this comparison is not that practices differ, and each practice may be well fit for the individual purpose. What is intriguing is that among the categories that Goffin *et al.* (2010) identified to be associated with tacit knowledge were also budgets and costs. Among the control-focused practices, unbiased reporting of achieved figures seems to be the main focus to ensure that forecasters are aware that their efforts will be reviewed (Farragher *et al.*, 1999). While this may be sufficient to evaluate, positively or negatively, a manager's performance, none of the control-focused articles reports on the use of this information in future projects. This is interesting because also the majority of the control-focused articles states that reviews aim at improving decision-making in future projects (e.g., Lefley, 2016; Morgan and Tang, 1993; Pierce and Tsay, 1992). As such, potentially fruitful future research avenues could explore how firms reconcile the aims of executing control vs. transferring knowledge. Researchers could explore whether

both objectives are realistic to achieve on the same project, and if not, how firms choose which investment projects qualify for each type of review.

The articles under review have led to further observations that could potentially inspire future research. While some articles are explicit about the timing of an investment review (e.g., Goffin *et al.* (2010), Huikku and Lukka (2016), and Von Zedtwitz (2002)), most leave it as an implicit fact that investment reviews are conducted after the completion of a project. Future research could explore additional uses and practices of investment review processes and their role during and hence prior to project completion. Further, while some criteria for selecting projects for reviews, e.g., cost, strategic value, risk, and net present value has been identified in the literature (Lefley, 2016), this review has not provided much insight into the type of investment projects which are most likely to benefit from investment reviews in terms of e.g., performance outcomes. Further, while many of the articles in the review offer very strict definitions of a formal review procedure, the articles also reveal less formal practices, from which firms seem to benefit (Huikku, 2007). Future studies may further explore the different roles of formal and informal procedures in investment reviews.

More general observations from the overview provided in tables 5-5 through 5-8 show an underrepresentation of research with experimental designs or use of archival data, which may present inroads for new contributions. Researchers may also discover new insights about the benefits or use of investment reviews by narrowing the setting, which based on this review is very focused on either general capital expenditure projects or R&D/NPD. Further, as the review of results reveal that firms do indeed implement investment review practices, it is surprising to find such a small representation of articles that are concerned with investment review outcomes. Future researchers may choose to go down this road.

5.6. Conclusion

The aim of this review has been to explore the status of research on investment reviews. The review includes 25 articles published in 20 different academic journals over a 30-year period and provides an overview of research on investment reviews with regard to topics, settings, methods, and theories. The overview showed that the research areas most active on this topic are innovation and accounting, collectively contributing with 60% of the articles reviewed. Most research on investment reviews has been conducted in a generic setting of capital expenditure (52%), but R&D/NPD projects are also gaining substantial attention (32%). The researchers included in this review have exhibited the use of a variety of research methods, though survey and case studies are the dominant choices, collectively representing 76% of the articles. The use of experimental designs and archival data is very scarce. The most researched topics were identified as adoption and knowledge transfer respectively, collectively accounting for 76% of the research. The review also provides a summary of the findings from the major topics. There is a consensus across the major topics, general capital expenditure, and NPD/R&D that

research on investment reviews is scarce and there is a need for additional empirical research on how they are conducted, and what they achieve. This review presents a discussion of results and a current tension between research topics and offers suggestions for future research based on the summarized findings and the overview presented in tables 5-5 through 5-8.

The approach used in this review is not without limitations. The semi-systematic approach used in this review was initiated by an ad-hoc search to identify relevant search terms, and the list of search terms has been expanded as new terms have surfaced throughout the review process. Nevertheless, it is unclear if a different approach would have yielded different search terms, and thus identified other articles suitable for a review with this purpose. Further, I apply the ProQuest database to locate relevant articles based on the chosen inquiries, and while ProQuest represents the most comprehensive database which for all practical purposes has been available for this review, I cannot rule out that using a different database would have yielded different results. Due to such limitations, Appendix B includes a comprehensive list, intended to allow readers to follow the search process. Appendix B lists all journals included in the search process and lists both the total number of hits (articles) as well as the number of useful articles.

5.7. Appendix A: Articles in review

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Pierce and Tsay, 1992)	Adoption	Capital expenditure (general)	None/None stated	Survey	The degree of perceived importance is higher than the actual usage	The process of comparing actual results of the project with predicted results	Gaining experience for future proposals
(Arnold and Hatzopoulos, 2000)	Adoption	Capital expenditure (general)	None/None stated	Survey	Only 12% of the firms surveyed never or rarely undertake post auditing. The vast majority always or sometimes post-audit projects	na.	na.
(Chenhall and Morris, 1993)	Outcomes	Capital expenditure (general)	Organization	Survey	Environmental uncertainty moderates the association between PCAs and enhanced project learning, which in turn is associated with higher managerial performance	A feedback device that systematically monitors the progress of an investment project by comparing actual performance with budgets developed when a project is originally evaluated	Provide information to evaluate the efficiency of managers in implementing investment projects

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Turner and Coote, 2018)	Outcomes	Capital expenditure (general)	Agency	Experiment	When there is a presence of monitoring through a post-audit and a personal incentive, decision makers place a higher degree of emphasis on cash outflows.	na.	Serve as a mechanism of financial control, to provide information pertaining to future capital expenditure decisions, to eliminate psychological and/or political impediments associated with asset control and abandonment, and they can have a psychological impact on the proposers of capital investments
(Huikku and Lukka, 2016)	Persuasiveness	Strategic investments	ANT	Case study	Key elements in constructing persuasiveness includes a collective process to harden the process, existence of objective reference points, and sufficient following of the guidance	A formal review of a commissioned investment project, focusing on a comparison between the pre-investment estimates and the achievements after completion	Enhancement of organizational learning for future capital investments

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Huikku, 2007)	Adoption	Capital expenditure (general)	Organization	Case study / interviews	Management of smaller companies not having major strategic, complex and repetitive capital investments achieve sufficiently close to equal performance with alternative investment review processes	A formal process that checks the outcomes of individual investment projects after the initial investment is completed and the project is operational	Aid a company in systematically identifying successful processes that can be repeated in future capital investment projects, and to help avoid previous mistakes
(Batra and Verma, 2014)	Adoption	Capital expenditure (general)	None/None stated	Survey	Project review is viewed as the least important stage of capital budgeting though viewed as comparatively less difficult than other stages	na.	Helps in providing useful feedback to project appraisal or strategy formulation by analyzing the past 'rights' and 'wrongs'
(Lefley, 2013)	Adoption	ICT/non-ICT	None/None stated	Survey	Factors revealed in the post audit which should have been known at the pre-investment stage include flawed data, risk, supplier/capacity constraints, etc.	na.	na.

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Lefley, 2016)	Adoption	Capital expenditure (general)	Organization	Mixed methods (survey / semi-structured interviews)	The paper discovered nine important reasons for undertaking post-audits and ten for not	A formal procedure (based on written guidelines) aimed, in part, at comparing the benefits derived from a project compared with the pre-investment appraisal estimates and are conducted after the completion stage of the project.	A control process which aims to assess the efficiency and effectiveness of the investment decision, a process of learning, control, and management assessment
(Neale and Buckley, 1992)	Adoption	Capital expenditure (general)	None/None stated	Survey	PCA is seen as an aid to improving decision quality rather than as a device for enhancing the control of people or projects	Explain divergence between forecast and actual cash flows	na.
(Koners and Goffin, 2005)	Knowledge transfer	NPD	None/None stated	Case study	Confirmation of the learning potential of PPRs	A formal review which examines the lessons which may be learnt and used to the benefit of future projects	Make every project contribute to an organization's continuous improvement

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Von Zedtwitz, 2002)	Adoption	R&D	None/None stated	Mixed methods (Case study interviews / survey)	Many companies give away great potential for competence building by neglecting post-project reviews as a tool for systematic inter project learning.	A formal review of the project examining the lessons that may be learned and used to the benefit of future projects.	Systematically improve performance in subsequent projects.
(Goffin and Koners, 2008)	Knowledge transfer	NPD	Organization	Case study	Proposal of conceptual model of the factors that appear to influence knowledge generation and transfer. Social interaction, the use of metaphors and stories, and the method for discussion are all likely to directly lead to the generation and transfer of tacit knowledge	A formal review of the project which examines the lessons which may be learnt and used to the benefit of future projects	Stimulate knowledge which, if disseminated effectively, will help future NPD projects to be more successful

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Goffin and Koners, 2011)	Knowledge transfer	NPD	Psychology	Case study / interviews	Eight lessons learned were identified. Three of the key lessons learnt from NPD—dealing with project budgets, problem solving, and changing product specifications—appear to be closely linked to tacit knowledge. Lessons for tacit knowledge are typically communicated through metaphors.	Formal meetings of the project team to discuss what can be learnt for the future projects	Stimulate NPD learning for future projects
(Von Zedtwitz, 2003)	Best practices	R&D	None/None stated	Survey	Best practice is identified as a five step incremental model: 1) Initial, 2) Repeatable, 3) Defined, 4) Managed, and 5) Optimizing	A formal review of the project that examines the lessons learned	Benefit future projects

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Goffin et al., 2010)	Knowledge transfer	NPD	Psychology	Case study / interviews	Knowing what experienced NPD personnel perceive as the most important lessons they have learned and which of these lessons are most closely associated with tacit knowledge gives managers new possibilities for disseminating learning throughout the organization.	A formal review of the project examining the lessons that may be learned and used to the benefit of future projects	Stimulate NPD learning for future projects
(Azzone and Maccarrone, 2001)	Adoption	Capital expenditure (general)	None/None stated	Survey	The process should be aligned with the objective to be effective.	A control process aimed at making an overall revision of all those activities concerning the management of an investment proposal, from its definition to tis completion.	Decisional support, learning, and motivation
(Hlavacek et al., 2009)	Best practices	R&D	None/None stated	Case study	Proposal of four step model for conduction new product reviews	na.	Organizational learning and improving new product success rates

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Morgan and Tang, 1993)	Adoption	Capital expenditure (general)	None/None stated	Mixed methods (Case study interviews / survey)	State of use in the UK	A control mechanism helping to ensure that investment decision is in accordance with original expectations	Impact future investment decision by encouraging more realistic project appraisals
(Cheng et al., 2009)	Knowledge transfer	Marketing campaign	Agency	Experiment	High perceived personal responsibility and the use of project reviews for performance evaluation result in a greater tendency for managers to withhold negative private information	A mechanism that provides both feedback and accountability to managers involved in the decision process.	Organizational learning and improving future decisions/project implementations within the organization.
(Farragher et al., 1999)	Adoption	Capital expenditure (general)	None/None stated	Survey	High adoption, poor implementation	Report by individuals not associated with the investment to report whether variances between forecasted and actual outcomes are due to forecasting or operating errors	Foster unbiased forecasting by making forecasters aware that their efforts will be reviewed

Article	Topic	Setting	Theory	Method	Results	Definition	Purpose
(Soares et al., 2007)	Outcomes	Capital expenditure (general)	None/None stated	Archival	Costs are forecasted with great accuracy whereas revenues are forecasted with great negative deviations	na.	na.
(Lefley, 2019)	Adoption	Capital expenditure (general)	Organization	Survey	Identifies statistically significant differences in perceived importance of PCA between adopters and non-adopters	A system of control which is both part of the capital budgeting system and also a regulator of it	Benefit future capital investment decisions by providing valuable feedback from current investments
(Koners and Goffin, 2007)	Knowledge transfer	NPD	Psychology	Case study	NPD personnel perceive investment reviews as useful, and tacit knowledge plays a key part in NPD learning	A formal review of the project which examines the lessons which may be learnt and used to the benefit of future projects	Capture the knowledge generated during the course of a NPD project
(Christiansen and Mouritsen, 2021)	Knowledge transfer	IT	None/None stated	Case study	No conclusive outcomes	Multiple	Help managers and employees to learn from the past and create new knowledge in order to make projects more predictable and generate knowledge for future use as in facilitating foresight

5.8. Appendix B: Research method

ISSN	Field	Journal	ABS Ranking	Total hits	Useful articles
0001-4826	ACCOUNT	Accounting Review	4*	4	0
0361-3682	ACCOUNT	Accounting, Organizations and Society	4*	3	0
0165-4101	ACCOUNT	Journal of Accounting and Economics	4*	2	0
0021-8456	ACCOUNT	Journal of Accounting Research	4*	3	0
0823-9150	ACCOUNT	Contemporary Accounting Research	4	2	0
1380-6653	ACCOUNT	Review of Accounting Studies	4	1	0
0001-3072	ACCOUNT	Abacus	3	2	0
0001-4788	ACCOUNT	Accounting and Business Research	3	2	1
0155-9982	ACCOUNT	Accounting Forum	3	0	0
0888-7993	ACCOUNT	Accounting Horizons	3	5	0
0951-3574	ACCOUNT	Accounting, Auditing and Accountability Journal	3	0	0
0278-0380	ACCOUNT	Auditing: A Journal of Practice and Theory	3	9	0
1050-4753	ACCOUNT	Behavioral Research in Accounting	3	2	0
0890-8389	ACCOUNT	British Accounting Review	3	1	0

0007-1870	ACCOUNT	British Tax Review	3	0	0
1045-2354	ACCOUNT	Critical Perspectives on Accounting	3	2	0
0963-8180	ACCOUNT	European Accounting Review	3	1	1
0267-4424	ACCOUNT	Financial Accountability and Management	3	0	0
1554-0642	ACCOUNT	Foundations and Trends in Accounting	3	0	0
1094-4060	ACCOUNT	International Journal of Accounting	3	1	0
0278-4254	ACCOUNT	Journal of Accounting and Public Policy	3	2	0
0737-4607	ACCOUNT	Journal of Accounting Literature	3	1	0
0148-558X	ACCOUNT	Journal of Accounting, Auditing and Finance	3	1	0
0306-686X	ACCOUNT	Journal of Business Finance and Accounting	3	2	1
1061-9518	ACCOUNT	Journal of International Accounting, Auditing and Taxation	3	2	0
0198-9073	ACCOUNT	Journal of the American Taxation Association	3	0	0

1044-5005	ACCOUNT	Management Accounting Research	3	1	0
0810-5391	ACCOUNT	Accounting and Finance	2	3	1
1530-9320	ACCOUNT	Accounting and the Public Interest	2	0	0
1744-9480	ACCOUNT	Accounting in Europe	2	0	0
1030-9616	ACCOUNT	Accounting Research Journal	2	0	0
2152-2820	ACCOUNT	Accounting, Economics and Law - A Convivium	2	0	0
0882-9073	ACCOUNT	Advances in Accounting (incorporates "Advances in International Accounting" ISSN 0897-3660)	2	0	0
1475-1488	ACCOUNT	Advances in Accounting Behavioral Research	2	0	0
1474-7871	ACCOUNT	Advances in Management Accounting	2	0	0
1058-7497	ACCOUNT	Advances in Taxation	2	0	0
1608-1625	ACCOUNT	Asia-Pacific Journal of Accounting and Economics	2	1	0
1321-7348	ACCOUNT	Asian Review of Accounting	2	0	0
1035-6908	ACCOUNT	Australian Accounting Review	2	1	0

1755-3091	ACCOUNT	China Journal of Accounting Research	2	0	0
1936-1270	ACCOUNT	Current Issues in Auditing	2	0	0
1834-7649	ACCOUNT	International Journal of Accounting & Information Management	2	0	0
1740-8008	ACCOUNT	International Journal of Accounting Auditing and Performance Evaluation (IJAAPE)	2	1	0
1467-0895	ACCOUNT	International Journal of Accounting Information Systems	2	0	0
1090-6738	ACCOUNT	International Journal of Auditing	2	3	0
1741-3591	ACCOUNT	International Journal of Disclosure and Governance	2	0	0
1753-6723	ACCOUNT	International Journal of Managerial and Financial Accounting	2	0	0
1832-5912	ACCOUNT	Journal of Accounting and Organizational Change	2	0	0
2042-1168	ACCOUNT	Journal of Accounting in Emerging Economies	2	1	0

0967-5426	ACCOUNT	Journal of Applied Accounting Research	2	3	1
1815-5669	ACCOUNT	Journal of Contemporary Accounting and Economics	2	0	0
1542-6297	ACCOUNT	Journal of International Accounting Research	2	0	0
1467-646X	ACCOUNT	Journal of International Financial Management and Accounting	2	1	0
1049-2127	ACCOUNT	Journal of Management Accounting Research (AAA)	2	1	1
2191-4761	ACCOUNT	Journal of Management Control	2	0	0
1096-3367	ACCOUNT	Journal of Public Budgeting, Accounting and Financial Management	2	1	0
2059-190X	ACCOUNT	Journal of Tax Administration	2	1	0
0268-6902	ACCOUNT	Managerial Auditing Journal	2	11	0
1176-6093	ACCOUNT	Qualitative Research in Accounting and Management	2	0	0
1052-0457	ACCOUNT	Research in Accounting Regulation	2	0	0

2040-8021	ACCOUNT	Sustainability Accounting, Management and Policy Journal	2	0	0
2009-8766	ACCOUNT	Accounting, Finance & Governance Review (formerly the Irish Accounting Review)	1	0	0
1479-3598	ACCOUNT	Advances in Environmental Accounting and Management	1	0	0
1041-7060	ACCOUNT	Advances in Public Interest Accounting	1	0	0
2046-8083	ACCOUNT	African Journal of Accounting Auditing and Finance (AJAAF)	1	0	0
1543-866X	ACCOUNT	ATA Journal of Legal Tax Research	1	0	0
1834-2000	ACCOUNT	Australasian Accounting, Business and Finance Journal	1	0	0
2169-7213	ACCOUNT	China Journal of Accounting Studies	1	0	0
1262-2788	ACCOUNT	Comptabilité Contrôle Audit	1	1	0
1757-9856	ACCOUNT	International Journal of Critical Accounting	1	1	0

1583-4387	ACCOUNT	Journal of Accounting and Management Information Systems	1	0	0
2141-6664	ACCOUNT	Journal of Accounting and Taxation	1	0	0
2165-3755	ACCOUNT	Journal of Forensic and Investigative Accounting (previsously Journal of Forensic Accounting)	1	0	0
1942-9053	ACCOUNT	Journal of Forensic Studies in Accounting and Business	1	0	0
2155-3815	ACCOUNT	Journal of Governmental & Nonprofit Accounting	1	0	0
1759-0817	ACCOUNT	Journal of Islamic Accounting and Business Research	1	0	0
2209-0398	ACCOUNT	Management Accounting Frontiers	1	0	0
1528-5350	ACCOUNT	Management Accounting Quarterly	1	0	0
2049-372X	ACCOUNT	Meditari Accountancy Research	1	2	1
0114-0582	ACCOUNT	Pacific Accounting Review	1	0	0

0884-0741	ACCOUNT	Research in Governmental and Non-Profit Accounting	1	0	0
1574-0765	ACCOUNT	Research on Professional Responsibility and Ethics in Accounting	1	0	0
0969-160X	ACCOUNT	Social and Environmental Accountability Journal	1	0	0
1029-1954	ACCOUNT	South African Journal of Accounting Research	1	0	0
1988-4672	ACCOUNT	Spanish Accounting Review	1	0	0
0210-2412	ACCOUNT	Spanish Journal of Finance and Accounting	1	0	0
0736-6981	ACCOUNT	The EDP Audit, Control, and Security Newsletter	1	3	0
1878-4917	ACCOUNT	World Tax Journal	1	0	0
0001-4273	ETHICS-CSR-MAN	Academy of Management Journal	4*	1	0
0363-7425	ETHICS-CSR-MAN	Academy of Management Review	4*	0	0
0001-8392	ETHICS-CSR-MAN	Administrative Science Quarterly	4*	0	0
0149-2063	ETHICS-CSR-MAN	Journal of Management	4*	0	0
1941-6520	ETHICS-CSR-MAN	Academy of Management Annals	4	0	0

1045-3172	ETHICS-CSR-MAN	British Journal of Management	4	1	0
1052-150X	ETHICS-CSR-MAN	Business Ethics Quarterly	4	0	0
0022-2380	ETHICS-CSR-MAN	Journal of Management Studies	4	1	0
1558-9080	ETHICS-CSR-MAN	Academy of Management Perspectives	3	0	0
0007-6503	ETHICS-CSR-MAN	Business and Society	3	0	0
0008-1256	ETHICS-CSR-MAN	California Management Review	3	0	0
1740-4754	ETHICS-CSR-MAN	European Management Review	3	0	0
0891-2432	ETHICS-CSR-MAN	Gender and Society	3	1	0
0968-6673	ETHICS-CSR-MAN	Gender, Work and Organization	3	0	0
0017-8012	ETHICS-CSR-MAN	Harvard Business Review	3	6	0
1460-8545	ETHICS-CSR-MAN	International Journal of Management Reviews	3	0	0
0167-4544	ETHICS-CSR-MAN	Journal of Business Ethics	3	1	0
0148-2963	ETHICS-CSR-MAN	Journal of Business Research	3	1	0
1056-4926	ETHICS-CSR-MAN	Journal of Management Inquiry	3	0	0
1532-9194	ETHICS-CSR-MAN	MIT Sloan Management Review	3	0	0
2332-2373	ETHICS-CSR-MAN	Africa Journal of Management	2	0	0

0312-8962	ETHICS-CSR-MAN	Australian Journal of Management	2	0	0
1469-3569	ETHICS-CSR-MAN	Business and Politics	2	0	0
0962-8770	ETHICS-CSR-MAN	Business Ethics: A European Review	2	0	0
0007-6813	ETHICS-CSR-MAN	Business Horizons	2	2	0
0825-0383	ETHICS-CSR-MAN	Canadian Journal of Administrative Sciences	2	1	0
1024-5294	ETHICS-CSR-MAN	Competition and Change	2	0	0
0955-534X	ETHICS-CSR-MAN	European Business Review	2	0	0
1350-5068	ETHICS-CSR-MAN	European Journal of Women's Studies	2	0	0
0263-2373	ETHICS-CSR-MAN	European Management Journal	2	1	0
1354-5701	ETHICS-CSR-MAN	Feminist Economics	2	0	0
0141-7789	ETHICS-CSR-MAN	Feminist Review	2	0	0
2321-029X	ETHICS-CSR-MAN	IIM Kozhikode Society & Management Review	2	0	0
1741-802X	ETHICS-CSR-MAN	International Journal of Business Governance and Ethics	2	0	0
1756-6266	ETHICS-CSR-MAN	International Journal of Gender and Entrepreneurship	2	0	0

0020-8825	ETHICS-CSR-MAN	International Studies of Management and Organization	2	0	0
0306-3070	ETHICS-CSR-MAN	Journal of General Management	2	0	0
1469-1930	ETHICS-CSR-MAN	Journal of Intellectual Capital	2	0	0
1833-3672	ETHICS-CSR-MAN	Journal of Management & Organization	2	0	0
1476-6930	ETHICS-CSR-MAN	Journal of Revenue and Pricing Management	2	0	0
0025-1747	ETHICS-CSR-MAN	Management Decision	2	5	1
1861-9908	ETHICS-CSR-MAN	Management Revue: Socio-economic Studies	2	0	0
1863-6683	ETHICS-CSR-MAN	Review of Managerial Science	2	0	0
0956-5221	ETHICS-CSR-MAN	Scandinavian Journal of Management	2	0	0
1439-2917	ETHICS-CSR-MAN	Schmalenbach Business Review	2	0	0
0360-0025	ETHICS-CSR-MAN	Sex Roles	2	0	0
0097-9740	ETHICS-CSR-MAN	Signs	2	2	0
0277-2027	ETHICS-CSR-MAN	Business and Professional Ethics	1	0	0
2331-1975	ETHICS-CSR-MAN	Cogent Business & Management	1	2	0
1580-0466	ETHICS-CSR-MAN	Economic and business review	1	0	0

0261-0159	ETHICS-CSR-MAN	Equality, Diversity and Inclusion: an International Journal	1	0	0
1309-4297	ETHICS-CSR-MAN	Eurasian Business Review	1	0	0
0955-808X	ETHICS-CSR-MAN	European Business Journal	1	1	0
0964-9425	ETHICS-CSR-MAN	Gender in Management: An International Journal	1	0	0
0972-1509	ETHICS-CSR-MAN	Global Business Review	1	1	1
1447-9524	ETHICS-CSR-MAN	International Journal of Knowledge, Culture and Change Management	1	0	0
1462-4621	ETHICS-CSR-MAN	International Journal of Management and Decision Making	1	0	0
1741-8143	ETHICS-CSR-MAN	International Journal of Management Practice	1	0	0
2304-1366	ETHICS-CSR-MAN	International Journal of Management, Economics and Social Sciences	1	0	0
1753-8378	ETHICS-CSR-MAN	International Journal of Managing Projects in Business	1	10	2
2008-7055	ETHICS-CSR-MAN	Iranian Journal of Management Studies	1	1	0

1649-248X	ETHICS-CSR-MAN	Irish Journal of Management	1	0	0
1746-9678	ETHICS-CSR-MAN	Journal for Global Business Advancement (JGBA)	1	0	0
1470-5001	ETHICS-CSR-MAN	Journal of Corporate Citizenship	1	0	0
2075-6291	ETHICS-CSR-MAN	Journal of Islamic Business & Management	1	0	0
1385-3457	ETHICS-CSR-MAN	Journal of Management and Governance	1	0	0
1476-6086	ETHICS-CSR-MAN	Journal of Management, Spirituality & Religion	1	0	0
2040-8269	ETHICS-CSR-MAN	Management Research Review	1	1	0
1368-3047	ETHICS-CSR-MAN	Measuring Business Excellence	1	0	0
1541-6518	ETHICS-CSR-MAN	Organization Management Journal	1	0	0
1477-3996	ETHICS-CSR-MAN	Policy and Practice in Health and Safety	1	0	0
0961-7353	ETHICS-CSR-MAN	Safety and Reliability	1	0	0
0129-5977	ETHICS-CSR-MAN	Singapore Management Review	1	0	0
2044-4087	ETHICS-CSR-MAN	Social Business	1	0	0
1593-0319	ETHICS-CSR-MAN	Symphonya. Emerging Issues in Management	1	0	0

2198-2627	ETHICS-CSR-MAN	The Journal of Corporate Citizenship	1	0	0
0047-2506	IB&AREA	Journal of International Business Studies	4*	4	1
1090-9516	IB&AREA	Journal of World Business (formerly Columbia JWB)	4	0	0
0001-9909	IB&AREA	African Affairs	3	1	0
0217-4561	IB&AREA	Asia Pacific Journal of Management	3	1	0
0969-5931	IB&AREA	International Business Review	3	1	0
0021-9886	IB&AREA	Journal of Common Market Studies	3	2	0
1075-4253	IB&AREA	Journal of International Management	3	0	0
1740-8776	IB&AREA	Management and Organization Review	3	0	0
0938-8249	IB&AREA	Management International Review	3	2	0
1360-2381	IB&AREA	Asia Pacific Business Review	2	0	0
1472-4782	IB&AREA	Asian Business and Management	2	0	0
0305-7410	IB&AREA	China Quarterly	2	2	0
1742-2043	IB&AREA	Critical Perspectives on International Business	2	0	0
2059-5794	IB&AREA	Cross Cultural & Strategic Management	2	0	0

1566-0141	IB&AREA	Emerging Markets Review	2	0	0
1538-7216	IB&AREA	Eurasian Geography and Economics	2	0	0
0966-8136	IB&AREA	Europe-Asia Studies	2	4	0
1471-0374	IB&AREA	Global Networks	2	0	0
1611-1699	IB&AREA	Journal of Business Economics and Management	2	0	0
0022-216X	IB&AREA	Journal of Latin American Studies	2	0	0
0022-278X	IB&AREA	Journal of Modern African Studies	2	2	0
1011-6702	IB&AREA	Journal of World Trade	2	1	0
1525-383X	IB&AREA	Multinational Business Review	2	0	0
1740-1720	IB&AREA	Review of African Political Economy	2	0	0
0143-6597	IB&AREA	Third World Quarterly	2	2	0
1096-4762	IB&AREA	Thunderbird International Business Review	2	3	0
1014-9562	IB&AREA	Transnational Corporations	2	1	0
1012-8255	IB&AREA	Academia Revista Latinoamericana de Administración	1	0	0
1746-5265	IB&AREA	Baltic Journal of Management	1	0	0
2051-8757	IB&AREA	Business, Peace and Sustainable Development	1	0	0
1059-5422	IB&AREA	Competitiveness Review	1	0	0

1450-2194	IB&AREA	EuroMed Journal of Business	1	0	0
1751-6757	IB&AREA	European Journal of International Management	1	0	0
1097-4954	IB&AREA	Global Business and Economics Review	1	0	0
1753-6227	IB&AREA	International Journal of Business and Emerging Markets	1	0	0
1470-5958	IB&AREA	International Journal of Cross Cultural Management	1	0	0
1753-0896	IB&AREA	International Journal of Indian Culture and Business Management	1	0	0
1747-6763	IB&AREA	Journal for International Business and Entrepreneurship Development	1	0	0
1522-8916	IB&AREA	Journal of African Business	1	0	0
1558-7894	IB&AREA	Journal of Asia Business Studies	1	0	0
1059-9231	IB&AREA	Journal of Asia Pacific Business	1	0	0
1476-5284	IB&AREA	Journal of Chinese Economic and Business Studies	1	0	0
0949-6181	IB&AREA	Journal of East European Management Studies	1	0	0

1066-9868	IB&AREA	Journal of East-West Business	1	0	0
1547-5778	IB&AREA	Journal of Transnational Management	1	0	0
1097-8526	IB&AREA	Latin American Business Review	1	1	0
1536-5433	IB&AREA	Management Research, The Journal of the Iberoamerican Academy of Management	1	0	0
2059-6014	IB&AREA	Review of International Business and Strategy	1	1	0
2078-5976	IB&AREA	South African Journal of Business Management	1	0	0
0019-5308	IB&AREA	The Indian Journal of Labour Economics	1	0	0
1746-8809	IB&AREA	The International Journal of Emerging Markets	1	0	0
0885-3908	IB&AREA	The International Trade Journal	1	0	0
1918-6444	IB&AREA	Transnational Corporations Review	1	1	0
0048-7333	INNOV	Research Policy	4*	2	0
0737-6782	INNOV	Journal of Product Innovation Management	4	3	1
0033-6807	INNOV	R and D Management	3	1	1
0166-4972	INNOV	Technovation	3	4	0

0963-1690	INNOV	Creativity and Innovation Management	2	1	1
1366-2716	INNOV	Industry and Innovation	2	0	0
1447-9338	INNOV	Innovation: Organization & Management	2	0	0
1363-9196	INNOV	International Journal of Innovation Management	2	0	0
0923-4748	INNOV	Journal of Engineering and Technology Management	2	0	0
1047-8310	INNOV	Journal of High Technology Management Research	2	0	0
0892-9912	INNOV	Journal of Technology Transfer	2	0	0
0810-9028	INNOV	Prometheus	2	0	0
0895-6308	INNOV	Research Technology Management: international journal of research management	2	11	3
2243-4690	INNOV	Science & Technology Studies	2	0	0
0162-2439	INNOV	Science, Technology & Human Values	2	0	0
0138-9130	INNOV	Scientometrics	2	3	0
0306-3127	INNOV	Social Studies of Science	2	0	0

0954-349X	INNOV	Structural Change and Economic Dynamics	2	0	0
1976-1597	INNOV	Asian Journal of Technology Innovation	1	0	0
1460-1060	INNOV	European Journal of Innovation Management	1	1	1
1751-0260	INNOV	International Journal of Business Innovation and Research	1	1	0
1368-275X	INNOV	International Journal of Entrepreneurship and Innovation Management (IJEIM)	1	0	0
1740-2816	INNOV	International Journal of Foresight and Innovation Policy	1	0	0
0219-8770	INNOV	International Journal of Innovation and Technology Management	1	0	0
1741-8194	INNOV	International Journal of Technology and Globalization	1	0	0
1740-2832	INNOV	International Journal of Technology Intelligence and Planning	1	1	1

1474-2748	INNOV	International Journal of Technology Management and Sustainable Development	1	0	0
1468-4322	INNOV	International Journal of Technology Policy and Management	1	0	0
1741-5284	INNOV	International Journal of Technology Transfer and Commercialisation	1	0	0
2046-3383	INNOV	International Journal of the Digital Human	1	0	0
2213-7149	INNOV	International Technology Management Review	1	0	0
1751-1577	INNOV	Journal of Informetrics	1	0	0
2053-4620	INNOV	Journal of Science and Technology Policy Management	1	0	0
0272-6963	OPS&TECH	Journal of Operations Management	4*	0	0
0144-3577	OPS&TECH	International Journal of Operations and Production Management	4	3	1
1059-1478	OPS&TECH	Production and Operations Management	4	1	0

0166-3615	OPS&TECH	Computers in Industry	3	3	0
0018-9391	OPS&TECH	IEEE Transactions on Engineering Management	3	4	0
0925-5273	OPS&TECH	International Journal of Production Economics	3	3	1
0020-7543	OPS&TECH	International Journal of Production Research	3	3	0
1094-6136	OPS&TECH	Journal of Scheduling	3	0	0
1523-2409	OPS&TECH	Journal of Supply Chain Management	3	0	0
1523-4614	OPS&TECH	Manufacturing and Service Operations Management	3	0	0
0953-7287	OPS&TECH	Production Planning and Control	3	1	0
1359-8546	OPS&TECH	Supply Chain Management: An International Journal	3	0	0
1463-7154	OPS&TECH	Business Process Management Journal	2	2	0
0360-8352	OPS&TECH	Computers and Industrial Engineering	2	0	0
0951-192X	OPS&TECH	International Journal of Computer Integrated Manufacturing	2	0	0

0960-0035	OPS&TECH	International Journal of Physical Distribution and Logistics Management	2	0	0
0263-7863	OPS&TECH	International Journal of Project Management	2	14	0
0265-671X	OPS&TECH	International Journal of Quality and Reliability Management	2	2	0
0267-5730	OPS&TECH	International Journal of Technology Management	2	0	0
0735-3766	OPS&TECH	Journal of Business Logistics	2	0	0
0733-9364	OPS&TECH	Journal of Construction Engineering and Management	2	4	0
1478-4092	OPS&TECH	Journal of Purchasing and Supply Management	2	0	0
1478-3363	OPS&TECH	Total Quality Management and Business Excellence	2	0	0
1463-5771	OPS&TECH	Benchmarking: An International Journal	1	1	0
1063-293X	OPS&TECH	Concurrent Engineering: Research and Applications	1	1	0

0969-7012	OPS&TECH	European Journal of Purchasing and Supply Management	1	0	0
1936-6582	OPS&TECH	Flexible Services and Manufacturing Journal (formerly 0920-6299 "International Journal of Flexible Manufacturing Systems")	1	0	0
1571-9545	OPS&TECH	Foundations and Trends in Technology, Information and Operations Management	1	0	0
0737-0024	OPS&TECH	Human-Computer Interaction	1	0	0
1741-9174	OPS&TECH	International Journal of Agile Systems and Management	1	0	0
1368-4892	OPS&TECH	International Journal of Business Performance Management	1	0	0
1562-3599	OPS&TECH	International Journal of Construction Management	1	0	0
1847-9790	OPS&TECH	International Journal of Engineering Business Management	1	0	0

1748-1252	OPS&TECH	International Journal of Enterprise Network Management	1	0	0
1748-5037	OPS&TECH	International Journal of Industrial and Systems Engineering	1	0	0
2217-2661	OPS&TECH	International Journal of Industrial Engineering and Management	1	0	0
1935-5726	OPS&TECH	International Journal of Information Systems and Supply Chain Management	1	0	0
1751-6048	OPS&TECH	International Journal of Internet Manufacturing and Services	1	0	0
2040-4166	OPS&TECH	International Journal of Lean Six Sigma	1	1	0
0957-4093	OPS&TECH	International Journal of Logistics Management	1	0	0
1367-5567	OPS&TECH	International Journal of Logistics: Research and Applications	1	0	0

1741-0401	OPS&TECH	International Journal of Productivity and Performance Management	1	1	0
1756-6703	OPS&TECH	International Journal of Quality and Service Sciences	1	0	0
1744-2370	OPS&TECH	International Journal of Services and Operations Management	1	1	0
1741-539X	OPS&TECH	International Journal of Services Operations and Informatics	1	0	0
1756-6517	OPS&TECH	International Journal of Shipping and Transport Logistics	1	0	0
1741-5357	OPS&TECH	International Journal of Value Chain Management	1	0	0
2042-6747	OPS&TECH	Journal of Humanitarian Logistics and Supply Chain Management	1	0	0
0956-5515	OPS&TECH	Journal of Intelligent Manufacturing	1	0	0
0278-6125	OPS&TECH	Journal of Manufacturing Systems	1	0	0

1741-038X	OPS&TECH	Journal of Manufacturing Technology Management (formerly "Integrated Manufacturing Systems")	1	1	0
1535-0118	OPS&TECH	Journal of Public Procurement	1	2	0
1355-2511	OPS&TECH	Journal of Quality in Maintenance Engineering	1	0	0
2055-6225	OPS&TECH	Journal of Service Theory and Practice	1	1	0
1092-4604	OPS&TECH	Knowledge and Process Management	1	0	0
1936-9735	OPS&TECH	Operations Management Research: Advancing Practice through Theory	1	0	0
0954-4054	OPS&TECH	Proceedings of Institute of Mechanical Engineers Part B: Journal of Engineering Manufacture	1	1	0
8756-9728	OPS&TECH	Project Management Journal	1	13	0
0748-8017	OPS&TECH	Quality and Reliability Engineering International	1	0	0
0033-524X	OPS&TECH	Quality Progress	1	14	0

2164-3970	OPS&TECH	Service Science	1	0	0
1625-8312	OPS&TECH	Supply Chain Forum: an International Journal	1	0	0
1754-2731	OPS&TECH	The TQM Journal	1	0	0
0022-1082	FINANCE	Journal of Finance	4*	1	0
0304-405X	FINANCE	Journal of Financial Economics	4*	0	0
0893-9454	FINANCE	Review of Financial Studies	4*	0	0
0929-1199	FINANCE	Journal of Corporate Finance	4	2	0
0022-1090	FINANCE	Journal of Financial and Quantitative Analysis	4	0	0
1042-9573	FINANCE	Journal of Financial Intermediation	4	0	0
0022-2879	FINANCE	Journal of Money, Credit and Banking	4	0	0
1572-3097	FINANCE	Review of Finance (formerly European Finance Review)	4	1	0
1941-1367	FINANCE	Annual Review of Financial Economics	3	0	0
0964-8410	FINANCE	Corporate Governance: An International Review	3	0	0
1354-7798	FINANCE	European Financial Management	3	0	0

1351-847X	FINANCE	European Journal of Finance	3	0	0
0949-2984	FINANCE	Finance and Stochastics	3	0	0
0015-198X	FINANCE	Financial Analysts Journal	3	2	0
0046-3892	FINANCE	Financial Management (USA)	3	0	0
0963-8008	FINANCE	Financial Markets, Institutions and Instruments	3	0	0
0732-8516	FINANCE	Financial Review	3	0	0
0167-6687	FINANCE	Insurance: Mathematics and Economics	3	1	0
1076-9307	FINANCE	International Journal of Finance and Economics	3	0	0
1057-5219	FINANCE	International Review of Financial Analysis	3	0	0
0378-4266	FINANCE	Journal of Banking and Finance	3	1	0
0927-5398	FINANCE	Journal of Empirical Finance	3	0	0
1479-8409	FINANCE	Journal of Financial Econometrics	3	0	0
1386-4181	FINANCE	Journal of Financial Markets	3	0	0
0270-2592	FINANCE	Journal of Financial Research	3	0	0
0920-8550	FINANCE	Journal of Financial Services Research	3	0	0

1572-3089	FINANCE	Journal of Financial Stability	3	0	0
0270-7314	FINANCE	Journal of Futures Markets	3	0	0
1042-4431	FINANCE	Journal of International Financial Markets, Institutions and Money	3	0	0
0261-5606	FINANCE	Journal of International Money and Finance	3	0	0
0895-5638	FINANCE	Journal of Real Estate Finance and Economics	3	0	0
0022-4367	FINANCE	Journal of Risk and Insurance	3	0	0
0960-1627	FINANCE	Mathematical Finance	3	0	0
1469-7688	FINANCE	Quantitative Finance	3	0	0
2045-9939	FINANCE	Review of Asset Pricing Studies	3	0	0
2046-9136	FINANCE	Review of Corporate Finance Studies	3	0	0
0924-865X	FINANCE	Review of Quantitative Finance and Accounting	3	0	0
1614-2446	FINANCE	Annals of Finance	2	1	0
0960-3107	FINANCE	Applied Financial Economics	2	0	0
1350-486X	FINANCE	Applied Mathematical Finance	2	0	0
1387-2834	FINANCE	Asia-Pacific Financial Markets	2	0	0

0515-0361	FINANCE	ASTIN Bulletin: Journal of International Actuarial Association	2	0	0
1472-0701	FINANCE	Corporate Governance: The International Journal of Business in Society	2	2	0
1540-496X	FINANCE	Emerging Markets Finance and Trade	2	0	0
1544-6123	FINANCE	Finance Research Letters	2	0	0
1567-2395	FINANCE	Foundations and Trends in Finance	2	0	0
1018-5895	FINANCE	Geneva Papers on Risk and Insurance: Issues and Practice	2	0	0
1554-964X	FINANCE	Geneva Risk and Insurance Review	2	0	0
1044-0283	FINANCE	Global Finance Journal	2	0	0
1755-3830	FINANCE	International Journal of Banking, Accounting and Finance	2	0	0
1815-4654	FINANCE	International Journal of Central Banking	2	0	0
1743-9132	FINANCE	International Journal of Managerial Finance	2	0	0

0219-0249	FINANCE	International Journal of Theoretical and Applied Finance	2	0	0
0927-5940	FINANCE	International Tax and Public Finance	2	1	0
1520-3255	FINANCE	Journal of Alternative Investments	2	1	0
1470-8272	FINANCE	Journal of Asset Management	2	1	0
1745-6452	FINANCE	Journal of Banking Regulation	2	0	0
1542-7560	FINANCE	Journal of Behavioral Finance	2	0	0
1074-1240	FINANCE	Journal of Derivatives	2	0	0
1753-9641	FINANCE	Journal of Derivatives and Hedge Funds	2	0	0
0972-6527	FINANCE	Journal of Emerging Market Finance	2	0	0
1059-8596	FINANCE	Journal of Fixed Income	2	0	0
1042-444X	FINANCE	Journal of Multinational Financial Management	2	0	0
1744-6740	FINANCE	Journal of Operational Risk	2	0	0
1474-7472	FINANCE	Journal of Pension Economics and Finance	2	0	0
0095-4918	FINANCE	Journal of Portfolio Management	2	1	0

1465-1211	FINANCE	Journal of Risk	2	0	0
1092-0277	FINANCE	North American Actuarial Journal	2	0	0
0927-538X	FINANCE	Pacific-Basin Finance Journal	2	0	0
0378-4371	FINANCE	Physica A: Statistical Mechanics and Its Applications	2	0	0
0275-5319	FINANCE	Research in International Business and Finance	2	1	0
1475-7702	FINANCE	Review of Accounting and Finance	2	1	0
1380-6645	FINANCE	Review of Derivatives Research	2	0	0
1879-9337	FINANCE	Review of Development Finance	2	1	0
1945-497X	FINANCE	SIAM Journal on Financial Mathematics	2	0	0
1605-9786	FINANCE	African Finance Journal	1	0	0
0002-1466	FINANCE	Agricultural Finance Review	1	0	0
0005-4623	FINANCE	Bancaria The Journal of the Italian Banking Association	1	0	0
1357-3217	FINANCE	British Actuarial Journal	1	1	0
2044-1398	FINANCE	China Finance Review International	1	0	0
2164-5760	FINANCE	Critical Finance Review	1	0	0

2164-9480	FINANCE	Economics and Finance Research	1	0	0
1057-0819	FINANCE	Financial Services Review	1	0	0
1099-1174	FINANCE	Intelligent Systems in Accounting, Finance and Management	1	0	0
1753-8394	FINANCE	International Journal of Islamic and Middle Eastern Finance and Management	1	1	0
1029-3523	FINANCE	Investment Analysts Journal	1	0	0
1757-6385	FINANCE	Journal Financial Economic Policy	1	0	0
1078-1196	FINANCE	Journal of Applied Corporate Finance	1	0	0
2214-6350	FINANCE	Journal of Behavioral and Experimental Finance	1	0	0
1460-1559	FINANCE	Journal of Computational Finance	1	0	0
1744-6619	FINANCE	Journal of Credit Risk	1	0	0
1756-3615	FINANCE	Journal of Energy Markets	1	0	0
1475-1283	FINANCE	Journal of Finance and Management in Public Services	1	0	0
2282-717X	FINANCE	Journal of Financial Management, Markets and Institutions	1	0	0

2049-5404	FINANCE	Journal of Financial Market Infrastructures	1	0	0
1358-1988	FINANCE	Journal of Financial Regulation and Compliance	1	1	0
2047-1246	FINANCE	Journal of Investment Strategies	1	0	0
2070-4658	FINANCE	Journal of Islamic Economics, Banking and Finance	1	0	0
1750-676X	FINANCE	Journal of Prediction Markets	1	0	0
1463-578X	FINANCE	Journal of Property Investment and Finance	1	1	0
1526-5943	FINANCE	Journal of Risk Finance	1	0	0
1753-9579	FINANCE	Journal of Risk Model Validation	1	0	0
2043-0795	FINANCE	Journal of Sustainable Finance & Investment	1	0	0
0307-4358	FINANCE	Managerial Finance	1	3	0
1096-1879	FINANCE	Multinational Finance Journal	1	0	0
1755-4179	FINANCE	Qualitative Research in Financial Markets	1	0	0
2010-1392	FINANCE	Quarterly Journal of Finance	1	0	0
1940-5979	FINANCE	Review of Behavioral Finance	1	0	0

0346-1238	FINANCE	Scandinavian Actuarial Journal	1	1	0

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Chapter 6. Capital budgeting post-decision control: Performance implications for innovation investments

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Abstract

This paper examines how capital budgeting post-decision controls may help or hinder translating investments in exploration and exploitation into performance. Effective allocation of a firm's scarce resources is of paramount importance for long-term survival, and likewise is the management of these resources. This study furthers our understanding of how management controls can contribute to managing innovation. We hypothesize on the relationship between post-decision control and innovation investments and on how their fit may translate into performance. The results show that the formal (informal) post-decision control positively moderates the effect of exploration (exploitation) on performance. We contribute to the debate of whether exploitative and explorative investments require different control mechanisms, with results that indicate that firms should indeed apply different control mechanisms to exert influence on the outcome of exploration and exploitation.

Key words: post-decision control; innovation management; management control; capital budgeting

6.1. Introduction

Our aim in this paper is to extend the research on how firms apply control mechanisms to exert influence on the outcome of exploratory and exploitative innovations (e.g., Bedford (2015), Bedford *et al.* (2019), Benner and Tushman (2003), Davila *et al.* (2009), Hill and Rothaermel (2003), Ylinen and Gullkvist (2014)). We are motivated by the debate of whether exploratory and exploitative investments require different control mechanisms (Jansen *et al.*, 2006; Ylinen and Gullkvist, 2014), and are especially motivated by the recent results of Holahan *et al.* (2014), which diverge from commonly held beliefs about the management of radical (exploration) and incremental (exploitation) innovation. We aim to extend the literature into the context of post-decision controls as known from the capital budgeting literature (Huikku, 2008, 2011; Lefley, 2016, 2019; Neale, 1991; Neale and Buckley, 1992), by introducing measures of formal and informal post-decision control.

Investments in exploration are characterized by clear departures from existing practices, which cause fundamental changes by developing new products and services (March, 1991; Ylinen and Gullkvist, 2014). Exploitation investments on the other hand relate to changes in existing products or processes, and do not introduce significant novelty, but rather builds on existing knowledge to extend existing products and services to customers (Benner and Tushman, 2003; March, 1991). Researchers have already documented many antecedents of exploration, exploitation, and ambidexterity, but there is still only limited research on how organizations employ controls in such contexts (Bedford, 2015; Ylinen and Gullkvist, 2014). A firm's investments in exploration and exploitation are of strategic importance, and to ensure long-term survival, firms should engage in both activities simultaneously (March, 1991). While extant literature has shown that firms do prioritize activities in exploration and exploitation, the process with which these activities are managed is less clear (Bedford, 2015). Capital budgeting is the process of choosing between alternative strategic investments, including exploration and exploitation. This is an important topic because ineffective resource allocation may lead to loss of value (Arnold and Hatzopoulos, 2000). This provides a solid argument for implementing strong financial management in order to secure firms´ long-term success and survival (Bennouna *et al.*, 2010). Further, the distribution of a firms' capital to investment projects is among the most top strategic management priorities (Bowman and Hurry, 1993; McGrath *et al.*, 2004). However, while efficient decision-making among alternative capital investment projects is certainly of importance, a firm's long-term survival and success are not ensured at the time of the capital allocation decision. Rather, there may be a long way from project initiation to project completion, and in that process, a firm has the opportunity to manage and gain valuable knowledge from its ongoing investment projects (Huikku, 2007; Huikku and Lukka, 2016). Controls prior to the capital allocation, such as project proposal and investment appraisal, are termed pre-decision controls, while controls after the capital allocation, such as implementation and post completion audits, are termed post-decision controls (Huikku *et al.*, 2018). Although the interest in conducting research on post-decision controls has increased in recent years, the research is still limited compared to research on the earlier stages of the capital budgeting process (Huikku and Lukka, 2016; Lefley, 2019). It is important that actors with responsibilities for the investment decisions not only consider the selection stage of an investment. It is central for decision makers to also consider how the organization can learn from and make appropriate adjustments to ongoing investment projects. In this paper, we are concerned with such control form. Specifically, we explore how post-decision controls may assist a firm in enhancing the performance potential of investments in exploration and exploitation. The interplay between exploration and exploitation investments and post-decision controls is interesting because management controls systems (MCS) can play a crucial role for innovation management (Chenhall and Moers, 2015; Gschwantner and Hiebl, 2016; Lövstål and Jontoft, 2017).

The extant literature on how control mechanisms influence outcomes of exploration and exploitation has produced mixed results and are relatively scattered with the use of various conceptualizations of control. In a study of input and output control, Cardinal

(2001) for example concluded that incremental (exploitation) and radical (exploitation) innovations should not be managed differently. Jansen *et al.* (2006) on the other hand, showed that centralization had a negative impact on exploratory innovation, whereas formalization positively influenced exploitation investments. Ylinen and Gullkvist (2014) studied organic and mechanistic controls, which have a practical similarity to informal and formal controls as applied in this study. They examined how innovativeness mediates the effect of organic (informal) and mechanistic (formal) controls on project performance[2]. Their results show that the direct positive effect of organic controls on project performance is stronger for exploitative innovations than for exploratory. They also find a direct positive relation between mechanistic controls and project performance for firms scoring high on exploratory innovations. Holahan *et al.* (2014) find that firms in their sample tend to manage exploratory activities less flexibly than exploitative ones, and rather than being informally introduced, exploration activities are the result of formal planning. These latter results are in opposition to the results of Jansen *et al.* (2006), and to previously held beliefs about how radical (exploration) projects should be managed (Holahan *et al.*, 2014; Leifer *et al.*, 2000; Veryzer, 1998).

As such, the question of whether exploitative and exploratory innovations require different control mechanisms remains relatively unresolved. In line with the method of previous such studies (e.g. Bedford (2015), Ylinen and Gullkvist (2014)), we examine investments in exploration and exploitation separately, but in a context of how formal and informal post-decision control exerts influence on the outcomes of these investment types. We propose two hypotheses: 1) the effect of exploration on performance is positively moderated by the level of formal post-decision control, and 2) the effect of exploitation on performance is positively moderated by the level of informal post-decision control. A key question in this paper is therefore whether the more recent findings of e.g., Holahan *et al.* (2014), showing that flexibility is more important for exploitation than exploration, transfers into a context of post-decision control.

We apply a complementarity theory approach to examine the performance effects of applying post-decision control in combination with exploration and exploitation. We, therefore, assume that certain organizational choice variables – in this case, post-decision control and exploration/exploitation – are reinforcing each other such that doing more of one thing increases the value of doing more of the other (Ennen and Richter, 2010; K., 1995; Roberts, 2007). We make explicit tests on the performance effects, assuming that strategic choice variables – exploration and exploitation – depends on organizational choice variables – post-decision control. As such, we base our study on a cartesian approach, with a focus on how combinations of choice variable pairs affect performance

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[2] We use the control forms from Ylinen and Gullkvist (2014) as comparisons to formal and informal post-decision control as they use the following definitions: 'Mechanistic project controls rely on formal rules, standardized operating procedures and routines, whereas organic project controls are more flexible, responsive, involve fewer rules and standardized procedures and tend to be richer in data (Chenhall, 2003)'.

by means of a moderation form of fit (Drazin and Van de Ven, 1985; Gerdin and Greve, 2004).

The data used in this study was collected through an online questionnaire distributed to Danish companies with more than 100 employees. We expand on the data collection in the empirical section. To test the hypotheses, we relied on exploration and exploitation measures used in the extant literature (Atuahene-Gima, 2005; Bedford *et al.*, 2019), while we developed new measures for formal and informal post-decision control for the purpose of this study. We find empirical support for both our hypotheses and show that formal post-decision control positively moderates exploration's effect on performance. Further, that informal post-decision control positively moderates exploitation's effect on performance. As such, this study contributes to the debate of whether exploration and exploitation should be managed with different control mechanisms. Our results are in support of the view that they should indeed be managed differently, and support recent challenging findings from Holahan *et al.* (2014), by showing that in a context of post-decision control, formal (informal) control is more important for exploration (exploitation).

In the next section, we describe the theoretical background and develop our hypotheses. In section 6.3, we present the research method, sample selection, and variable measurement. Section 6.4 presents the results, and the final section provides a discussion of the results and concludes the paper.

6.2. Background

For the purpose of this study, we have chosen to develop new scale items for formal and informal post-decision control. We have chosen to do so because the extant literature shows a depth in post-decision control, which is not reflected in the survey items, used in the extant literature. Assuring accuracy of measurement of a construct of organizational behavior is challenging (Barrett, 1972). However, Hinkin (1998) notes that the key to successful item generation lies in the development of a well-articulated foundation which indicates the domain for the new measures. In doing so, we follow the method for defining constructs of Bisbe *et al.* (2007). Bisbe *et al.* (2007) showed that by reviewing the literature on interactive controls, they could observe the attributes of interactive control as observed in practice, and develop their scale based on these practices. Thus, we review the literature on PCA to build an understanding of what precisely is post-decision control. The studies in the upcoming two subsections provide ample reference to the attributes of post-decision control as observed in practice.

As mentioned in the introduction, PCA is the dominant theme in research on capital budgeting post-decision control, and therefore our main source of inspiration. In the following, we will refer only to post-decision control, though the referenced research may label itself as PCA. We do so, not because the terms are interchangeable, but because the PCA literature reveals various practices and definitions of PCA that relate to monitoring

and control practices much earlier than the completion stage of a capital investment project (Chenhall and Morris, 1993; Clarke *et al.*, 2015; Huikku, 2008a).

The main objective of post-decision control is organizational learning (Azzone and Maccarrone, 2001; Lefley, 2016). Its purpose is to clarify successful and failing aspects of an investment, as well as required actions regarding the project or the capital allocation going forward (Chenhall and Morris, 1993). As such, the benefits relate to both current and future capital investments (Neale and Buckley, 1992). It can also act as a mechanism that identifies whether the abandonment of a project is the appropriate choice and may reveal strategic opportunities (Neale, 1995). Consequently, the domain in which post-decision control may be observed is one in which a firm seeks to take control of the progress of a capital investment project after it has been initiated. The practices for doing so, as we shall discuss in the following, may be considered in two different camps. One of formal control and one of informal control.

6.2.1. Formal post-decision control

The literature shows examples of post-decision control processes where firms monitor the progress by evaluating ex-ante objectives to realized performance. Lefley (2016) and Morgan and Tang (1993) researched managerial processes of post-decision control as processes that seek to ensure that the performance of an investment is in accordance with the original expectations. In addition, Huikku (2008, 2007) research formal investment reviews that compare objectives with outcomes. More than simply comparing ex-ante objectives to actual performance, the formal post-decision controls are also characterized by being standardized and systematically executed. Chenhall and Morris (1993) used the definition '[…] a feedback device that systematically monitors the progress of an investment project by comparing actual performance with budgets developed when a project is originally evaluated [Horngren and Foster, 1991; Brealy and Meyers, 1984; Gordon and Pinches, 1984]'. Further, Neale's (1994) research reveals practices where quantifiable financial metrics, such as cost, is the basis of monitoring of objectives.

These observations led to the identification of the following properties reflecting formal post-decision control:

1) Systematic execution of monitoring and control of investment projects
2) A standardized process for monitoring and control of investment projects
3) A comparison of ex-ante objectives to realized performance
4) A comparison of quantifiable metrics

6.2.2. Informal post-decision control

In contrast to his own definition and to the processes laid out in the above, Lefley (2016) found that for a subpart of his sample organizations, the post-decision controls revealed

significant factors about the current investment project, which the firms did not know about at the appraisal stage. Such a process clearly not does fit control forms intended to compare ex-ante objectives with realized performance. Further, Clarke *et al.* (2015) deliberately set out to research ad-hoc designs of post-decision control, and their study reveals designs where managers figure out what has to be measured along the way. Lefley (2016) also provides indications of post-decision controls that are much more loosely defined and showed anecdotal evidence of firms that refrained from executing scheduled investment reviews, because they undertook continual reviews of projects along the way as they saw fit. In a similar vein, Chenhall and Morris (1993) found that managers who are not subject to formal post-decision controls still receive information about the progress of investment projects in their managerial function. Huikku (2008) found that among the non-adopters of PCA, a subgroup did indeed conduct informal investment monitoring[3]. Clarke *et al.* (2015) find evidence in support of a non-formal process that the majority of their sample reports to be using, and Williams (2008) shows results of organizations encouraging informal and ad-hoc approaches to project management. The information used in these types of post-decision controls also seems to differ. Lefley (2016) finds that qualitative assessment factors revealed significant factors about the current investment project the firms did not know about at the appraisal stage. While Huikku and Lukka (2016) find that firms include personnel who are not part of the executing team to conduct PCA in order to increase persuasiveness, they also report that managers themselves report on numbers. Clarke *et al.* (2015) support the latter view and finds that managers execute their post-decision controls themselves. As such, prior empirical studies provide clear indications that some firms execute post-decision controls where subjective judgment plays a major role.

These observations led to the identification of the following properties reflecting informal post-decision control:

1) An arbitrary and loosely defined process for monitoring and control of investment projects
2) An unstandardized process for monitoring and control of investment projects
3) An evaluation based on measures and objectives that were not based on ex-ante objectives
4) An evaluation of investment projects based on personal subjective judgment

6.2.3. Positioning of the scale

The above outline of managerial practices in capital budgeting post-decision controls shows two distinct types of controls. To the best of our knowledge, such distinctions have not been made before in the context of post-decision control. The revelation of formal and informal processes, however, is of no surprise and shares many similarities to the formal and informal processes found elsewhere in management accounting, such as

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[3] Here described as an arbitrary and unsystematic version of PCA.

the performance measurement literature (Ferreira and Otley, 2009). Chenhall (2003) argues that formal dimensions of control refer to whether the organization has established procedures with clear responsibilities to carry out a task. Further, Hartmann and Slapničar (2009) note that the wider organizational literature defines the formal controls as tight, deliberate, and bureaucratic, while the literature perceives informal controls as loose, spontaneous, and casual. We find these definitions to align well with the practices of post-decision control that we address above.

While the post-decision control scales that we propose have similarities to related areas of management accounting, we chose to take a different measurement approach. In studies such as Hartmann and Slapničar (2009), formality is measured on a scale from 1 to 5, where 1 = 'less formal' and 5 = 'more formal'. In this study, we chose to treat formality and informality as orthogonal. As such, we allow firms to be both very formal and very informal, potentially at the same time. Our reason for doing so is that exploration and exploitation are capital investment types of different natures, and there is no reason to believe that the type of control that is effective for exploitation, will also be effective for exploration (Roberts, 2006). Ambidextrous firms need to balance a wider array of measures to satisfy the managerial demand, rather than making a tradeoff between measures (Dekker *et al.*, 2013; Lillis and van Veen-Dirks, 2008). As an example, Bedford (2015) found that diagnostic controls were performance-enhancing for exploitation activities, while interactive controls were performance-enhancing for exploration activities. Firms are likely to engage in both exploration and exploitation activities (Cao *et al.*, 2009; He and Wong, 2004; Raisch and Birkinshaw, 2008), and potentially to a high extent in both. It is therefore conceivable that a high extent of control, specifically directed at each activity, is needed to realize the full performance potential. Consequently, if we measure formality on a spectrum from e.g., 1-5, a firm scoring the middle value of 3 could convert to a 1-1 as well as a 5-5 score on the orthogonal scale. Since we are interested in the extent to which a firm implements practices of both formal and informal post-decision control, we chose to measure the constructs as orthogonal.

6.3. Hypotheses

It is generally accepted that organizations can establish effective designs of MCS, which can be crucial for fostering innovation management (Chenhall and Moers, 2015; Gschwantner and Hiebl, 2016; Lövstål and Jontoft, 2017). However, since exploration and exploitation are such different investment activities, we seek to identify how the required performance feedback varies for the different investment types. Performance feedback is feedback about the performance levels to attain (Steelman *et al.*, 2004). For any performance evaluation, the feedback that users obtain should assist them in understanding how they can adapt behavior to enhance performance. The firms should therefore be able to apply different types of post-decision controls, as a firm's ability to compete over time depends on both efficiency improvements and simultaneous innovations (Adler *et al.*, 2009). The remainder of this section describes how we expect

post-decision controls will improve financial performance when applied to exploration and exploitation, respectively. In doing so, we draw on the above-developed dimensions of post-decision control.

6.3.1. Formality, Exploration and Financial Performance

Exploratory activities have less certainty (than exploitation activities), are more slowly implemented, and have a lack of clarity of feedback, which makes it increasingly difficult to make quick and precise ties from exploration to its consequences (March, 1991). This difficulty comes from changing environmental conditions, a well-established relationship in the literature (Raisch and Birkinshaw, 2008). Environmental changes are of paramount importance to obtaining returns from exploration (Jansen *et al.*, 2006). However, the uncertainty surrounding such changes does not resolve itself but requires active effort (Mcgrath, 2001). Solutions may include formal post-decision control, as authors have argued that formal control aids organizations in exploring the nature of a complex changing external environment (Lefley, 2016; Neale, 1991). While empirical evidence is somewhat mixed, some research has shown that firms investing in exploration do prefer formal performance metrics (Cardinal, 2001; Holahan *et al.*, 2014). Ylinen and Gullkvist (2014) reported a direct positive relation between mechanistic controls and project performance for firms scoring high on exploratory innovations. Simons (1987) reported that prospectors that embraced innovation employed forecast data, tight budgets, and carefully monitored outputs. Holahan *et al.* (2014) find that radical product development (PD) projects are more formally controlled and have more clearly assigned roles than incremental PD projects. Williams (2008) showed similar results. He surveyed project managers and found that users of formal project evaluations are more likely to respond that they identify the root causes of project outcomes. We, therefore, believe that a firm has a clear incentive to implement formal post-decision control as a response to exploration investments because formal analysis of e.g. investment appraisal and budgeting can be used to test the technical and commercial outcomes from different innovative ideas or ways of configuring ideas to suit customer needs (Davila *et al.*, 2009). Because explorations develop under changing conditions, the number of trajectories in which they can develop also increases, which increases the need for real time decision-making and information sharing (Holahan *et al.*, 2014). It is therefore increasingly important to establish controls that systematically obtain the necessary information (Zollo and Winter, 2002). Formal evaluations clearly specify the dimensions of performance that are being evaluated (Moers, 2005) and provide a systematic effort, which can be used to ensure that the innovative effort does not drift away from planned activities (Chenhall *et al.*, 2011; Jørgensen and Messner, 2009), which ensures the necessary information. Further, formal control of performance outcomes aids the firm in creating information about future profitable trajectories by challenging existing ideas and prompting discussions by signaling the need to investigate an issue further (Hall, 2010). Processes under tight control help organizations to better understand and identify causal relationships between organizational activities (Bohn, 1995; Jaikumar and Bohn, 1992; Schroeder *et al.*, 2008). A detailed focus on target deviation can assist the firm in

adhering to project boundaries and thus establish a focus on scarce resources, which can reduce costly errors and consequently protect performance in exploratory activities (Chenhall and Morris, 1995). As such, when a project is off track, organizations can use formal controls, even in the absence of cause-effect knowledge, to steer attention back on track (Thomas and Ambrosini, 2015). We therefore predict:

H1: *The effect of exploration on performance is positively moderated by the extent of formal post-decision control.*

6.3.2. Informality, Exploitation and Financial Performance

As an organization increases its efficiency through the repetition of activities, its innovations become increasingly incremental and variation-reducing (Benner and Tushman, 2003). It searches to invest in incremental improvements in already established routines and proficiencies. This ensures that innovation stays in the same zone as prevailing capabilities. Innovations that are in the same zone of prevailing capabilities are what characterizes exploitation investments (March, 1991). Investments in exploitation are largely executed as part of the daily operations, where experienced organizational members search for investments in improvements in the context of the existing business agenda (Roberts, 2006). As such, exploitation is a rather irregular occurrence, which shifts the control demand from a systemic nature to one of autonomy (Zollo and Winter, 2002). Exploitation improves much faster than exploration (March, 1991), and is also more difficult to separate from other activities. Exploitation is much more likely to share commonalities with other processes in the firm, as it is incremental in nature (March, 1991). Prior research provides indications that informal control may be an appropriate means of control for exploitation. Neale (1995, 1994) found that problems with post-decision control implementation related to difficulties in measuring the effect of an investment when its activities cannot be separated from other activities, e.g., shared facilities causing a rise in common overhead. Further, Huikku (2008) found that separation of cash flows is a major difficulty in conducting post-decision control. The idea that the disentanglement issue is strongest for exploitation activities is supported by Zollo and Winter's (2002) notion that explicitness of objectives peaks in the exploration phase, but when replication and retention of knowledge become dominant in the exploitation phase, the knowledge becomes ever more rooted in human behavior. The results pertain to gains in effectiveness but a decline in abstraction because the firm applies its specific knowledge to a variety of situations. With a decline in abstraction, we find it intuitively appealing that exploitative activities will benefit from the autonomy of informal control, which in the absence of clearly defined objectives may increase the shared understanding of common objectives, which has the potential to increase efficiency and performance (Ylinen and Gullkvist, 2014). We find support for this view in Abernethy and Stoelwinder (1995), who note that when individuals perform complex tasks requiring experience and expertise, formal controls are poor means of control. Rather, creating an environment in which individuals' self-regulatory activities are not restricted by any specific outcome controls can have positive performance effects. The

positive effects of a non-outcome-based control are also highlighted by Cole (1998), who argues that improving the quality of existing operations can be well worth it even though the exact cost-benefit is unknown. As such, informal control enables individuals who have the experience and expertise to not only execute complex routines but to search for and implement desired solutions (Abernethy and Stoelwinder, 1995). As exploitations occur irregularly and intertwine more with other activities (Roberts, 2006; Zollo and Winter, 2002), we believe that they have more to gain from the richness of the information produced by informal control, as the autonomy to apply expertise and experience enables employees to account for features specific to the situation when monitoring performance (Whitley, 1999). Hence, we predict:

H2: *The effect of exploitation on financial performance is positively moderated by the extent of informal post-decision control.*

6.4. Methods

6.4.1. Sample selection and data collection[4]

To test the hypotheses, we collected data through a cross-sectional questionnaire, which we addressed to the CFO of the firm, with the assumption that the CFO would be among those of the top management team with most knowledge about the organization's investments. The target population consisted of 1,059 Danish firms, which we acquired through the Navne and Numre Erhverv database. To ramp up the probability of getting a sample from firms who have formal policies for investments, we chose only firms with a minimum of 100 employees. We applied guidelines for survey research described by Dillman et al. (2014). The questionnaire was originally sent to 1,056 and we sought to encourage participation by offering an opt-in option to receive a summary of the questionnaire's findings. As the study intends to capture aspects of organizational investment behavior, we chose to address the questionnaire to CFOs. We assumed that, generally, the CFO would have one of the highest levels of knowledge about investments in their organization. We sent the CFOs an e-mail including a link to the online questionnaire, and after three weeks, we sent a reminder by postal mail, accompanied by a signed letter. Another three an weeks and six weeks later, respectively, we sent out an additional two reminders, while seeking to increase interest in the study by calling target persons on the telephone. We concluded the data collection with a final sample of 98

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[4] As the data used in this article originates from the same survey as used Jensen and Kristensen (2021), there is a significant overlap between this section and the section on data collection in Jensen and Kristensen (2021), and as such the reporting of the sample selection and data collection (section 6.4.1.) is produced with reference to Jensen and Kristensen (2021)

firms, corresponding to a usable response rate of 9.3%[5]. That response rate is similar to other ROR studies using survey method (Brouthers and Dikova, 2010; Verdu et al., 2012). The appropriateness of the respondents was assessed with a question about their involvement in the investment decision-making-process on a scale from 1 to 7. The obtained score for the sample is a satisfactory 6.0. The average tenure for the respondents is 10.6 year for the firm and 7.2 for the current position. Common method bias may a problem in singly method studies like this one (Speklé and Widener, 2018). We made several preparations to protect against it, and introduced temporal separation, meaning a time lag between questions used as dependent and independent variables respectively. This ought to reduce saliency of contextually provided retrieval cues (Podsakoff et al., 2003). We also ensure to protect respondents' anonymity, which according to Podsakoff et al. (2003) should decrease the apprehension toward more socially desirable, lenient, acquiescent, and consistent answers. At last, bivariate correlations are especially prone to common method bias (Speklé and Widener, 2018), and although we are indeed interested in bivariate correlations, all regression models are specified as multivariate, which should have a mitigating effect as long as additional variables shows correlation less than or equal to 0.30 with the existing variables (Speklé and Widener, 2018). This may be confirmed by studying Table 7-2. A χ^2-test is used to assess sample representativeness. We compare our sample with that of full list of firms and find insignificant differences ($\chi^2 = 9.099$, degrees of freedom = 8, p > 0.10). The sample industry classifications are presented in Table 6-1. T-tests are used to assess mean firm size differences and mean differences in all variables. Comparing this sample ($\bar{X} = 406.90$) compared to the full sample ($\bar{X} = 376.44$) with the t-test shows no significant differences (t = 0.58, p > 0.10). The late response bias test, comparing scores of the variables between the 25% first and last responses showed no significant differences (not reported).

Table 6-1: Industry classification

DB07* industry classification	Frequency	%
Administrative services	6	6%
Construction and civil engineering	8	8%
Wholesale and retail	13	13%
Real estate	2	2%
Manufacturing	35	36%
Liberal, scientific and technical services	7	7%
Accommodation facilities and restaurants	5	5%
Transportation and freight handling	7	7%
Other	15	15%

[5] We removed respondents who significantly failed to answer parts of the survey (e.g. full range of items for a construct is missing). We otherwise retained missing survey items that do not appear to be missing inadvertently. Little's MCAR test revealed that the data was missing completely at random $\chi^2 = 1702.96$, degrees of freedom = 1686, p > 0.10. Since the missing data is MCAR, we appropriately apply expectation-maximization (EM) to impute the missing values (Hair Jr. et al., 2014).

Total sample	98	100%

Note:
[i] *DB07 - Danish standard industry classification

6.4.2. Variable measurement

The variables that we apply in this study are a mix of previously developed and empirically tested constructs, combined with the newly developed scales for formal and informal post-decision control. The constructs will be described in turn in this section. The survey items used in this paper all apply a seven-point Likert scale. For each point on the scale, we provided labels in order to minimize response bias as well as measurement error. According to Eutsler and Lang (2015) this method is better than five- or nine-point Likert scales. Further, Eutsler and Lang (2015) notes that labeling all choice options is a better approach than only labeling at the ends of the scale. For all survey constructs used in this study, that they are computed as the average of the item scores. To improve the general understanding of the questionnaire, we informed the respondents that the questionnaire was part of a larger research project on investment decisions. We offered a broad definition of an investment/investment project as follows: The term investment/investment project refers to the allocation of your organization's capital to assets that your organization controls and from which your organization expects to derive long-term (more than one year) value'[6]. We report all survey items in the appendix of this paper.

Post-decision control

A total of 12 survey items covers the two post-decision control dimensions. The survey items are based on the properties identified for formal and informal post-decision control that we identified in the previous section. We measure the degree of formal post-decision control [FORM] by regularity of execution (form1), standardization of processes (form2 and form3), how quantitative the evaluation approach is (form4 and form5), and the degree to which measures are predetermined (form6). Informal post-decision control [INFORM] is measured by arbitrariness of execution (inform1), flexibility and absence of standardization in processes (inform2 and inform3), use of non-predetermined objectives (inform4), use of personal judgment (inform5), and degree of qualitative assessment (inform6).

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[6] We broadened the definition by including the following statement, intended to provide a non-exhaustive list of examples of investments/investment projects. 'Depending on your specific organization, investments/investment projects can include fixed assets (buildings, machinery, production equipment, computer systems, M&A, etc.), intangible assets (research and development, product development, goodwill, etc.), as well as non-capitalized expenditures for activities related to e.g. research or marketing'

Exploration and exploitation

The constructs for exploitation [EXPLOIT] and exploration [EXPLORE] are based on ten survey items. We use the measures developed by Atuahene-Gima (2005). In a recent paper by Bedford *et al.* (2019), the constructs were empirically validated in a modified version, intended to reflect ex-ante objectives, as it were the case in He and Wong (2004). For the purpose of this study, as well as others where the same data was used (Jensen and Kristensen 2021), we refined the framing of the questions to the context of the organization's prioritization of investments in exploration and exploitation. The ten items are treated as reflective indicators of the two constructs.

Firm financial performance

A subject of debate in management research is the subjectivity versus objectivity of performance measures. Venkatraman and Ramanujam (1987) argue that in terms of validity and reliability, neither subjective nor objective measures can claim superiority and Chenhall (2003) has shown significant correlations between subjective and objective performance measures in a number of studies. We take a subjective measure of financial performance [PERF] as a three-item reflective measure, derived from Chapman and Kihn (2009). Objectively measured performance (e.g., profitability or return on investment), may only partially reflects what the researcher wishes to measure (Speklé and Widener, 2018). We chose to rely on a subjective measure of performance because in this case, we wish to assess performance with the firm's competition as a reference level. While objective measures may be available through financial accounting data, a broad or even a narrower industry comparison may not reflect the actual benchmark with which the firm is competing.

Control variables

Previous research on exploitation and exploration empirically found significant performance effects, which indicates the importance of including potential contingencies as control variables. McGrath (2001) notes that size can have critical consequences for measures of innovation. Sorensen and Stuart (2000), for example, showed stronger reliance on earlier work for innovation conducted in larger organizations. Additionally, larger firms are also more prone to have additional resources available for non-budgeted purposes (Lubatkin *et al.*, 2006). Size may also affect the choice of post-decision control, as extant research shows that as a firm grows larger and becomes more complex, it tends to adopt a more decentralized structure and rely on higher degrees of behavior formalization and formal patterns of communication (Bruns and Waterhouse, 1975; Merchant, 1984, 1981), such as budgetary systems with more formal information flows. On the other hand, smaller and more homogeneous firms tend to be centralized, and to a higher degree, rely on informal types of control. Clarke *et al.* (2015) simply note that smaller firms may not have the critical mass required to perform formal PCAs. Size is measured as the logarithm of the number of employees. We control for age [AGE] using the number of years since the founding of the firm. Age is an important control variable, because young firms tend to pursue radical innovations more than their older equivalents do (Jahanshahi and Zhang, 2015). Other researchers (e.g. Gibson and Birkinshaw (2004),

Levinthal and March (1993) and Siggelkow and Levinthal (2003)) have noted that environmental factors, such as unpredictability and competitiveness may affect the performance effects from exploration and exploitation. We take account of these factors by including measures for environmental dynamism and environmental hostility. Prior research provides empirical validation for both measures; see e.g. Bedford (2015) and Jansen *et al.* (2006). As also defined in Jensen and Kristensen (2021) *"Environmental hostility is a measure of competitiveness and the degree of pressure for market demand, resources, and growth opportunities (Dess and Beard, 1984; Miller and Friesen, 1983). Hostility increases the attractiveness of exploitation while limiting profitability from exploration due to increased risk (Levinthal and March, 1993; Zahra, 1996)".* We construct environmental hostility as an index of three dimensions by following Miller and Friesen (1983) and Tan and Litschert (1994). Dess and Beard (1984) notes that environmental dynamism is a measure of the predictability in the firm's environment. Jansen *et al.* (2006) argue that stability is associated with increasing returns to exploitation, while expectations for higher returns from exploration increase under dynamic conditions. As in Chenhall and Morris (1993) and Gordon and Narayanan (1984), we measure dynamism as an index of five dimensions. For either environmental construct, the dimensions do not necessarily relate to one another, and we therefore compute both as formative constructs. At last, we include industry dummy variables.

6.4.3. Exploratory factor analysis

The measures for post-decision control are based on a newly developed scale, whereas the other constructs are validated elsewhere and have clear hypotheses as to their relationship. As such, we assess these latent factors for the formal and informal post-decision control in an exploratory factor analysis (EFA), using principal component analysis with oblique rotation. As opposed to orthogonal methods of rotation, the oblique factor rotation is more flexible in the sense that factors need not be assumed uncorrelated (Hair Jr. *et al.*, 2014). For conceptual reasons, the oblique method is a more appropriate choice since it is better suited to obtain several theoretically meaningful factors, as completely uncorrelated factors are an unrealistic assumption in the real world. Due to a loading below 0.4, we removed inform6, followed by conducting a new EFA subsequent to the item removal. The final EFA produces 2 factors with eigenvalues greater than 1, and 62.0 percent cumulative variance explained. Table 6-2 presents the results from the EFA including cross-loadings. Sampling adequacy is within the generally accepted level, with a KMO measure of 0.760, and Bartlett's test of sphericity is significant at $p < 0.000$ (Hair Jr. *et al.*, 2014). The Cronbach α's are between 0.78 and 0.89, confirming acceptable reliability for all constructs (see Table 6-3).

Table 6-2: Exploratory factor analysis

	FORM	INFORM
form1	**0.88**	0.04
form2	**0.87**	0.00
form3	**0.79**	-0.04

form4	**0.82**				0.04
form5	**0.70**				0.03
form6	**0.75**				0.02
inform1	-0.11				**0.77**
inform2	0.14				**0.84**
inform3	0.01				**0.84**
inform4	0.15				**0.67**
inform5	-0.25				**0.58**
Eigenvalue	4.01				2.77
Cumulative variance explained	0.36				0.62
KMO	0.76				
Bartlett's test of sphericity	0.00				

Note:
[i] Principal components analysis with oblique rotation

6.4.4. Confirmatory Factor Analysis[7]

Table 6-3 reports the result of a confirmatory factor analysis (CFA) for the five reflective factors used in this study.

Table 6-3: Confirmatory factor analysis

Latent variable indicators	Standardized loadings	z-value (all sig. at $p < 0.01$)	Composite reliability	Cronbach's alpha	Square root of average variance extracted (AVE)
Exploration			0.832	0.892	0.773
explore1	0.788				
explore2	0.814	8.734			
explore3	0.804	8.506			
explore4	0.859	9.186			
explore5	0.544	5.308			
Exploitation			0.856	0.844	0.777
exploit2	0.825				
exploit3	0.663	6.907			
exploit4	0.693	7.301			
exploit5	0.886	9.698			
Formal			0.836	0.889	0.746
form1	0.939				
form2	0.749	8.807			

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[7] The data used in this article originates from the same survey as used Jensen and Kristensen (2021), and the methods used to evaluate the survey constructs are the same. Therefore, there is a significant overlap between this section and the section on confirmatory factor analysis in Jensen and Kristensen (2021), and as such the reporting of the confirmatory factor analysis (section 6.4.4.) is produced with reference to Jensen and Kristensen (2021).

form3	0.898	12.23			
form4	0.645	7.387			
form5	0.524	5.606			
form6	0.575	6.304			
Informal			0.771	0.797	0.688
inform1	0.646				
inform2	0.846	6.691			
inform3	0.894	6.731			
inform4	0.445	3.960			
inform5	0.357	3.222			
Performance			0.959	0.957	0.942
perf3	0.996				
perf2	0.941	23.655			
perf1	0.883	17.301			

Note:
[i] RMSEA: 0.077, SRMR: 0.078, IFI: 0.921, CFI: 0.919, TLI: 0.905, Chi-squared to degrees of freedom: 1.339 (338.707/253). Blank cells in z-value column indicate loadings fixed to 1.

To evaluate the fit of the model we use a selection of fit indices as suggested by Kline (2011). The fit is deemed acceptable when the χ^2 to degrees of freedom is below 3 (Kline, 2011). Additionally, the root mean square error of approximation (RMSEA) is adequate with a score below 0.8. Also the standardized root mean square residual (SRMR) is adequate score below 0.1 (Browne and Cudeck, 1993; Kline, 2011; Schermelleh-Engel *et al.*, 2003). We use the incremental fit index (IFI) (Bollen, 1989), the Tucker Lewis Index (TLI) (Tucker and Lewis, 1973), and comparative fit index (CFI) (Bentler, 1990). Those three indices are all evaluated by how close they are to one and because all are above 0.9, they are deemed satisfactory (Bentler, 1992; Kline, 2011). Composite reliability is acceptable, as the model reports CR above 0.7 (Hair Jr. *et al.*, 2014) for all constructs. At last, the CFA is in support of satisfactory discriminant validity, as the square root of the average variance extracted (AVE) is larger than any correlation between reflective factors (Chin, 1998). Table 6-4 presents the correlation matrix.

Table 6-4: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Financial performance	-							
(2) Formal PCA	0.29*	-						
(3) Informal PCA	-0.01	-0.03	-					
(4) Dynamism	-0.05	0.14	0.13	-				
(5) Hostility	-0.02	0.32*	0.09	0.52*	-			
(6) Exploration	0.13	0.14	-0.04	0.55*	0.27	-		
(7) Exploitation	0.12	0.22*	0.01	0.34*	0.26*	0.63*	-	
(8) Size	0.16	0.18	0.14	0.04	0.07	0.17	0.09	-
(9) Age	-0.14	0.08	0.07	-0.01	-0.06	-0.12	-0.08	-0.03

Note:
[i] * correlation significant at $p < 0.05$.

6.4.5. OLS Regression

All hypotheses in this study take the form of a moderation form of fit, for which ordinary least squares (OLS) regression analysis is an appropriate method. Burkert *et al.* (2014) note that OLS provides two appropriate methods for testing the moderation form of fit, namely the moderated regression analysis (MRA) and sub-group regression analysis. We apply the MRA method, which includes a product term between the choice variables of interest, which pertains to post-decision controls and capital investment emphasis (exploration/exploitation). We chose the MRA method over the sub-group analysis to avoid loss of information (Burkert *et al.*, 2014). The proceeding section presents the results of the analysis. We thus formally assess the hypotheses using the following equation:

$$PERF_i = \alpha + \beta_1 FORM_i + \beta_2 INFORM_i + \beta_3 EXPLORE_i + \beta_4 EXPLOIT_i + \beta_5 FORM_i \\ * EXPLORE_i + \beta_6 INFORM_i * EXPLOIT_i + \beta_7 FORM_i * EXPLOIT_i \\ + \beta_8 INFORM_i * EXPLORE_i + \beta_{9-12} CONTROLS_i + \epsilon_i$$

Table 6-5: Descriptive statistics

	Mean	Median	Std.dev	Theoretical range	Min	Max
Financial performance	4.90	5.00	1.6	1-7	1.0	7.0
Formal PCA	4.35	4.50	1.28	1-7	1.0	7.0
Informal PCA	3.92	4.00	1.11	1-7	1.0	6.2
Dynamism	4.31	4.20	0.84	1-7	2.2	6.6
Hostility	4.78	5.00	0.72	1-7	2.0	6.3
Exploration	4.57	4.80	1.3	1-7	1.0	6.8
Exploitation	5.03	5.12	1.09	1-7	2.0	7.0
Size	2.42	2.32	0.33	N/A	2.0	3.4
Age	45.21	36.00	23.71	N/A	3.0	100.0

6.5. Empirical Findings

Prior to estimating the models, we examine the descriptive statistics, as reported in Table 6-5. We are interested in whether the practices studied in this paper form a system, and to do so, the variables need to covary. To observe this empirically, the variables in question must exhibit some variation (Speklé and Widener, 2020). Table 6-5 confirms this attribute, showing that for the survey measures, which are all measured on a 1-7 scale, the variables exhibit standard deviations between 0.7 to 1.6. Observing Table 6-4, we find that financial performance is positively associated with formal PCA while being slightly negatively associated with informal PCA. Financial performance correlates positively with both exploitation and exploration. We observe that both exploration and

exploitation are positively correlated with formal PCA, while informal PCA correlates slightly negatively with exploration and slightly positively with exploitation. We are estimating a pay-off function to examine the joint effect of two choice variables, and therefore the unconditional correlations are not of particular interest. The reason being that since we are estimating a pay-off function the underlying assumption is that managers are not always behaving optimally (Speklé and Widener, 2020). Table 6-6 presents the results of the MRA analysis. Prior to estimating the regressions, we mean center the independent and moderator variables to eliminate issues of multicollinearity (Cohen *et al.*, 2003).

Table 6-6: Regression results

Dependent variable: Financial performance	beta	t value
Intercept	3.44	1.78*
Controls		
Size	0.35	1.69*
Dynamism	-0.57	-2.27**
Hostility	0.22	0.85
Age	0.00	-0.48
Independent variables		
Exploration	0.15	0.91
Exploitation	0.09	0.53
Formal PCA	0.50	3.93***
Informal PCA	0.19	1.36
Multiplicative terms		
Exploration * Informal PCA	-0.30	-2.02**
Exploration * Formal PCA	0.32	2.47**
Exploitation * Informal PCA	0.43	2.67***
Exploitation * Formal PCA	-0.07	-0.47
Adjusted R-squared		0.28***

Note:
[i]* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

The results show that the moderation effect between exploration and formal post-decision control is positive and significant ($\beta = 0.32$, $t = 2.47$, $p < 0.05$), thus in support of H1. We find support for H2, as the moderation effect between exploitation and informal post-decision control is positive and significant ($\beta = 0.43$, $t = 2.67$, $p < 0.01$).

Figure 6-1 illustrates the moderation hypothesized in H1 and H2. For H1, the figure illustrates a symmetrical non-monotonic interaction function (Gerdin and Greve, 2008), thus indicating that the relationship between exploration and performance is positive high levels of formal post-decision control, but negative for low levels of formal post-decision control. As such, the illustration depicts that the positive effect of exploration on performance is stronger when the extent of formal post-decision control is also high, thus in support of H1. For H2, the figure shows a cross-over interaction (Burkert *et al.*, 2014), thus indicating that the costs of executing informal post-decision control exceed the benefits as the organization moves into a misfit. Consequently, performance is impaired, as no congruence exists between the choice variables (Schoonhoven, 1981). As such, the illustration shows that a firm moves into fit when a high extent of exploitation is simultaneously implemented with a high extent of informal post-decision control, and thus in support of H2.

A non-hypothesized result obtained in the regression model is worth mentioning, namely that the level of informal post-decision control significantly moderates the effect of exploration on performance in a negative direction. We believe that this strengthens our beliefs in H1, that formal control is the best fit for exploration, as the autonomy granted by informal control seems to deteriorate the performance. Explanations may include that as the number of trajectories in which explorations can develop increases (Holahan *et al.*, 2014), the lack of systematic control hinders the development of necessary information about performance implications (Zollo and Winter, 2002), as the exploration process drifts away from planned activities (Alkaraan and Northcott, 2006; Chenhall *et al.*, 2011; Jørgensen and Messner, 2009).

Figure 6-1: Illustration of the moderation effect
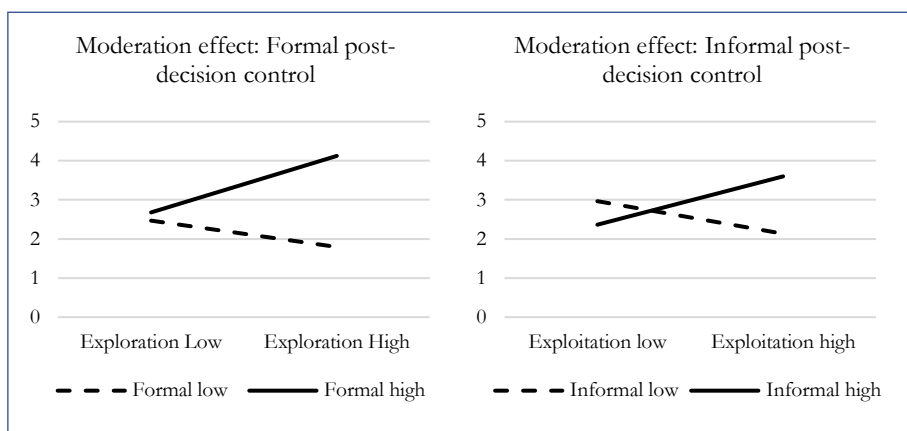
In general, for all the obtained moderation fits for the hypothesized relations, the moderator variables alter the form of the relationship between the choice variable and performance in the expected direction. Finally, we also perform an alternative specification of the regression model, where we include quadratic terms of the independent variables (exploration/exploitation) to rule out the possibility that missing squared terms drive the hypothesized interaction effects (Burkert *et al.*, 2014; Grabner and Moers, 2013). Such specification does not alter the obtained results.

6.6. Discussion and conclusion

Our empirical findings suggest that high exploration (exploitation) firms will, in terms of performance, benefit from implementing formal PCA (informal PCA). These results may seem ambiguous in comparison to certain other empirical studies on management control and exploration and exploitation activities. In partial support of our findings is Ylinen and Gullkvist (2014). They showed that the direct positive effect of organic controls on project performance is stronger for exploitative innovations than for exploratory. Additionally, they found a direct positive relation between mechanistic controls and project performance for firms scoring high on exploratory innovations. The comparison,

however, serves only as indicative since there are substantial differences regarding research objectives and measurements. Other studies, however, show contradicting results. One aspect that is subject to ambiguity is our finding regarding the positive relation between informal post-decision control and exploitation investments. While primarily studying the use of levers of control (LoC) and PMS, a recent survey study by Bedford (2015) provides results showing a positive performance relation with diagnostic controls for high exploitation firms but no relation for high exploration firms[8]. Such a strong focus on output has previously been expected to shift the focus to shorter-term, more predictable, and incremental innovations, as ex-ante outcomes of radical innovations are difficult to determine (Cardinal, 2001). This does not necessarily appear to be the case in practice, as shown in this paper as well as in Cardinal (2001) and Holahan *et al.* (2014). In search of some reconciliation between the different results, it may be useful to think of the difference between e.g., LoC and post-decision controls. While LoC refers to top-management control (Simons, 1995), which may entail a firm's overall capital investment strategy, post-decision control is executed on individual capital investment projects. It is conceivable that top management may place a high emphasis on diagnostic controls for capital investments in exploitation. As an example, some pool from the capital budget may be allocated to exploitative investments with the objective of reaching some level of IRR. However, on 'the floor', for the manager overseeing an exploitative investment, IRR may have only little informational value in determining whether an incremental innovation is improving the way of doing business.

To the best of our knowledge, this is the first study to show how a deliberate design of informality can assist the exploitation activities. It should be noted, however, that our model does take somewhat a leap in logic, as the theorized autonomy that informal controls create builds on certain contexts for which we cannot control in our statistical model. Some authors argued that the direction of control materializes through a common goal. This implies that employees can execute a certain amount of discretion with regard to the application of control (Ahrens and Chapman, 2004; Thomas and Ambrosini, 2015). This discretion is justified through their expertise and experience, but effective execution of such self-control rests on the assumption of supplementary training and socialization strategies implemented to reinforce congruence between the goal of the individual and those of the organization (Abernethy and Stoelwinder, 1995; Ouchi, 1979).

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[8] Diagnostic control is in Bedford (2015) largely measured as the degree to which PMS follows up on preset measurable objectives, and thus conceptually comparable to formal controls.

[9] Note that in comparison to Bedford (2015), our outcome variable has a considerably stronger emphasis on financial outcomes, which may also alter the results. We do seek to neither disproof nor discredit Bedford's (2015) result, but to position our results, it is useful think about Ferreira and Otley's (2009) notion that the LoC framework does not cope well with the informal controls that exist in lower hierarchical levels of organizations.

6.6.1. Conclusion

In this study, we show that the joint implementation of exploration (exploitation) and formal (informal) PCA leads to increased performance. We argue that exploitative and explorative investments require different control mechanisms. We draw links from theory and the extant empirical literature on innovation and MCS to argue for a complementary relationship between exploration (exploitation) and formal (informal) PCA, and empirically show a statistically significant moderation on financial performance.

Our study contributes to the debate of whether exploration and exploitation should be managed with different control mechanisms (e.g. Bedford (2015), Bedford *et al.* (2019), Cardinal (2001), Holahan *et al.* (2014), Jansen *et al.* (2006) and Ylinen and Gullkvist (2014)). Our results are in support of the view that they should indeed be managed differently and support recent challenging findings from Holahan *et al.* (2014). As such, we contribute by extending recent findings from the literature into the context of post-decision control. The study also contributes to the literature on management control and capital budgeting with the development of a scale for post-decision control, by extending the breadth of post-decision control measures to, in our assessment, better reflect the full use of post-decision control. The findings also contribute with practical implications that inform managers about effective choice variables to exert influence over exploration and exploitation investments. Our findings suggest that managers should rely on informal post-decision control to exert influence over exploitation investments. On the contrary, our findings suggest that managers should rely on formal post-decision control to exert influence over exploration investment. While we do not hypothesize on the specific relationship, the empirical results even suggest that managers should refrain from using informal post-decision control to exert influence over exploration investments.

This paper applies data from the same survey as used in Jensen and Kristensen (2021), as well as the same statistics methods, and therefore has similar limitations. There are several limitations to the study, and the results should be interpreted in light of these limitations. This study applies a new survey instrument, and while it demonstrated acceptable statistical properties, other researchers who wish to go down this road may want to further develop and validate the instrument. The cross-sectional design also has implications for the causal inference. Although our choice of control variables is informed by both theory and prior empirical studies, it cannot be rule out that the evidence is driven by variables that are not included in the model. The study is also based on a small sample size with a somewhat low response rate, which is a limitation even though the non-response bias test indicates a representative sample.

Our study supports the view that firms should use different control forms to exert influence over exploration and exploitation. While our study is not alone in suggesting that formal (informal) controls are more appropriate for exploration (exploitation) than vice versa (e.g. Holahan *et al.* (2014)), other empirical studies, as well as theories, are in

conflict with these results. Future studies should seek reconciliation as to how management controls may help or hinder innovation investments.

6.7. Appendix: List of survey items

Post-decision control

We sought to ensure that respondents answered questions regarding post-decision control with a distinction from a more general evaluation process. As such, we offered the following definition in the question introduction prior to answering the related questions: 'In the following, we ask you to answer a range of questions regarding your organization's processes for post-decision controls. These are post-evaluations of investment projects, meaning the evaluation and monitoring of an investment/investment project after the initial capital allocation to the investment/investment project. While the questions seem like each other's inverse, they should not be interpreted as mutually exclusive. Rather, because the type of investments/investment projects varies, we intend to measure the degree to which the processes for post evaluations also vary.

Please indicate the degree to which your organization's behavior for investment monitoring fits the following statements

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Formal post-decision control

Post-evaluations are regularly executed

The post-evaluations process is clearly defined

The post-evaluations process is standardized

The post-evaluations process assesses quantitative financial goals that were determined when the investment was made (e.g. payback period, NPV, IRR, etc.)

The objectives that are evaluated in the post-evaluation process are measured in quantitative terms

The post-evaluations process is based on predetermined measures/objectives (e.g. discounted cash flows, payback period, etc.)

Informal post-decision control

Post-evaluations are arbitrarily executed

The post-evaluations process is loosely defined

The post-evaluations process is unstandardized

The post-evaluations process is based on subjective measures/objectives (e.g. objectives that were not determined at the time the investment was made)

The post-evaluations process is based on the personal judgment from the person executing the evaluation

The post-evaluations process assesses objectives/goals that depend on how the investment develops after it has been initiated*

Note:
[i] Scale: 1 = Very low extent; 2 = Low extent; 3 = Somewhat low extent; 4 = Neither low/high extent; 5 = Somewhat high extent; 6 = High extent; 7 = Very high extent

ii * Dropped items

Exploration and exploitation[10]

Please indicate the extent to which the following have been prioritized investments of the organization that you lead over the last 2 years:

Exploration

Acquiring entirely new skills that are important for product/service innovation (such as identifying emerging markets and technologies; coordinating and integrating R&D, marketing, manufacturing, and other functions; managing the product development process)

Learning product/service development skills and processes entirely new to your industry (such as product design, prototyping new products, timing of new product introductions)

Acquiring product/service technologies and skills entirely new to the organization

Learning new skills in key product/service innovation-related areas (such as funding new technology, staffing R&D function, training and development of R&D, and engineering personnel for the first time)

Strengthening product/service innovation skills in areas where it had no prior experience

Exploitation

Upgrading current knowledge and skills for familiar products/services and technologies *

Investing in enhancing skills in exploiting mature technologies in your industry that improve productivity of current product/service innovation operations

Enhancing competencies in searching for solutions to customer problems that are near to existing solutions

Upgrading skills in product/service development processes in which the firm already possesses significant experience

Strengthening knowledge and skills for projects that improve efficiency of existing product/service innovation activities.

Note:
i Scale: 1 = Very low extent; 2 = Low extent; 3 = Somewhat low extent; 4 = Neither low/high extent; 5 = Somewhat high extent; 6 = High extent; 7 = Very high extent
ii * Dropped items

Environmental hostility[11]

Over the past two years…

How intense you rate the competition for your primary products/services (1 = very low intensity, 7 = very high intensity)

How difficult has it been to acquire the necessary input for your business (1 = very low difficulty, 7 = very high difficulty)

How many strategic opportunities have been available for your business (1 = extremely few, 7 extremely many)

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[10] The table is reproduced from Jensen and Kristensen (2021)

[11] The table is reproduced from Jensen and Kristensen (2021)

Environmental dynamism[12]

Over the past two years, how predicable or unpredictable have important changes in your external environment been with regard to the following?
Customer (e.g. demand, preferences)
Suppliers (e.g. key markets, quality of resources)
Competitors (e.g. competitors entering/exiting, tactics, strategies)
Technology (e.g. R&D, process innovations)
Regulations (e.g. economics, processes)

Note:
[i] Scale: 1 = Very predictable; 2 = Predictable; 3 = Somewhat predictable; 4 = Neither predictable/unpredictable; 5 = Somewhat unpredictable; 6 = Unpredictable; 7 = Very unpredictable

Financial performance

Please rate your organization's performance on the following dimension compared to your competitors over the past year
Return on investment
Profit
Cash flow from operations

Note:
[i] Scale: 1 = Significantly under average; 2 = Under average; 3 = Somewhat under average; 4 = Neither under/over average; 5 = Somewhat over average; 6 = Over average; 7 = Significantly over average

6.8. References

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[12] The table is reproduced from Jensen and Kristensen (2021)

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Chapter 7. Implementation of a real options reasoning design as a response to environmental uncertainty

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Abstract

We study real options reasoning (ROR) as a multidimensional construct that organizations implement as a response to environmental uncertainty. In innovative firms where environmental uncertainty is a key driver of expected future returns, the design of effective organizational control forms to support decision-making under uncertainty may be particularly challenging. When such efforts aim at strategic opportunities where managers can actively participate in resolving the uncertainty, ROR has been put under scrutiny and its applicability has been challenged. We show that that ROR firms may effectively manage investments with endogenous uncertainty by implementing a reallocation policy where the scope of the investment is specified ex-ante. Further, our findings indicate that environmental uncertainty is an important contingency to consider when studying ROR as a multidimensional construct. We find that the conditional correlations between the ROR constructs are only significant in a context of high environmental uncertainty. We contribute with new insight to the debate of reallocation regimes and the appropriateness of applying ROR in a context of active uncertainty resolution.

7.1. Introduction

Our aim in this paper is to advance the understanding of how firms implement real options reasoning (ROR). We are motivated by the debate of the applicability of ROR for strategic investment where managers actively participate in resolving the underlying uncertainty in contrast to a wait and see strategy (Adner, 2007; Adner and Levinthal, 2004; Barnett, 2008; Cuypers and Martin, 2010; Klingebiel and Adner, 2015).

ROR is an appealing topic due to its argued superiority to the static assumptions in well-known resource allocation regimes such as net present value approaches (Bowman and Hurry, 1993; Dixit and Pindyck, 1994). Rather than assuming deterministic futures, a ROR approach accounts for the value of flexibility which is argued to increase upside potential and decrease downside risk when operating under great environmental uncertainty (Bowman and Moskowitz, 2001; Ipsmiller *et al.*, 2019; Trigeorgis and Reuer,

2017). Much effort has been allocated to defining real options and empirically testing related conceptualizations. Examples include scholars' identification of companies with option-like assets such as joint ventures, multinationality, minority equity interest, etc., and empirical testing to determine whether these assets are associated with outcomes predicted by real options theory, such as upside potential and downside risk (Andersen, 2012, 2011; Belderbos *et al.*, 2014; Driouchi and Bennett, 2011; Elango, 2010; Reuer and Leiblein, 2000; Tong *et al.*, 2008; Tong and Reuer, 2007).

As such, the relationship between real options investing and the predicted outcomes of decreased downside risk and increased upside potential is already well documented in the literature. Less attention, however, has been attributed to how ROR is implemented in organizations. We apply a multidimensional construct of ROR to examine how firms set behavioral boundaries to guide investment behavior when uncertainty is resolved endogenously. First, firms using ROR invest sequentially and with low initial commitments (Bowman and Hurry, 1993), which entails a resource allocation strategy with multiple steps. Second, ROR entails resolving the uncertainty surrounding the investment, which may be characterized as either exogenous or endogenous (Adner and Levinthal, 2004; Cuypers and Martin, 2010). We are interested in endogenously resolved uncertainty, and the potential problems this entails when engaging in a multi-step investment process. The ROR literature has identified problems associated with lost course of action resulting in exaggerating the sunk costs fallacy and escalation of commitment (Adner and Levinthal, 2004). As such, a third element, reallocation, is introduced to examine how firms set boundaries for the sequential investment behavior to ensure that failing projects are abandoned timely and only successful ones receive additional funding. There has been much discussion about the importance of reallocation as well as its usefulness when uncertainty is resolved endogenously (Adner and Levinthal, 2004). Existing empirical literature in this area is not exactly unequivocal (Cuypers and Martin, 2010; Klingebiel and Adner, 2015), so we seek to address this gap. Therefore, a key question in this paper is whether a reallocation policy based on setting boundaries for the investment scope ex-ante is a cost-effective strategy when uncertainty is resolved endogenously. Further, because of the unequivocal result, we believe it is important to consider the contingent factors that may lead to different results. Verdu *et al.* (2012) for example found that environmental uncertainty moderated the effect of ROR on product/process innovation. This paper addresses the literature that treats ROR as a multidimensional construct (Klingebiel and Adner, 2015), and we find it both interesting and important to consider the known contingency factors when studying the fit between individual constructs of ROR. As such, the paper also addresses the question of whether environmental uncertainty is an important contingency factor to consider when examining fit between ROR constructs.

We propose four hypotheses: 1) that sequential low commitment and endogenous active resolution are complements in a context of high environmental uncertainty, 2) that sequential low commitment and reallocation are complements in a context of high environmental uncertainty, 3) that active uncertainty resolution and reallocation are

complements in a context of high environmental uncertainty, and 4) that in a context of high environmental uncertainty, firms are more likely to implement all three ROR constructs simultaneously.

We apply a contingency framework to examine the effectiveness of ROR. We, therefore, assume that certain configurations of organizational controls – in this case, ROR – are more suited to certain environmental contexts and that managers will adjust their use of ROR in accordance with the environmental context to achieve fit and enhanced performance (Chenhall, 2003). While there is no one optimal firm structure, managers can adapt the firm structure to fit the environmental contingencies (Chenhall, 2003; Gerdin and Greve, 2004). We assume that structure – here, ROR – depends on the context, and make no explicit tests on the relation between ROR and performance. As such, we base our study on a congruence or selection fit approach to contingency theory (Drazin and Van de Ven, 1985; Gerdin and Greve, 2004).

This data used in this paper is based on the same questionnaire as in Jensen and Kristensen (2021) where we note that *"the data used in this study comes from a questionnaire distributed to Danish companies with more than 100 employees. We expand on the data collection in the empirical section. To test the hypotheses, we relied on conceptual constructs already known in the ROR literature, but as survey research in ROR is scarce, the survey items are newly developed for the purpose of this study."*

We find empirical support for all four hypotheses. In a context of high uncertainty, we find that the following pairs of ROR constructs are complements. Sequential low commitment and active uncertainty resolution, sequential low commitment and reallocation, and active uncertainty resolution and reallocation. At last, we show that in a context of high environmental uncertainty, firms are more likely to implement all three ROR constructs to a high degree.

Our paper addresses the debate of how ROR may be appropriately used under uncertainty. As our study relies on newly developed survey items, we confirm some existing knowledge about ROR to increase the validity of our paper. First, Driouchi and Bennett (2011) showed that controlling for managerial awareness of real options was an important factor to statistically show the effect of ROR. We confirm the importance of option awareness by showing that it is an important predictor of implementing the ROR constructs used in this paper. Second, Klingebiel and Adner (2015) also researched ROR using separate constructs. They applied separate constructs for sequential investment and low initial commitment and find that only sequential investment had a direct impact on increased innovation performance for projects prone to active uncertainty resolution. Further, Cuypers and Martin (2010) found no indication that JV's prone to active uncertainty resolution was likely to invest with low initial commitments. In contrast, we find that sequential investment and low initial commitment loads on a single construct, thus sequential low commitment, and that this construct is complementary with active uncertainty resolution in a context of high environmental uncertainty. We acknowledge

that the basis for comparison is limited due to the different conceptualization and that we may lose some informational value by measuring sequential investment and low initial commitment as a single construct. However, in contrast to the existing studies, we find that there is a positive statistical relationship between the two and that it is contingent on high environmental uncertainty, and thus contributes, at least with the interesting observation that environmental uncertainty may be an important contingency factor to consider when studying the relationship between individual ROR constructs. Third, Klingebiel and Adner (2015) showed that a fit between low initial commitment and reallocation increased innovation performance. With the same caveat as described above regarding the sequential low commitment construct, we find similar results by showing that sequential low commitment and reallocation are complements in a context of high environmental uncertainty. Fourth, Klingebiel and Adner (2015) found that reallocation had no direct effect on innovation performance for projects prone to active uncertainty resolution. It is here important to consider the conceptualization of reallocation in Klingebiel and Adner's (2015) study, which was measured by the project abandonment rate, and thus not addressing the firms' policies for abandonment. We treat reallocation as a strict policy of specifying the investment scope at the time of initial investment and find that active uncertainty resolution and reallocation are complements in a context of high uncertainty. As such, we contribute with important insights into ROR firms' internal policy setting for limiting the scope of investments. Such policy setting in connection with active uncertainty resolution has been heavily discussed in the literature (Adner, 2007; Adner and Levinthal, 2004; Cuypers and Martin, 2010; Klingebiel and Adner, 2015), and it has been questioned whether active uncertainty resolution is appropriate for ROR investing due to potential cost of specifying the scope of the investment ex-ante (Adner and Levinthal, 2004). As such, our findings indicate that in a context of high environmental uncertainty, the benefits of specifying strict ex-ante rules for the investment scope do indeed outweigh the costs when uncertainty is resolved endogenously. Sixth and last, while we already know that environmental uncertainty is an important factor to consider when researching ROR (Verdu *et al.*, 2012), our study contributes with insights into the importance of considering the environmental uncertainty as a contingent factor when studying the interdependence of ROR constructs. While other studies have already studied ROR as a multidimentional construct (Klingebiel and Adner, 2015), we believe that this is the first to show that the constructs are interdependent, only in the context of high environmental uncertainty.

In the next section, we describe the theoretical background and develop our hypotheses. In Section 7.3, we present our data and variable measurement. In Section 7.4, we present our results, and in Section 7.5 we discuss and conclude the paper.

7.2. Theory and hypotheses

The purpose of ROR is to generate and access flexibility in the capital budgeting process (Driouchi and Bennett, 2012; O'Brien and Folta, 2009), such that risk is sheltered from uncertainty while the upside from uncertainty is maintained. In the ROR literature,

uncertainty is a key accelerator for real option value because the variance of an asset's expected return drives the potential profits (McGrath, 1999). As stated in Jensen and Kristensen (2021) *"Firms that operate under uncertainty may commit small sums of capital to investments, which provides options to act on future contingent opportunities (Ipsmiller et al., 2019). Small initial commitments limit financial loss, thus limiting the downside risk if events unfold unfavorably (McGrath, 1997). ROR is intended to aid managers' decision-making under uncertain conditions (Ipsmiller et al., 2019). The flexibility that ROR builds into the capital budgeting process allows managers to make future adjustments to investment decisions in order to protect firms from downside risk while maintaining access to upside potential (Copeland and Keenan, 1998; Krychowski and Quélin, 2010)."*

For this study, as well as Jensen and Kristensen (2021) four constructs was developed to measure the individual elements of ROR: (1) option awareness, (2) sequential low commitment, (3) active uncertainty resolution, and (4) reallocation. The idea of treating ROR as separate constructs is not a new one. Klingebiel and Adner (2015) for example treated sequencing, low initial commitment, and reallocation as separate constructs of ROR. In comparison, as will be shown in the empirical section, we find that low initial commitment and sequencing correlate to a single factor, while we treat the process of uncertainty resolution and reallocation as separate constructs. What follows is an introduction to the constructs of ROR used in this paper.

Option awareness does not specify a particular type of control or action. Rather, option awareness refers to the degree to which managers are aware of opportunities to acquire option-generating resources (Barnett, 2008). As mentioned above, managers must generate access to flexibility to respond to future events. However, such opportunity for change exists only to the extent that managers recognize that flexibility may be inherent in the assets they acquire (Bowman and Hurry, 1993). As such, part of the underlying logic of ROR is that future opportunities are contingent on past investments (Adner and Levinthal, 2004; McGrath *et al.*, 2004). We, therefore, believe that any motivation to implement decision-making based on ROR principles is first motivated by managers' attention to opportunities where flexibility can be built into the investment decision. Such attention to real options has previously been shown to be an important factor in obtaining the desired outcomes of ROR (Driouchi and Bennett, 2011).

Sequential low commitment refers to the use of uncertainty to guide the investment process. In essence, ROR firms invest sequentially and with low initial commitment. Managers should hold on to their options and defer exercise while uncertainty is high, which allows them to reduce downside risk in the case of adverse outcomes but retains the opportunity to take advantage of future opportunities in case of favorable events (Ipsmiller *et al.*, 2019; Li and Chi, 2013; Vassolo *et al.*, 2004). Note that this is not to say that firms should pursue low-uncertainty opportunities. Rather, uncertainty is an important antecedent of an option's value. Greater variation in the expected payoffs will facilitate additional upside potential without increasing downside risk (Ziedonis, 2007). However, this is only to the extent that uncertainty is managed by deferring exercise until the uncertainty is resolved

(Ziedonis, 2007). Investing sequentially is thus a key part of ROR, and McGrath (1999) argues that managers should only commit small sums when uncertainty is high, and only commit larger capital outlays when they have obtained knowledge that reduces uncertainty.

Active uncertainty resolution is a set of organizational routines that maintain and develop knowledge about an option's value (Barnett, 2008). Managers must take an active role over the lifetime of the option and exert ongoing effort to respond to environmental changes to maximize the potential of the option (Barnett, 2005). The option value may erode or never be realized if management fails to properly exert its discretion over investment decisions (Barnett, 2008; Coff and Laverty, 2008; Song *et al.*, 2015). As such, managers need to establish routines to continuously manage value-driving factors and oversee their options' exposure to the environment (Miller and Waller, 2003). Such routines allow managers to be responsive to changes and utilize flexibility in the face of uncertainty (Jahanshahi and Nawaser, 2018) because managers need information and knowledge to adapt and to reduce uncertainty (Janney and Dess, 2004; McGrath and Nerkar, 2004). Such reduction in uncertainty informs managers about the likelihood of an outcome and is a key factor in limiting downside risk while maintaining access to upside potential (Leslie and Michaels, 1997; McGrath *et al.*, 2004). The ROR literature distinguishes between exogenous and endogenous uncertainty resolution, of which exogenous uncertainty resolution is unaffected by the actions of the firm (Cuypers and Martin, 2010). Since this study is concerned with the effort that managers put into resolving uncertainty about its options, we are here interested in endogenous uncertainty resolution.

Reallocation is a control to ensure that managers set disciplinary boundaries in which ROR can be applied to investment strategy (Adner and Levinthal, 2004; Driouchi and Bennett, 2012). Appropriate implementation of ROR includes explicitly defined circumstances under which an investment project is allocated further capital or is abandoned (Adner, 2007). Under uncertainty, reallocation is important, as boundaries enable better use of knowledge when uncertainty resolves over time (Wang, 2017). Because uncertainty resolves over time, ROR becomes prone to escalation of commitment in the absence of reallocation procedures (Adner, 2007). Adner and Levinthal (2004) argue that disciplining managers is especially difficult in situations where uncertainty is resolved endogenously. Such situations include strategic opportunities where the scope for potential modifications to the initial initiative is vast. Negative information about an investment's development can occasionally be interrupted by positive developments, which escalates the probability that managers convince themselves that they should keep pursuing the opportunity rather than abandoning it (Adner, 2007). Setting explicit boundaries for real options helps mitigate this issue by informing managers when an option is no longer worth pursuing (Song *et al.*, 2015). Managers are presented with many choices regarding whether to invest in certain developments. Such choices must be carefully weighed against alternatives in order not to compromise the existence of the firm, which makes it important that flexibility does not suffer due to escalation of commitment (Adner, 2007;

Ragozzino *et al.*, 2016). As such, we seek to position this study with other studies on reallocation regimes in ROR. Reallocation meaning the process with which investment projects are abandoned or continued.

7.2.1. Hypotheses

The previous subsection describes the different controls in the ROR framework, and while each is argued to be an important element in ROR, it is unclear how such a system is implemented. In the following, we will hypothesize on the implementation, arguing that in a context of uncertainty, the ROR constructs are complements and are implemented interdependently. We aim to use the work of Roberts (2006) to argue that several choice variables are complementary if each of them is a complement for each of the others.

Sequential low commitment, as mentioned above, is implemented to guide a firm's investments under uncertainty. It essentially entails sequential commitment of resources to a project based on its perceived uncertainty, by initially allocating low commitments to a project and only through uncertainty resolution, committing further resources (Adner and Levinthal, 2004; Cuypers and Martin, 2010). However, as Cohen and Levinthal (1994) argue, an organization's alternatives are a function of the organization's involvement with them. As such, uncertainty is not resolved by itself and demands frequent environmental scans and information updates (Barnett, 2005). Firms should not remain idle and wait for signals from the environment indicating opportunities, but rather take an active part in resolving the uncertainty (Cohen and Levinthal, 1994). Thus, through sequencing, firms can acquire information about the project during its advancement, and by actively reducing uncertainty managers can update their beliefs about the commercial viability (Klingebiel and Adner, 2015). As such, we would expect firms with a policy of low initial commitment, to seek to optimize the potential of the policy by actively managing the uncertainty and thus creating the flexibility to make informed decisions about further commitment to the project. In comparison, a firm with a one-off non-sequential policy would have only little to gain from uncertainty resolving procedures, as the flexibility to make project alterations will be limited (Klingebiel and Adner, 2015).

We consequently expect that firms operating in a high-uncertainty context and that implement sequential low commitment to guide their investment decisions will also implement active uncertainty resolution to optimize the flexibility offered by low initial commitments.

H1: *Sequential low commitment and active uncertainty resolution are complements for firms operating in a high-uncertainty context.*

Our second element of interest in the interplay between ROR constructs concerns sequential low commitment and reallocation. Above, we argued that the flexibility offered

by sequential low commitment will be accompanied by active uncertainty resolution to inform decisions about further capital commitment. However, "*Adner and Levinthal (2004) argue, information about the value of an investment may improve managerial decision-making, but flexibility is revealed in the abandonment decision. An option is flexible because, in the event of information about negative outcomes, it can be abandoned. However, low initial commitment often leads to escalation of commitment where there are no proper de-escalating procedures in place (Klingebiel and Adner, 2015)*" – (Jensen and Kristensen, 2021). There are numerous examples in the literature of firms who struggle to effectively reallocate resources away from failing projects after initiating with low initial commitments (e.g., Coff and Laverty (2001), Guler (2007)). "*Reasons for such biases may be explained by a focus on sunk costs, personal interest, aversion to failure, and overconfidence (Camerer and Lovallo, 1999; Klingebiel and Adner, 2015; McGrath, 1999; Samuelson and Zeckhauser, 1988). As such, the effectiveness of sequential low commitment is conditional on firm procedures that ensure efficient reallocation of capital at later stages of the investment process*" – (Jensen and Kristensen, 2021). McGrath (1999) notes that firms should quickly terminate non-performing projects and that such capping of losses will reduce the downside exposure of a firm's portfolio. Consequently, without the ability to define failure with strict and structured abandonment policies, firms will face difficulties in exploiting the flexibility offered by low initial commitment and sequential investment (Adner and Levinthal, 2004).

Thus, we expect that reallocation reduces the costs of sequential low commitment by limiting behavioral biases. Consequently, we expect that firms that implement sequential low commitment to guide their investments in a context of high uncertainty would also implement reallocation to avoid escalation of commitment.

H2: *Sequential low commitment and reallocation are complements for firms operating in a high-uncertainty context.*

We have now discussed some of the behavioral biases that may be related to an investment strategy that is characterized by sequential investments and low initial commitment. While this is an interesting topic in the literature of ROR, it serves more as a confirmatory test in this study. Klingebiel and Adner (2015) already showed that initial low commitment combined with reallocation increases innovation performance. However, such issues as escalation of commitment may be especially problematic in a context where uncertainty is resolved endogenously (Cuypers and Martin, 2010; Klingebiel and Adner, 2015). Active uncertainty resolution is a procedure, which is expected to create a flow of information that provides managers with insights into the value of a firm's options (Barnett, 2008; Jahanshahi and Zhang, 2015). In a high-uncertainty context, future outcomes are unclear. As such, ceteris paribus, firms holding options on their assets face uncertainty about the future value of those options and the value of exercising. Firms that implement active uncertainty resolution will seek to reduce the uncertainty in the period between obtaining the options and exercising them (Barnett, 2008). This implies the establishment of an information flow that reduces the adverse effects of uncertainty (Janney and Dess, 2004; McGrath and Nerkar, 2004) by searching

the environment for hints about future outcomes (Miller and Waller, 2003), and through an active effort to learn about the commercial viability of an investment project (Cohen and Levinthal, 1994; McGrath, 1997). However, it is important to consider the applicability of ROR, when moving from a 'wait and see' to an 'act and see' context, where uncertainty is resolved inside the firm (Adner and Levinthal, 2004). When the scope of the investment is explicitly defined at the time of the initial investment, then the decision to abandon can be clearly articulated, and therefore the flexibility can be maintained (Adner and Levinthal, 2004). According to Adner and Levinthal (2004), the issue of ROR, then becomes that in the case of e.g., strategic opportunities for which a firm's actions create new possibilities, ex-ante specification of the investment scope may be neither possible nor desirable. As such, the difficulty in making the abandonment decision increases with the potential for ex-post discovery of possible directions for an investment (Adner and Levinthal, 2004). Therefore, when ROR is applied in connection with active uncertainty resolution, it must be implemented with appropriate controls (McGrath and MacMillan, 2000). Adner and Levinthal (2004) argue that in order to maintain the flexibility of abandonment, when the investment can present many possible paths after initiation, firms should seek to counterbalance these possibilities with rigidities in specifying the allowable courses of action for the investment.

In sum, we expect that in a context of high uncertainty, active uncertainty resolution is favorable to a firm, as it aids managers in obtaining information about future outcomes. However, there are significant costs of such a system, including escalation of commitment. Firms may mitigate escalation of commitment by implementing a reallocation policy, thus reducing the costs of active uncertainty resolution. Thus, we expect that because a shift in uncertainty will be associated with a shift in active uncertainty resolution, it will also be associated with a shift in reallocation.

H3: *Active uncertainty resolution and reallocation are complements for firms operating in a high-uncertainty context.*

The hypotheses proposed above imply that the three ROR controls are complements. The most critical environmental factor considered in the ROR literature is environmental uncertainty, and it is proposed that ROR is implemented as a response. Complementarity theory specifies that for a set of complementary choice variables, an environmental change that would raise the returns of increasing the level of any choice variable would raise the returns of increasing the level of the other choice variables (Roberts, 2006). The greater a firm's exposure to environmental uncertainty, the greater the potential returns are from implementing the system (Ipsmiller *et al.*, 2019; McGrath, 1999). This implies that the benefits of joint use of sequential low commitment, active uncertainty resolution, and reallocation increase with environmental uncertainty. We, therefore, expect that firms operating in a high-uncertainty context are more likely to implement extensive use of all three ROR controls.

H4: *The likelihood of implementing extensive use of sequential low commitment, active uncertainty resolution, and reallocation increases with environmental uncertainty.*

7.3. Data and variable measurement[13]

To test the hypotheses, we collected data through a cross-sectional questionnaire, which we addressed to the CFO of the firm, with the assumption that the CFO would be among those of the top management team with most knowledge about the organization's investments. The target population consisted of 1,056 Danish firms, which we obtained from the Navne and Numre Erhverv database. To increase the probability of obtaining a sample from firms with formalized investment policies, we chose only firms with a minimum of 100 employees. We used the guidelines for survey research described by Dillman et al. (2014). The questionnaire was originally sent to 1,056 and we sought to encourage participation by offering an opt-in option to receive a summary of the questionnaire's findings. As the study intends to capture aspects of organizational investment behavior, we chose to address the questionnaire to CFOs. We assumed that, generally, the CFO would have one of the highest levels of knowledge about investments in their organization. We sent the CFOs an e-mail including a link to the online questionnaire, and after three weeks, we sent a reminder by postal mail, accompanied by a signed letter. Another three an weeks and six weeks later, respectively, we sent out an additional two reminders, while seeking to increase interest in the study by calling target persons on the telephone. We concluded the data collection with a final sample of 95 firms, corresponding to a usable response rate of 9.0%. That response rate is similar to other ROR studies using survey method (Brouthers and Dikova, 2010; Verdu et al., 2012). The appropriateness of the respondents was assessed with a question about their involvement in the investment decision-making-process on a scale from 1 to 7. The obtained score for the sample is a satisfactory 6.0. The average tenure for the respondents is 10.6 year for the firm and 7.2 for the current position. Common method bias may a problem in singly method studies like this one (Speklé and Widener, 2018). We made several preparations to protect against it, and introduced temporal separation, meaning a time lag between questions used as dependent and independent variables respectively. This ought to reduce saliency of contextually provided retrieval cues (Podsakoff et al., 2003). We also ensure to protect respondents' anonymity, which according to Podsakoff et al. (2003) should decrease the apprehension toward more socially desirable, lenient, acquiecent, and consistent answers. At last, bivariate correlations are especially prone to common method bias (Speklé and Widener, 2018), and although we are indeed interested in bivariate correlations, all regression models are specified as multivariate, which should have a mitigating effect as long as additional variables shows correlation less than or equal

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[13] As the data used in this article originates from the same survey as used Jensen and Kristensen (2021), there is a significant overlap between this section and the section on data collection in Jensen and Kristensen (2021), and as such the reporting of the data collection (section 7.3) is produced with reference to Jensen and Kristensen (2021).

to 0.30 with the existing variables (Speklé and Widener, 2018). This may be confirmed by studying Table 7-2. A χ^2-test is used to assess sample representativeness. We compare our sample with that of full list of firms and find insignificant differences ($\chi^2 = 11.73$, degrees of freedom = 8, p > 0.10). The sample industry classifications are presented in Table 7-1. T-tests are used to assess mean firm size differences and mean differences in all variables. Comparing this sample ($\bar{X} = 392$) compared to the full sample ($\bar{X} = 406$) with the t-test shows no significant differences (t = 0.58, p > 0.10). The late response bias test, comparing scores of the variables between the 25% first and last responses showed no significant differences (not reported).

Table 7-1: : Industry classification

DB07* industry classification	Frequency	%
Administrative services	6	6%
Construction and civil engineering	8	8%
Wholesale and retail	14	15%
Real estate	1	1%
Manufacturing	36	38%
Liberal, scientific and technical services	5	5%
Information and communication	6	6%
Accommodation facilities and restaurants	1	1%
Transportation and freight handling	7	7%
Other	11	12%
Total sample	**95**	**100%**

Note:
[i] *DB07 - Danish standard industry classification

7.3.1. Variable measurement

The variables that we apply in this study are a mix of previously developed and empirically tested constructs, combined with the newly developed scales for ROR, which are also used in Jensen and Kristensen (2021). The constructs will be described in turn in this section. The survey items used in this paper all apply a seven-point Likert scale. For each point on the scale, we provided labels in order to minimize response bias as well as measurement error. According to Eutsler and Lang (2015) this method is better than five- or nine-point Likert scales. Further, Eutsler and Lang (2015) notes that labeling all choice options is a better approach than only labeling at the ends of the scale. For all survey constructs used in this study, that they are computed as the average of the item scores.

Real options reasoning

As no appropriate measure for our ROR constructs is available, we developed scales for the constructs, which we based on the literature cited in the theory section. Since the ROR measures are used in previous published work we cite Jensen and Kristensen (2021) for their explanations in the following. We developed a scale for reallocation [REAL] using three items, intended to measure *"the extent to which management clearly specifies an asset's embedded options prior to investment in the said asset (real1), the extent to which circumstances for abandonment (real2), and further capital allocation (real3), are specified ex-ante of option acquisition"* – Jensen and Kristensen (2021). For the active uncertainty resolution [AUR] construct, we also developed three items, which are intended to assess "*the extent to which management continuously observes the environment to make assessments of the value of the firm's options (aur1 and aur2), and we assess the extent to which management puts continuous effort into creating value from its options (aur3)"* – Jensen and Kristensen (2021). Finally, we operationalized sequential low commitment [SLC] with three items intended to assess *"the degree to which management uses uncertainty to assess the size of capital commitments (slc1 and slc2), as well as the effect of resolving uncertainty on exercising options (slc3)"* – Jensen and Kristensen (2021). For each of the ROR constructs (also option awareness), we extract a factor score from the EFA, which we apply in the subsequent analyses.

Environmental uncertainty

Environmental uncertainty is the inability to predict future events that may have a material impact on a firm (Song *et al.*, 2015). As such, we apply a measure of environmental dynamism [DYN] as a proxy for environmental uncertainty. We adopt a measure from Gordon and Narayanan (1984) based on an index of five dimensions. The measure was previously validated by, e.g., Bedford (2015) and Jansen *et al.* (2006). The construct is a measure of the predictability in the firm's environment (Dess and Beard, 1984). The dimensions do not necessarily relate to one another, and we therefore compute it as a formative construct.

Control variables

We include several control variables that we expect to affect the joint movement of the ROR variables. The control variables are option awareness, size, age, environmental hostility, business strategy, managerial short-termism, and slack. As argued in Section 7-2, option awareness does not specify a particular type of control or action. Rather, option awareness relates to managerial awareness toward acquiring option-generating resources (Barnett, 2008). We believe that variance in the choice to implement ROR controls is likely determined by managers' attention to opportunities. We operationalize option awareness [AWARE] by three items, *"covering management's consideration of an investment's options, such as abandonment, expansion, etc. (aware1). We further asked about the importance of acquiring options (aware2), and the degree to which the firm recognize that future opportunities are contingent on prior investments in resources (aware3)"* – Jensen and Kristensen (2021). We measure size [SIZE] as the logarithm of the number of employees. Likewise, we control for age [AGE] using the natural logarithm of the number of years since the founding of the firm, which according to Jahanshahi and Zhang (2015) is an important control

variable in ROR studies because young firms tend to pursue radical innovations more than their older equivalents. We measure environmental hostility [HOST] as an index of three dimensions based on research by Miller and Friesen (1983) and Tan and Litschert (1994). The measure was recently used by, e.g., Bedford (2015) and Jansen *et al.* (2006). Environmental hostility may have implications for the choice to implement ROR, as it may decrease the willingness to venture into new areas (Wang and Dass, 2017). A more competitive environment makes it more challenging to find unique opportunities and therefore more costly perform activities related to search, learning, and action (Wang and Dass, 2017). As also defined in Jensen and Kristensen (2021) *"Environmental hostility is a measure of competitiveness and the degree of pressure for market demand, resources, and growth opportunities (Dess and Beard, 1984; Miller and Friesen, 1983).* We measure business strategy [STRATEGY] based on Slater and Olson's (2002) research. We provide respondents with five statements regarding business strategy and ask them which type they identify with. Firms are thus categorized into either prospectors, analyzers, defenders (Miles *et al.*, 1978), low-cost defenders, or differentiated defenders (Porter, 1980; Walker and Ruekert, 2006). We compute business strategy as a binary control variable to reflect if a firm is a prospector, as these organizations have a broad and expanding market due to a continuous innovation domain (Conant *et al.*, 1990). We believe that such an external focus may affect the choice of implementing ROR. We take a measure of managerial short-termism [SHORT] based on work by Merchant (1990). We ask respondents to state show large a share of the resources allocated to activities that they expect to see materialized in the income statement within a year. A short time horizon causes managerial attention to focus on only the downside of volatility and may lead to avoidance of pursuing longer-term growth opportunities with higher uncertainty (Hoskisson *et al.*, 1993; Shijun, 2004; Wright *et al.*, 2007). We measure growth opportunities [GROWTH] based on work by Abernethy *et al.* (2004), using a two-item construct which intends to assess how managers perceive growth opportunities for their organization and industry. The construct is computed as the average of the two items. Last, we measure organizational slack [SLACK] as SG&A divided by sales. Slack may be a factor of organizational responses to uncertainty and should be included in models considering ROR (Miller and Leiblein, 1996).

Table 7-2: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) DYN	-										
(2) HOST	0.57	-									
(3) SLACK	0.03	0.03	-								
(4) GROWTH	0.08	0.28	0.11	-							
(5) AGE	-0.22	-0.07	-0.05	-0.1	-						
(6) SIZE	-0.05	0.04	0.02	-0.04	-0.01	-					
(7) SHORT	0.13	0.07	0.11	-0.03	-0.04	-0.1	-				

(8) AWARE	0.18	0.11	0.01	0.03	-0.01	0.14	0.2	-			
(9) EUR	0.33	0.3	0.05	0.23	-0.12	0.21	-0.03	0.49	-		
(10) SLC	0.31	0.21	-0.09	-0.03	-0.03	0.13	-0.16	0.37	0.53	-	
(11) REAL	0.28	0.16	-0.11	0.08	-0.09	0.27	-0.06	0.37	0.57	0.49	-

7.3.2. Exploratory factor analysis

We assess the ROR variables as reflective factors using maximum-likelihood extraction with varimax rotation. Any items loading below 0.4 and cross-loading above 0.4 are removed from the model, which leaves the 12 items described above. We report the results in Table 7-3. We obtain four factors with eigenvalues above 1 and the cumulative variance explained is 72%. A Kaiser–Meyer–Olkin test shows the sampling adequacy to be 0.79. Further, for the Bartlett's test of sphericity, we obtain a significance level at $p <$ 0.000. Both measures are within generally accepted levels (Hair Jr. *et al.*, 2014). Cronbach's α is between 0.73 and 0.87, which confirms adequate reliability for all factors (reported in Table 7-4). We extract the factor scores for all four variables in the EFA and use these extracted scores as our measures of ROR in the analyses presented in Section 7.4.

Table 7-3: Exploratory factor analysis

	REAL	AWARE	SLC	EUR
aware1		0.739		
aware2		0.919		
aware3		0.436		
eur1				0.618
eur2				0.656
eur3				0.620
slc1			0.811	
slc2			0.715	
slc3			0.463	
real1	0.573			
real2	0.881			
real3	0.889			
Eigenvalue	4.505	1.555	1.381	1.197
Cumulative variance explained	0.375	0.505	0.620	0.720
KMO	0.774			
Bartlett's test of sphericity	0.000			

Note:
[i] Maximum Likelihood extraction with Varimax factor rotation.

7.3.3. Confirmatory factor analysis[14]

Table 7-4 reports the results of the confirmatory factor analysis. We evaluate the model with a range of fit indices as suggested by (Kline, 2011). The fit indices are the Tucker–Lewis Index (Tucker and Lewis, 1973), Comparative Fit Index (Bentler, 1990), and Incremental Fit Index (Bollen, 1989). We evaluate the indices based on how close they are to 1. All are above 0.9 and thus at acceptable levels (Bentler, 1992; Kline, 2011). The root mean square error of approximation (RMSEA) is below 0.08 and the standardized root mean square residual (SRMR) is below 0.1. Both are thus at acceptable levels (Browne and Cudeck, 1993; Kline, 2011; Schermelleh-Engel *et al.*, 2003). χ^2 to degrees of freedom is below 3, hence suggesting satisfactory fit (Kline, 2011). We find composite reliability (CR) levels above 0.6 for all factors and are thus accepted as reliable (Hair Jr. *et al.*, 2014). Standardized loadings are all above 0.5 (Bagozzi and Yi, 1988). The square root of average variance extracted (AVE) is larger than any correlation between reflective factors, thus supporting discriminant validity (Chin, 1998). Reflective factor correlations are presented with descriptive statistics in Table 7-5.

Table 7-4: Confirmatory factor analysis

Latent variable indicators	Standardized loadings	z-value (all sig. at $p < 0.01$)	Composite reliability	Cronbach's alpha	Square root of average variance extracted (AVE)
Growth			0.818	0.813	0.833
growth1	0.865				
growth2	0.794	3.624			
Option awareness			0.767	0.750	0.727
aware1	0.745				
aware2	0.957	6.816			
aware3	0.53	5.230			
Endogenous uncertainty resolution			0.720	0.725	0.681
eur1	0.632				
eur2	0.634	4.881			
eur3	0.784	5.401			

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[14] The data used in this article originates from the same survey as used Jensen and Kristensen (2021), and the methods used to evaluate the survey constructs are the same. Therefore, there is a significant overlap between this section and the section on confirmatory factor analysis in Jensen and Kristensen (2021), and as such the reporting of the confirmatory factor analysis (section 7.3.3.) is produced with reference to Jensen and Kristensen (2021).

Sequential low commitment			0.773	0.737	0.741
slc1	0.906				
slc2	0.675	5.761			
slc3	0.539	4.836			
Reallocation			0.890	0.867	0.860
reallocation1	0.623				
reallocation2	0.928	7.220			
reallocation3	0.941	7.228			

Note:
[i] RMSEA: 0.075, SRMR: 0.079, CFI: 0.936, TLI: 0.913, IFI: 0.938, Chi-squared to degrees of freedom: 1.56 (104.251/67).
[ii] Blank cells in z-value column indicates loadings fixed to 1.

Table 7-5: Descriptive statistics and correlation matrix for reflective factors

	Mean	Median	St.dev	Min	Max
Dynamism	4.37	4.40	0.84	2.20	6.80
Hostility	4.82	5.00	0.74	2.00	6.33
Slack	2.90	1.16	5.93	0.02	46.39
Growth	5.29	5.50	0.90	2.50	7.00
Age (log)	3.66	3.58	0.62	1.10	4.61
Size (log)	5.58	5.33	0.79	4.61	7.89
Horizon	67.07	75.00	29.00	0.00	100.00
Option awareness	-0.02	0.23	0.97	-4.02	1.40
Endogenous uncertainty resolution	0.01	0.05	0.88	-2.24	2.03
Sequential low commitment	0.02	0.03	0.89	-2.07	1.67
Reallocation	-0.01	0.00	0.94	-2.03	2.05
	(1)	(2)	(3)	(4)	(5)
(1) Option awareness	-				
(2) Endogenous uncertainty resolution	0.41***	-			
(3) Sequential low commitment	0.30***	0.41***	-		
(4) Reallocation	0.42***	0.42***	0.41***	-	
(5) Growth	0.12	0.23**	-0.02	0.05	-

Note:
[i] All correlations at and above $|0.25|$ are significant at $p < 0.05$.
[ii] Square root of AVE is greater than interfactor correlations.
[iii] Values for option awareness, endogenous uncertainty resolution, sequential low commitment, and reallocation are based on the factor values extracted from the exploratory factor analysis

7.4. Results

Complementarity between ROR choice variables

We predict complementarity between the three choice variables – reallocation, endogenous uncertainty resolution, and sequential low commitment – in H1, H2, and H3. Such complementarity implies joint implementation of the choice variables. We follow the literature and estimate the conditional correlations between the three choice variables (Grabner, 2014; Grabner and Moers, 2013; Masschelein and Moers, 2020). As such, we correlate the residuals of the following three OLS regressions:

$$REAL = \alpha + \beta_1 SHADOW + \beta_2 SIZE + \beta_3 AGE + \beta_4 HOST + \beta_5 STRATEGY + \beta_6 SHORT \\ + \beta_7 GROWTH + \beta_8 SLACK + \epsilon$$

$$EUR = \alpha + \beta_1 SHADOW + \beta_2 SIZE + \beta_3 AGE + \beta_4 HOST + \beta_5 STRATEGY + \beta_6 SHORT \\ + \beta_7 GROWTH + \beta_8 SLACK + \epsilon$$

$$SLC = \alpha + \beta_1 SHADOW + \beta_2 SIZE + \beta_3 AGE + \beta_4 HOST + \beta_5 STRATEGY + \beta_6 SHORT \\ + \beta_7 GROWTH + \beta_8 SLACK + \epsilon$$

Correlation between the error terms reflects a relationship between the choice variables that is not caused by their joint determinants. We split the sample at the median of environmental dynamism to assess whether the complementarity differs as a result of uncertainty. We compare conditional correlations in each group. Table 7-6 reports the regression analysis of the joint determinants of the ROR choice variables. Reallocation increases with option awareness and size. Endogenous uncertainty resolution also increases with option awareness and is used to a greater extent by firms operating in a hostile environment. Sequential low commitment also increases with option awareness and environmental hostility and is used to a lesser extent by firms with a short-term horizon.

Table 7-6: Regression analysis

	REAL		EUR		SLC	
	beta	T	beta	t	beta	t
(Intercept)	-1.284	-1.035	-1.944	-1.822*	0.248	0.212
Size	0.246	2.125**	0.150	1.512	0.044	0.4
Option awareness	0.333	3.416***	0.408	4.861***	0.373	4.042***
Growth opportunities	0.054	0.491	0.135	1.438	-0.144	-1.392
Hostility	0.132	1.033	0.234	2.129**	0.268	2.221**
Short-term horizon	-0.003	-0.898	-0.003	-1.201	-0.007	-2.33**

Age		-0.189	-1.175	-0.122	-0.884	-0.086	-0.564
Slack		-0.021	-1.359	0.004	0.301	-0.006	-0.431
Adj. R.squared		0.16***		0.29***		0.17***	

Note:
[i] * p < 0.10; ** p < 0.05; *** p < 0.01.
[ii] All regression models included the five strategy dummies, with Prospectors as the reference category.

In Table 7-7, we report the conditional correlations of the residuals for the two subgroups that we create by splitting the sample on the median value of environmental dynamism. In accordance with our expectations in H1, H2, and H3, all correlations are positive and significant for the high environmental dynamism sample, while the correlations are low and insignificant for the low environmental dynamism sample. We compute statistical differences between the groups using a Fischer transformation and report these results in Table 7-8. We find that the correlations are significantly different at $p < 0.05$ for the correlation between reallocation and sequential low commitment, and at $p < 0.01$ for the correlation between reallocation and endogenous uncertainty resolution, as well as between endogenous uncertainty resolution and sequential low commitment. The results of the analysis support H1, H2, and H3 by showing that complementarity between the ROR choice variables is higher for firms operating in a context of high environmental dynamism.

Table 7-7: Conditional residual correlations

	High dynamism				Low dynamism		
	REAL	EUR	SLC		REAL	EUR	SLC
REAL	-			REAL	-		
EUR	0.608***	-		EUR	0.207	-	
SLC	0.529***	0.586***	-	SLC	0.199	0.244	-

Note:
[i] * p < 0.10; ** p < 0.05; *** p < 0.01

Table 7-8: Z-test for the difference in conditional residual correlation

P.values for z-test of differences			
	REAL	EUR	SLC
REAL	-		
EUR	0.009***	-	
SLC	0.037**	0.023***	-

Note:
[i] * p < 0.10; ** p < 0.05; *** p < 0.01
[ii] P.values for z-test of differences corresponds to p.values for one-sided test.

Likelihood of implementing high levels of all ROR choice variables

In H4, we predict that the likelihood of choosing to implement high levels of all ROR choice variables increases with the level of environmental dynamism. We test this hypothesis by estimating the following probit model:

$$P(HIHIHI) = \alpha + \beta_1 DYN + \beta_2 SHADOW + \beta_3 SIZE + \beta_4 AGE + \beta_5 HOST + \beta_6 STRATEGY$$
$$+ \beta_7 SHORT + \beta_8 GROWTH + \beta_9 SLACK + \epsilon$$

We use HIHIHI to represent a binary variable that takes the value of 1 if reallocation, endogenous uncertainty resolution, and sequential low commitment are all above the sample median value, and 0 otherwise. Table 7-9 reports the results from the probit models. We present two specifications of the model. In Model 1, we let environmental dynamism be a continuous variable. To increase the comparability of the results with those of the previous section, we specify Model 2 with environmental dynamism as a binary variable that takes the value of 1 if environmental dynamism is above the sample median, and 0 otherwise. Of the sample firms, 27% scored 1 on the HIHIHI measure, and 20% are in the high environmental dynamism group. In accordance with our expectations, environmental dynamism is positive and significant at $p < 0.01$ in both Model 1 and Model 2. We compute fit measures for the models using guidelines from Wooldridge (2002). Model significance and pseudo R squared are at acceptable levels for both model specifications. Our results indicate that the probability of choosing high use of all three ROR choice variables increases with environmental dynamism. The results, therefore, support H4.

Table 7-9: Probit regression analysis

| | Model 1 | | Model 2 | |
	beta	z-value	beta	z-value
Intercept	-4.233	-1.809*	-1.012	-0.481
Size	0.297	1.533	0.257	1.358
Option awareness	0.385	1.956*	0.483	2.355**
Growth opportunities	0.024	0.128	-0.025	-0.133
Hostility	-0.144	-0.534	-0.043	-0.174
Short-term horizon	-0.006	-1.069	-0.008	-1.347
Age	-0.014	-0.054	-0.231	-0.907
Slack	0.009	0.337	0.023	0.915
Dynamism	0.657	2.630***	0.987	2.677***
p < chi.square	0.022		0.020	
Pseudo R.squared	0.174		0.176	

Note:
[i] * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.
[ii] All regression models included the five strategy dummies, with Prospectors as the reference category.

[iii] Model 1 includes a continuous measure of dynamism, whereas in model 2, dynamism is a binary variable specified as unity if dynamism is above the median and zero otherwise.

Alternative ROR variable measurement

To improve the completeness of our analyses, we make an alternative variable measurement of our ROR constructs. In the previous analyses, we apply factor scores that are extracted from the exploratory factor analyses. As an alternative, we compute the four ROR constructs as the average of individual items. The conditional correlation analysis is robust to this specification. Correlations in the high environmental dynamism sample are still high and significant, while correlations in the low environmental dynamism sample are low and insignificant. We observe a difference in the significance level for the difference between reallocation and sequential low commitment, which drops to $p < 0.10$, while the rest remains unchanged. As such, H1, H2, and H3 are robust to the alternative specification. We also reassess the probit model with the alternative ROR computation. Environmental dynamism continues to be positive and significant at $p < 0.01$. Therefore, H4 is also robust to the alternative specification.

7.5. Conclusion

In our study, we show that firms operating in a context of high environmental uncertainty have a preference for implementing ROR choice variables. We argue that the choice variables of ROR are complementary, such that an increase in the level of one choice variable will decrease the costs associated with another. We show that the joint implementation of sequential low commitment, endogenous uncertainty resolution, and reallocation is selected in a context of high environmental uncertainty. We identify conditions under which the ROR choice variables are complementary, and thereby contribute to the understanding of the costs associated with ROR implementation in an uncertain context.

Our study contributes to the area of ROR on several levels. Like Klingebiel and Adner (2015), we contribute with conceptual clarity by explicating the multidimensionality of ROR as a construct by developing separate measures for the choice variables in ROR. Further, we bring clarity to the interdependence between the ROR constructs. Contingency factors such as environmental uncertainty are important to consider, not only when testing for performance effects (Verdu *et al.*, 2012), but also when examining the joint implementation of ROR dimensions. Our study also contributes to an important empirical gap in the ROR literature regarding the appropriateness of using ROR when uncertainty is resolved endogenously (Adner and Levinthal, 2004; Cuypers and Martin, 2010). We thus address a long-standing call for ROR research demonstrating patterns of systematic and structured decision-making (Adner and Levinthal, 2004). By explicitly showing a fit between endogenous uncertainty resolution and systematic reallocation procedures, we provide a contribution to the discussion of whether ROR with endogenous uncertainty resolution should be abandoned altogether, with the indication that it should not.

There are several limitations to our study, and our results should be interpreted in light of these limitations. Our instruments for the ROR choice variables are based on newly developed survey items, and while these exhibited satisfactory properties, we encourage more research in this area to further develop and validate the ROR instruments. We base our analyses on cross-sectional data, which has implications for causal inference. We let prior empirical studies and theory inform our choice of control variables, but we cannot rule out that omitted variables are driving our results. However, for the conditional correlation analyses, omitted variables are unlikely to drive the results since we assess the difference between subsamples. Our study is conducted on a small sample size with a relatively low response rate. Even though the tests on non-response bias indicate a representative sample, this is a limitation of our study. In the alternative specification of the conditional correlations, we observe a drop in significance to $p < 0.10$ for the difference in correlation between reallocation and sequential low commitment. Determining statistical significance can be arbitrary, but Chenhall *et al.* (2011) argue that results in the range of 0.05–0.10 should at least be acknowledged as indicators of interest that are not completely due to chance[15].

Our study supports the hypotheses for complementarity between sequential low commitment, endogenous uncertainty resolution, and reallocation in a context of high uncertainty. However, it is not clear whether the complementarity observed in this study would be present if we took a finer-grained look at the different ways of implementing the ROR choice variables. For example, reallocation measures the extent to which clear boundaries are set forth when further capital commitments can be allocated to an investment. Such boundaries could potentially be set using financial objectives such as IRR, but might also be based on consumer sentiment. Future research could provide further insights on the more fine-grained mechanisms that managers use to select opportunities (Barnett, 2008).

7.6. Appendix: List of survey items

Real options reasoning

Please rate the extent to which your organization's investment behavior is in accordance with the following statements

Option awareness

Prior to an investment, we consider the potential future trajectories of its inherent opportunities (e.g. deferment, expansion, flexibility, redeployment, etc.)

Future opportunities are important for the decision to make an initial investment

The firm's future opportunities are contingent on our prior investments

Endogenous uncertainty resolution

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[15] Reporting findings at the $p < 0.10$ significance level is not uncommon in management accounting research (see, e.g., Ittner et al. (2003a, 2003b) and Chapman and Kihn (2009)).

We observe our environment on a continual basis to assess if an opportunity has become profitable

We observe our environment on a continual basis to assess if an opportunity is about to expire (e.g. patent expiration, competitive entry, etc.)

We put continual effort into creating value from the opportunities that are embedded in our investments

Sequential low commitment

When the uncertainty about an investment's outcome is resolved/low, we commit larger sums of capital

When the uncertainty about an investment's outcome is high, we commit smaller sums of capital

We realize our opportunities when we feel certain that we have resolved the uncertainty about its outcome

Reallocation

We clearly define which opportunities are inherent in an investment before committing capital to the initial investment

We clearly define under which circumstances an opportunity should be deferred or abandoned before committing capital to the initial investment

We clearly define under which circumstances an opportunity can be allocated further capital prior to the initial investment

Note:
[i] Scale: 1 = Very low extent; 2 = Low extent; 3 = Somewhat low extent; 4 = Neither low/high extent; 5 = Somewhat high extent; 6 = High extent; 7 = Very high extent

Environmental hostility

Over the past two years…

How intense you rate the competition for your primary products/services (1 = very low intensity, 7 = very high intensity)

How difficult has it been to acquire the necessary input for your business (1 = very low difficulty, 7 = very high difficulty)

How many strategic opportunities has been available for your business (1 = extremely few, 7 extremely many)

Environmental dynamism

Over the past two years, how predicable or unpredictable have important changes in your external environment been with regard to the following?

Customer (e.g. demand, preferences)

Suppliers (e.g. key markets, quality of resources)

Competitors (e.g. competitors entering/exiting, tactics, strategies)

Technology (e.g. R&D, process innovations)

Regulations (e.g. economics, processes)

Note:
[i] Scale: 1 = Very predictable; 2 = Predictable; 3 = Somewhat predictable; 4 = Neither predictable/unpredictable; 5 = Somewhat unpredictable; 6 = Unpredictable; 7 = Very unpredictable

Growth opportunities

What are your expectations to the growth opportunities that exists in the industry that you compete in?
What are your expectations to the growth opportunities that your organization has?

Note:
i Scale: 1 = Strong decrease, 2 = Decrease, 3 = Somewhat decrease, 4 = Neither decrease/increase, 5 = Somewhat increase, 6 = Increase, 7 = Strong Increase

Short-term horizon

Please rate the percentage of time used on activities that will show in the income statement within… (Sum must be 100)
1 month or less
1 month to 1 quarter
1 quarter to 1 year
1 year to 3 years
3 years to 5 years
More than 5 years

7.7. References

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Chapter 8. Relative exploration orientation and real options reasoning: Survey evidence from Denmark

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Abstract

Purpose: We aim to extend the understanding of how real options reasoning (ROR) is associated with downside risk, and how a firm's portfolio (explore and exploit) of investment activities affects managers' ability to effectively apply ROR in relation to downside risk.

Design/Methodology: The survey method is used. It is applied to a population of Danish firms, which in 2018 had more than 100 employees. The CFO was the target respondent.

Results: We find that a higher level of ROR is associated with lower levels of downside risk. ROR's association with lower levels of downside risk is also moderated by the level of relative exploration orientation in a negative direction.

Originality: The field of real options reasoning (ROR) research on downside risk and portfolio subadditivity has been dominated by research focused on multinationality. We extend extant literature on ROR by studying ROR as a multidimensional construct of firm action, which is associated with lower levels of downside risk, also when studied outside of a multinationality setting. This is the case when ROR is implemented as a complete system. This paper also applies a framework of exploitation and exploration to show that findings on subadditivity in options portfolios caused by asset correlations extend outside the scope of multinationality and into one of product/service innovation.

Key words: Real options reasoning, relative exploration orientation, downside risk, capital budgeting

8.1. Introduction

Our aim in this paper is to extend the understanding of how real options reasoning (ROR) is associated with downside risk, and how a firm's portfolio of investment activities affects managers' ability to effectively apply ROR. We are motivated by the literature on downside risk and subadditivity. Formally, downside risk is a probability-

weighted function of below-target performance outcomes (Reuer and Leiblein, 2000), and for the purpose of this study, it is considered as failure to meet an aspired to level of performance. Subadditivity considers the effectiveness of ROR when investment activities have correlated uncertainty profiles (Belderbos *et al.*, 2014, 2019; Belderbos and Zou, 2009; Ioulianou *et al.*, 2020; Li and Chi, 2013; McGrath, 1997; McGrath and Nerkar, 2004; Vassolo *et al.*, 2004).

Compared to static resource allocation regimes such as net present value (NPV), ROR is appealing to managers because it considers the value of managerial flexibility as an investment project develops (Bowman and Hurry, 1993). ROR provides options to defer or commit to a small investment, which can provide an option to take advantage of potential future opportunities, while reducing the financial commitment and thus lower downside risk in the event that conditions unfold unfavorably (Ipsmiller *et al.*, 2019; McGrath, 1997). Theory suggests that real options are associated with lower levels of downside risk because real options enable firms to benefit from uncertainties by flexibly managing them to their own advantage (Bowman and Hurry, 1993; McGrath, 1997). This inherent flexibility can enable firms to benefit from the environmental uncertainty that they face by proactively approaching the uncertainty in terms of how it affects the value of its strategic investments. Real options resemble financial options in that the underlying asset's volatility positively relates to the option value since the potential gains increase, while the costs remain constant. Potential profits thus increase while potential losses remain fixed to the cost of the option. The same is true for a real option, though for a real option it is the variance of assets' expected returns, which drives the potential profits, thus making uncertainty an accelerator for real option value (McGrath, 1999). Firms that operate under uncertainty may commit small sums of capital to investments, which provides options to act on future contingent opportunities (Ipsmiller *et al.*, 2019). Small initial commitments limit financial loss, thus limiting the downside risk if events unfold unfavorably (McGrath, 1997). ROR is intended to aid managers' decision-making under uncertain conditions (Ipsmiller *et al.*, 2019). The flexibility that ROR builds into the capital budgeting process allows managers to make future adjustments to investment decisions in order to protect firms from downside risk while maintaining access to upside potential (Copeland and Keenan, 1998; Krychowski and Quélin, 2010).

The extant empirical ROR literature has paid substantial attention to testing the relationship between ROR and downside risk. This relationship has mostly been studied in the context of multinational enterprises (MNE) based on the premise that MNEs possess real switching options, which for example allows them to shift production between sites in order to optimize changing macroeconomic conditions, and thereby reduce downside risk (Reuer and Leiblein, 2000). This relationship has been studied and confirmed in various contexts (see e.g. Reuer and Tong (2007); Andersen (2011, 2012); Driouchi and Bennett (2011)), and more recent studies have shown that the relationship is contingent on low correlation between MNE's switching options (Belderbos *et al.*, 2014; Ioulianou *et al.*, 2020). While RORs relation to downside risk has been mainly occupied by MNE researchers, other ROR scholars have studied the individual

constructs of ROR such as low initial commitment, sequential investments, and reallocation policies in the context of other strategic investments such as product/service innovation (Cuypers and Martin, 2010; Klingebiel and Adner, 2015). Further, survey research within ROR such as Verdu *et al.* (2012) has also considered the case of product/service innovation and found that in a context of high environmental uncertainty, ROR increases firms' innovativeness. As such, prior research on ROR and downside risk is largely limited to the context of MNEs. Recent results also suggest that if multiple options in a portfolio are correlated, they may interact negatively, causing the portfolio to be considered subadditive, which means that the option value of the portfolio is smaller than the sum of the options considered individually (Belderbos *et al.*, 2014; Girotra *et al.*, 2007; McGrath, 1997; Vassolo *et al.*, 2004).

We propose two hypotheses: 1) a higher level of ROR is associated with lower levels of downside risk, and 2) ROR's association with lower levels of downside risk is moderated by the level of relative exploration orientation in a negative direction. A key question in this paper is whether the relationship between higher levels of ROR and lower levels of downside risk extends outside the context of MNEs and into the context of ROR as a multidimensional construct, where companies´ simultaneous use of these constructs is required to produce the expected benefits. Further, whether the negative moderating effect of correlation in the options portfolio extends into the context of product/service innovation. We believe these are important questions to address in order to advance research on ROR. Studies on MNEs and studies of ROR as multidimensional constructs represent two separate lines of ROR research. ROR research on MNEs and JVs (e.g. Andersen (2011, 2012); Driouchi and Bennett (2011); Elango (2010); Tong and Reuer (2007)) studies the effect of having an asset that may constitute a real option, but not necessarily how a firm manages such asset. Studies on ROR as a multidimensional construct (e.g. Klingebiel and Adner (2015)) study whether managerial behavior is consistent with ROR. Because methods for real options valuation are complex and may require multiple sets of complex calculations (Bowman and Moskowitz, 2001), only few firms explicitly assess the financial value of real options (Rigby, 2001). As a result, many firms engage in ROR as a way to guide their strategic investments, meaning that they recognize their existence and behave in ways consistent with capturing real option value (Barnett, 2008; Busby and Pitts, 1997; McGrath and Nerkar, 2004). While prior studies have already shown some of the effects of possessing assets with real option-like features, there is still much to discover about how managers translate ROR behavior into tangible outcomes.

The data used in this study comes from a questionnaire distributed to Danish companies with more than 100 employees. We expand on the data collected in the empirical section. To test the hypotheses, we relied on conceptual constructs already known in the ROR literature, but as survey research in ROR is scarce, the survey items are newly developed for the purpose of this study. We find support for both our hypotheses. As such, this paper extends the literature on ROR and downside risk outside the context of MNEs and into the literature of ROR as a multidimensional construct. Extending findings on

the relationship between ROR and downside risk outside the scope of MNEs is important as it addresses the distinguishment of two separate ROR approaches to managing uncertainty. The two ROR approaches pertain to 'wait and see' and 'act and see' (Adner and Levinthal, 2004a; Barnett, 2008). ROR in the context of MNEs represents a 'wait and see' strategy, meaning a two-step approach to 1) obtain an option position for a period of time and 2) exercise or abandon the position (Barnett, 2008; Bowman and Moskowitz, 2001). Specifically, an MNE would wait and see if the macroeconomic conditions changed in a way that would make it preferable to switch production sites. Since macroeconomic fluctuations are outside the scope of a firm's influence, no active action would be taken to further the exercisability of the option. We specifically model into our measure the 'act and see' approach to ROR. This means that management takes an active effort to increase the likelihood of a project's success (Barnett, 2008; McGrath, 1997). We thus contribute with empirical findings showing that the relationship between ROR and lower levels of downside risk extends from a 'wait-and-see' to an 'act-and-see' ROR regime. We also extend the literature on the role of option portfolio correlation, and its moderating effect on ROR's relation to downside risk (Belderbos et al., 2014; Ioulianou et al., 2020), into the context of product/service innovation by applying March's (1991) framework of exploitation and exploration activities. Extending the literature into the context of product/service innovation further strengthens the contribution of showing ROR's impact on downside risk in an 'act-and-see' regime because product/service innovation explicitly represents an 'act-and-see' option (Cuypers and Martin, 2010). Our paper also contributes to the area of ROR research in the context of product/service innovation (Cuypers and Martin, 2010; Klingebiel and Adner, 2015; Verdu et al., 2012), which has not yet studied the effect of ROR on downside risk. As we study ROR in a context of balancing exploration with exploitation to show that ROR firms will favor from exploring well beyond current activities, we also add empirical insight to the discussion of antecedents in favor of ambidexterity (Berard and Fréchet, 2020). We believe that this is an important topic as exploration and exploitation activities are important strategic decisions for firms' long-term survival (Raisch and Birkinshaw, 2008), and as ROR has downside risk-reducing properties their combination may be particularly important for efficient capital allocation. Inefficient allocation of scarce resources will likely lead to value destruction (Arnold and Hatzopoulos, 2000), and as such, strong financial management is a crucial element in a firm's long-term success and survival (Bennouna et al., 2010), and the allocation of resources among alternative capital investment projects is one of the most pressing top management priorities, when implementing strategy (Bowman and Hurry, 1993; McGrath et al., 2004).

The remainder of this paper contains four sections. In section 2, we review the background literature on ROR and develop our hypotheses. Section 3 describes the research method, including data collection and variable measurement. Section 4 presents the results, and in section 5, we discuss the results and concludes the paper.

8.2. Background and hypotheses

Empirical studies on ROR have been dominated by strategic management scholars (Ipsmiller *et al.*, 2019), where the logic behind ROR is used rather than the determination of actual option value (Driouchi and Bennett, 2012). Such studies mainly focus on the value drivers of ROR, such as uncertainty. Examples include the line of research on multinationality, as discussed in the introduction, as well as other proxies of real options, such as joint ventures, equity alliances, acquisitions, etc. (Folta, 1998; Folta and Miller, 2002; Kogut, 1991; Leiblein and Miller, 2003; Tong and Li, 2013). One of the most researched outcomes of ROR is downside risk. This literature has been dominated by studies using multinationality and international joint ventures (IJV) as proxies for switching and growth options, respectively. Reuer and Leiblein (2000) argued that multinationality resembles a real option in that it enables managerial flexibility. Firms with multiple production sites can in the event of fluctuating exchange rates shift production between sites to optimally hedge their exposures and consequently reduce downside risk (Reuer and Leiblein, 2000). Additionally, changes in local demand may instead mean that multinationality can proxy a growth option, as the firm will be able to stage investments in local markets where demand is increasing (Reuer and Leiblein, 2000). Tong and Reuer (2007) confirmed the relationship and showed that cultural differences in firms' portfolios may exaggerate the coordination costs of operating a multinational corporation (MNC). Reasons include limits to leveraging brand, technology, and other knowledge, as well as issues of post-merger integration or additional costs in connection with international acquisitions (Tong and Reuer, 2007).

Reuer and Leiblein (2000) initially failed to confirm a significant relationship between multinationality and downside risk and pointed out that failure to confirm the relation could include a lack of control for management's actual adoption of an options approach to investments, that is, even though the company owns what could constitute a real option, there is no guarantee that management recognizes its value. The importance of such managerial awareness has later been highlighted by various scholars (Driouchi and Bennett, 2011; Ioulianou *et al.*, 2020). Driouchi and Bennett (2011) for example, included a measure of a firm's exposure to managerial training on the topic of real options. Their results showed that investment in knowledge acquisition of real options leads MNCs to outperform competitors with a lack of real option training in terms of downside risk.

While the literature has shown that managerial awareness of strategic options is an important factor in realizing returns to ROR, prior research has also shown that managers' ability to effectively realize returns to ROR is dependent on the firm's portfolio of investment activities. The results of prior studies suggest that if multiple options in a portfolio are correlated, they may interact negatively, causing the portfolio to be considered subadditive, which means that the option value of the portfolio is smaller than the sum of the options considered individually (Belderbos *et al.*, 2014; McGrath, 1997). As such, if a firm's strategic options overlap or duplicate because their uncertainty profiles are correlated, then the option value of the portfolio is reduced (Belderbos and

Zou, 2009; Girotra *et al.*, 2007; Vassolo *et al.*, 2004). Belderbos *et al.* (2014) argue that multinational firms' option portfolios will suffer from subadditivity when the economic conditions of the host countries are positively correlated. Such correlation decreases the flexibility to shift operations across countries. They find that the relationship between multinationality and downside risk is negatively moderated by the level of subadditivity. Similarly, Ioulianou *et al.* (2020) argue that the geographic dispersion of MNE affiliates increases the dispersion of possible likely outcomes, and that this lowers the portfolio correlation. They show that higher dispersion (lower correlation between affiliates) increases MNE's ability to reduce downside risk.

8.2.1. Hypotheses

As the above review of empirical ROR research suggests, there has been much interest in testing the relationship between ROR and lower levels of downside risk. In this paper, we are interested in expanding our understanding of this relationship, and because we utilize a newly developed conceptualization of ROR, we find it important to validate this conceptualization by confirming the base case finding of prior studies – that ROR is associated with lower levels of downside risk outside the context of MNEs. Complementarity theory specifies that the interaction and change in different organizational choice variables influence organizational performance (Roberts, 2007). Many interactions could be of interest when studying ROR (see for example Barnett (2008)), where in this paper we are particularly interested in portfolio constellation. Developing survey constructs to measure ROR opens an array of opportunities to study specific pairs of variables and how they interact with ROR, which could greatly improve our understanding of how firms successfully implement ROR.

ROR firms will make sequential investments by initially only committing small amounts of capital to learn about an opportunity if uncertainty is high (McGrath, 2001; McGrath *et al.*, 2004). This provides the firm with the option to wait or postpone action until further knowledge about the profitability is obtained (Copeland and Keenan, 1998; Krychowski and Quélin, 2010). As such, in contrast to resource allocation regimes such as NPV, which assumes deterministic futures (Dixit and Pindyck, 1994), ROR firms recognize that there is value in maintaining the flexibility to abandon the investment if events unfold unfavorably (Li and Chi, 2013; O'Brien and Folta, 2009; Vassolo *et al.*, 2004). To maintain such flexibility, ROR firms will develop routines designed to develop knowledge about the value of their strategic investments (Barnett, 2008). Thus, rather than launching a project and assuming that its developmental trajectory is static, ROR firms will take an active role in developing the project towards knowledge and certainty about its profitability (Barnett, 2005). If a project has developed unfavorably, such knowledge about a project's profitability allows the firm to shield its downside risk by abandoning the project with only a limited initial commitment, and instead reallocate resources to more promising projects. While both sequential capital commitment and uncertainty resolving routines are subject to managerial biases (Adner, 2007; Adner and Levinthal, 2004b; Cuypers and Martin, 2010; Klingebiel and Adner, 2015), ROR firms

mitigate such biases through reallocation policies. Reallocation policies aim to mitigate the problem of escalation of commitment that arises when negative information about an investment's development is occasionally interrupted by positive developments. Such occurrences tend to escalate the probability that managers pursue opportunities that should otherwise have been abandoned (Adner, 2007). Consequently, appropriate implementation of ROR includes explicitly defined circumstances under which an investment project is allocated further capital or is abandoned (Adner, 2007). Explicit boundaries aid managers in mitigating the issue by informing them when an option is no longer worth pursuing (Song *et al.*, 2015), thus preserving the value of abandonment. Consequently, ROR firms should experience lower levels of downside risk.

H1: *A higher level of ROR is associated with a lower level of downside risk.*

In this study, we are interested in how a firm's portfolio of investment activities may affect managers' ability to effectively manage options in their strategic investments. Cuypers and Martin (2010) and Klingebiel and Adner (2015) considered firms' investments in product/service innovation as real options, and we follow this line of thought by applying March's (1991) concepts of exploitation and exploration, which are both fundamental concepts in firms' attempts to be competitive in changing environments (Jurksiene and Pundziene, 2016). Exploitation is defined as investments in activities such as refinement, production, efficiency, implementation, and execution, whereas exploration captures investments such as search, variation, experimentation, discovery, and innovation (March, 1991). There is a greater variance of payoffs attached to exploration investments, and prior research shows that exploitation and exploration have opposite relations with environmental dynamism (uncertainty). Exploitation efforts yield higher performance when environmental dynamism is low, while exploration efforts yield higher performance effects when environmental dynamism is high (Raisch and Birkinshaw, 2008). Therefore, when a firm invests in exploitation, it builds on a portfolio of activities that thrives under the current environmental conditions. Contrary, investing in exploration means that the firm is building on a portfolio of activities that will only thrive if the current environmental conditions change. Consequently, if the environmental conditions change in favor of exploration activities, this likely means that exploitation activities will no longer be worth pursuing (Raisch and Birkinshaw, 2008). If exploration activities become profitable due to an environmental change that leaves exploitation activities with lower or no profits, it must mean that exploration and exploitation activities have either low or no correlation. (March, 1991) argues, and empirical studies (Cao *et al.*, 2009; He and Wong, 2004) show that maintaining a balance between exploitation and exploration activities is optimal for performance. The balance may also have implications for the use of ROR in the extent to which a firm emphasizes exploration activities over exploitation activities, which we will term 'relative exploration orientation', as in Uotila *et al.* (2009). Firms with a low degree of relative exploration orientation primarily conduct exploitation activities, while firms with a high degree of relative exploration orientation primarily conduct exploration activities. Given the above discussion, firms with a low degree of relative exploration orientation will have a portfolio

of investment activities optimized to benefit from current environmental conditions and will thus consist of activities with cash flows highly correlated with current operations. As the relative exploration orientation increases, the portfolio becomes increasingly optimized to benefit from environmental changes, i.e., changes that will likely seize cash flows from exploitation activities. As such, a higher extent of relative exploration orientation will yield a lower correlation between cash flows in the portfolio of investment activities and the current operations.

Dixit and Pindyck (1994) have suggested that a reasonable assumption for firms pursuing a ROR strategy would be that firms favor exploratory research well beyond the scope of current activities, and further, that decisions regarding investments ought to be studied in the context of a portfolio of investments. Correlation is suggested to be one of the key mechanisms that affect the value of options embedded in a portfolio of activities (Girotra *et al.*, 2007; Johnson, 1987; Margrabe, 1978; Stulz, 1982; Trigeorgis, 1993, 2005). A high positive correlation between options means that they are likely exercisable at the same point in time, thus having the same underlying factors driving their respective returns. A high negative correlation, on the other hand, means that an option is not likely exercisable at the time where another option is exercisable due to differences in the underlying factors driving their respective returns (Li and Chi, 2013). As such, a key factor affecting the combined value of multiple options is the correlation between factors that drives the exercisability of the different options. This means that in a portfolio with multiple options, the correlation between the return on the assets determines the likelihood that they will be exercisable at the same time. Portfolios with a high positive correlation between returns constitute a poor hedge against risk, as the portfolio faces the risk of being completely left 'out of money' if the 'right' circumstances present themselves (Li and Chi, 2013).

The benefits of ROR with regard to lower levels of downside risk are realized through the managerial discretion to withdraw or scale down a project (Li and Chi, 2013; McGrath, 1997), which we argue is determined by the correlation among projects in the portfolio of investment activities. Lower levels of portfolio correlation increase the dispersion of possible outcomes, which is characteristic of environments with high uncertainty (Ioulianou *et al.*, 2020). This is optimal for a portfolio with higher levels of relative exploration orientation (Raisch and Birkinshaw, 2008). Prior research shows that when correlations among portfolio projects are high, firms are found to have higher termination rates (Belderbos and Zou, 2009; Vassolo *et al.*, 2004). A project termination has a direct effect on losses and thus the level of downside risk, but firms with a high relative exploration orientation will likely find that effect less severe. Exploratory projects most often involve considerable uncertainty and are distant from the firm's core capabilities (March, 1991; Vassolo *et al.*, 2004). As the option value of a project increases with the level of environmental uncertainty, the option value of exploratory projects should be higher than that of an exploitative project. Exploratory projects have a higher chance of developing into profitable projects when environmental uncertainty is high (Raisch and Birkinshaw, 2008). With higher exposure to exploratory projects, the

portfolio variety increases, and thus the chance of advantage under uncertainty (McGrath and Nerkar, 2004). As such, ROR firms will prefer to maintain the option open to gain future possible rents. In the case, that an exploratory project is indeed withdrawn from, a ROR firm has invested with the downside limiting behavior of small initial investments, which reduces the downside risk (Bowman and Hurry, 1993; Ipsmiller *et al.*, 2019; McGrath and Nerkar, 2004). However, we believe that ROR firms with low levels of relative exploration orientation will have difficulties in limiting the downside risk. As exploitation builds on the competencies close to the firm's current operations, a low relative exploration portfolio will be prone to duplication, and thus projects with higher correlation to current operations. Such duplication makes the portfolio more vulnerable to environmental uncertainty, and thus a less effective hedge against downside risk (Li and Chi, 2013). The more overlap a project has with existing operations, the more redundant is its option value (Belderbos and Zou, 2009). Because changes due to environmental uncertainty are likely to negatively affect or seize profitability of exploitation projects, ROR firms will find only little or no option value in maintaining the options open (Belderbos and Zou, 2009). Hence, ROR firms will have a higher propensity to withdraw from such projects, but ROR firm's risk-limiting behavior of investing with small initial commitments will be less impactful for exploitation projects because the correlation with existing operations will likely mean that the firm is abandoning a project in which it is already heavily invested. We consequently predict that managers' ability to effectively manage a ROR approach is moderated by the level of relative exploration orientation.

H2: *ROR's association with lower levels of downside risk is moderated by the level of relative exploration orientation in a negative direction.*

8.3. Methods

8.3.1. Data

For this study, we administered an online questionnaire addressed to CFOs in Danish companies with more than 100 employees. The questionnaire was distributed in the summer period of 2018. Firms with more than 100 employees were chosen to increase the chance of obtaining data from firms with formalized policies regarding investments. We originally sent the questionnaire to 1056 organizations and we used the recommendations for survey research by Dillman *et al.*, (2014). To encourage participation, the respondents could opt-in for a summary of the findings by the end of the survey. We distributed an e-mail targeted directly to the target person (CFO), when possible, and otherwise to the e-mail address listed in the organization's contact information. The e-mail contained an electronic link to the questionnaire. After three weeks, we sent out a reminder accompanied by a signed letter. We sent out two further reminders, each with three weeks in between, where we supplemented the former by contacting the respondents through telephone to increase interest in the study. We obtained a final sample of 94 firms, and thus a usable response rate of 8.9%, which is

similar to other survey-based ROR studies (e.g. Brouthers and Dikova (2010) and Verdu *et al.* (2012)). The respondents had an average tenure of 10.6 years in the organization, and 7.2 years in their current position. We included a question about involvement in the organization's investment decisions as a way of ensuring that the responses originated from appropriate sources in the organizations. We assessed the involvement on a scale from 1-7 (1 = no involvement at all, 7 = extremely high involvement), and we obtained an average score of 6.0 for the sample.

We rely on a single method in our study, so the data may be subject to common method bias, although this may not necessarily be the case (Speklé and Widener, 2018). We took several design measures to limit the potential of common method bias. We designed the questionnaire with a temporal separation, meaning that we introduced a time lag between measuring the dependent and the independent variables. Temporal separation has the benefit of reducing the saliency of contextually provided retrieval cues, and it reduces the respondent's ability to use the previous answer as a guide to later answers (Podsakoff *et al.*, 2003). We also ensured the respondents that we would protect their anonymity, which should reduce respondents' apprehension to answer more socially desirable, lenient, acquiescent, and consistent (Podsakoff *et al.*, 2003). At last, common method bias is especially distortive in bivariate correlations (Speklé and Widener, 2018). While we are interested in bivariate relationships, all regressions used in this study are multivariate, which mitigates the occurrence of common method bias as long as the additional variables exhibit low to moderate correlation (≤ 0.30) with the dependent and independent variables (Speklé and Widener, 2018). This is confirmed by examining the correlation matrix in Table 8-6, except for the relationship between environmental dynamism and relative exploration orientation, which we know from the extant literature to be highly correlated (Raisch and Birkinshaw, 2008). Since the sample size and response rate are relatively low, we made a range of non-response bias tests to establish proof of sample representativeness. As in other small sample size survey studies (e.g. Bedford *et al.* (2019) and Hall (2008)), we compared industry representativeness and firm size of our sample firms to that of the full list of firms that originally received the questionnaire. We assess the difference in mean firm size between the two groups with a t-test. The comparison of our sample mean firm size ($\bar{X} = 392$) to the full list mean firm size ($\bar{X} = 406$), do not differ by statistical significance (t = 0.58, p > 0.10). We used a χ^2-test to test for differences in the industry proportions between our sample and the full list of firms. The results indicate that our industry proportions are representative of the full list, as the test produces insignificant differences ($\chi^2 = 11.73$, degrees of freedom = 8, p > 0.10). We present the industry classifications for the sample firms in Table 8-1. We conduct a final test for late response bias, comparing the scores for all variables between the first 25% and last 25% of responses. We executed the tests with t-test (results not reported here) and found no significant differences for any variables. For all financial accounting-based variables used in the study, we obtained data from Navne og Numre Erhverv, a Bisnode administered comprehensive database for firm level data on Danish firms.

Table 8-1: Industry classification

DB07* industry classification	Frequency	%
Administrative services	6	6%
Construction and civil engineering	8	9%
Wholesale and retail	15	16%
Real estate	2	2%
Manufacturing	33	35%
Liberal, scientific and technical services	6	6%
Information and communication	5	5%
Accommodation facilities and restaurants	1	1%
Transportation and freight handling	7	7%
Other	11	12%
Total sample	**94**	**100%**

Note:
[i] *DB07 - Danish standard industry classification

8.3.2. Variable measurement

We applied a mix of variables in this study, some of which are previously developed and empirically tested constructs, while others are newly developed measures. New measures pertain to the four constructs of ROR as well as two measures of perceived downside risk. The following subsections describe all constructs. All survey items were measured on a seven-point Likert scale, and we provide labels for each point on the scale to reduce measurement error and response bias. Eutsler and Lang (2015) conclude that this approach is superior to five- or nine-point Likert scales and that labeling is superior to scales that only labels at the ends. It pertains to all survey constructs, formative and reflective, that they are computed as the average of their items.

Dependent variables

Downside risk: Reuer and Leiblein (2000) argue that "formally stated, downside risk is a probability-weighted function of below-target performance outcomes". In a review of variance-based measures of risk in finance theory, behavioral decision theory, and management research, Miller and Reuer (1996) find several rationales for moving toward a downside conceptualization of risk. Reuer and Leiblein (2000) argue that in particular, a downside conceptualization incorporates reference levels, which are identified as determinants of risk preferences in behavioral decision theory, thus indirectly controlling for risk appetite. The reason being that performance and aspiration constructs are central to managers' concept of risk (Miller and Leiblein, 1996). They reviewed past surveys of managers' perception of risk and mention studies such as March and Shapira (1987), who found that negative outcomes were the sole focus of risk consideration for 80 percent of the surveyed executives. March and Shapira (1987) argue that managers' decision-making considers risk not as variance in outcomes, but rather as negative outcomes. Further, out of seven definitions of risk, Baird and Thomas (1990) found that financial analysts

considered size and probability of loss as the most important. As such, Miller and Leiblein (1996) argue that the surveys suggest that failure to meet an aspired to level of performance is the best-suited conceptualization of downside risk. Further, Reuer and Leiblein (2000) argue that the downside conceptualization is a particularly good fit for studying the outcomes of real options theory, as real options reasoning seeks to cushion only against the downside of variation.

For our operationalization of downside risk [DSR], we apply both traditional measures used in prior ROR studies, while also responding to calls for increased use of perceived measures in ROR research (e.g. Ipsmiller *et al.* (2019)). While several measures of downside risk have been used in the past, Miller and Reuer (1996) argue that while variance considers the entire distribution of outcomes, downside risk measures should explicitly incorporate a reference level, such as a target or aspiration. Studies that have used downside risk operationalization with such reference features include Andersen (2011, 2012), Reuer and Leiblein (2000), and Tong and Reuer (2007). We follow this convention and use one of the measures introduced by Reuer and Leiblein (2000), where the firm's prior year return on assets (ROA) and return on equity (ROE) are used as reference levels.

$$Downside\ risk, ROA_i = \sqrt{\frac{1}{2} \sum_{ROA_i < BROA_i} (BROA_i - ROA_i)^2}$$

Where ROA_i is firms i's ROA, and $BROA_i$ (benchmark ROA) is firm i's ROA in the preceding year. The squared difference term is summed over the two years 2016-2017[16], in those years where the firm fell short of this benchmark. We use a similar conceptualization, Downside risk, ROE, where we apply the same method but replace ROA with ROE.

We also apply two newly developed constructs that have been adapted from other contexts. These are intended to measure downside risk in terms of the managerially perceived chance of obtaining below target performance outcomes on the organization's investment activities. To operationalize such perceived chances of obtaining outcomes from investments that fall below the objectives, we sought distant works of literature for items with similar intentions. We draw on Grewal *et al.*'s (1994) operationalization of Bauer's (1960) definition of performance risk. "Perceived performance risk refers to the possibility that the product will not function as expected and/or will not provide the desired benefit" - (Grewal *et al.*, 1994). We modify the measure to fit the purpose of this paper with two different conceptualizations. We term the first construct, Perceived downside risk, business (DSR_business), and define three items intended to assess an investment's risk in terms of the perceived chance of performing in accordance with

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[16] The period chosen matches the period in which investments in relative exploration orientation is measured.

expectations set at the time of investment (bdsr1). Additionally, the chance of an investment performing the expected features (bdsr2), and the chance of an investment performing with the expected functionality (bdsr3). For ease of interpretation, we reverse code the items to reflect that more downside risk corresponds to a higher score. We term the second construct, Perceived downside risk, financial ($DSR_{financial}$), and ask the respondents to assess the perceived overall risk of allocating capital to an investment project (fdsr1). The risk of a capital allocation to an investment project due to events that will increase operational costs (fdsr2), and the perceived risk of a capital allocation to an investment project given the financial costs associated with the average investment project (fdsr3).

Independent variables

Real options reasoning [ROR]. In this paper, we have developed four new constructs to conceptualize a measure of ROR. We reviewed the literature on ROR to establish the basis for the scale development of ROR. In doing so we followed the guidance of Bisbe *et al.* (2007) and Hinkin (1998) for defining survey constructs. Based on a total of 12 survey items, the constructs pertain to (1) option awareness, (2) sequential low commitment, (3) active uncertainty resolution, and (4) reallocation. The use of multiple constructs is not entirely new in the ROR literature. Klingebiel and Adner (2015) for example applied multiple constructs. In this paper, we are not particularly interested in the relationships between the individual ROR constructs, but rather the effect of ROR in connection with exploration and exploitation investments. As such, we choose to collapse the individual constructs into a single measure. In collapsing the constructs into a single composite, we exclude option awareness and treats this separately from the other constructs. This mirrors the practice of prior research including an option awareness measure such as Driouchi and Bennett (2011) and Ioulianou *et al.* (2020). Option awareness is not a key variable in developing the hypotheses relating ROR to outcome variables. We, therefore, believe that option awareness is an important control variable, but not a core part of linking ROR to outcomes. In the following, we introduce the constructs used in this paper.

Sequential low commitment [SLC] refers to the resource allocation policy applied in the context of ROR. In contrast to the static assumptions used in resource allocation regimes such as NPV (Bowman and Hurry, 1993; Dixit and Pindyck, 1994), ROR firms do not assume deterministic futures, and will invest in projects sequentially and with low initial commitment which allows a firm to reduce downside risk, if the events unfold unfavorably, but maintains the option of taking advantage of future opportunities, if events unfold favorably (Ipsmiller *et al.*, 2019; Li and Chi, 2013; Vassolo *et al.*, 2004). As such, the theory suggests that there is value in deferring full commitment to an investment project until the underlying uncertainty is resolved (Song *et al.*, 2015). We operationalize sequential low commitment with items intended to assess the degree to which management uses uncertainty to assess the size of capital commitments (slc1 and slc2), as well as the effect of resolving uncertainty on exercising options (slc3).

Active uncertainty resolution [AUR] refers to actions that will maintain an organization's access to opportunities, which means establishing routines that maintain and develop knowledge about an option's value (Barnett, 2008). While the NPV technique fundamentally assumes that the project will be launched and then left on its own, ROR expects managers to take an active role throughout the lifetime of the project, where managers exert an ongoing effort to respond to changing conditions to maximize the assets' potential (Barnett, 2005). If such management of options is not executed, or if management misuses its discretion over investment decisions, the theoretical value of real options may never be realized (Barnett, 2008; Coff and Laverty, 2008; Song *et al.*, 2015). As such, a key part of ROR is to establish practices that produce the knowledge necessary to adapt to uncertainty (Driouchi and Bennett, 2012) and a flow of information that reduces uncertainty (Janney and Dess, 2004; McGrath and Nerkar, 2004). We ask about the extent to which management continuously observes the environment to make assessments of the value of the firm's options (aur1 and aur2), and we assess the extent to which management puts continuous effort into creating value from its options (aur3)

Reallocation [REAL] refers to how managerial boundaries are set with regard to capital commitments after the initial investment has been made. Reallocation has especially been promoted by Adner and Levinthal (2004a), who argue that to create value from ROR, firms must restrict the area in which their real options are defined. Appropriate implementation of ROR includes explicitly defined circumstances under which an investment project is allocated further capital or is abandoned (Adner, 2007). The justification of a well-specified reallocation policy is found in the managerial biases inherent in policies of both low initial commitment and endogenous uncertainty resolution. (Adner and Levinthal, 2004) argue that information about the value of an investment may improve managerial decision-making, but the flexibility is revealed in the abandonment decision. An option is flexible because, in the event of information about negative outcomes, it can be abandoned. However, low initial commitment often leads to escalation of commitment where there are no proper de-escalating procedures in place (Klingebiel and Adner, 2015). Reasons for such biases may be explained by a focus on sunk costs, personal interest, aversion to failure, and overconfidence (Camerer and Lovallo, 1999; Klingebiel and Adner, 2015; McGrath, 1999; Samuelson and Zeckhauser, 1988). As such, the effectiveness of sequential low commitment is conditional on firm procedures that ensure efficient reallocation of capital at later stages of the investment process. Further, actively resolving uncertainty may also lead to escalation of commitment in the absence of well-specified reallocation procedures (Adner and Levinthal, 2004a). Barnett (2008) argue that ROR firms will seek to reduce the uncertainty of a project from the time of the initial investment to the time of a potential subsequent investment, which implies a flow of information seeking to reduce adverse effects of uncertainty (Janney and Dess, 2004; McGrath and Nerkar, 2004). However, negative information about the development of an investment may not arrive all at once but be interrupted by occasional positive developments. According to Adner (2007), this escalates the chance that managers are convinced that an opportunity is worthy of continuation rather than abandonment. To mitigate such effects, ROR firms should set

explicit boundaries for real options to ensure that managers abandon options that are no longer worth pursuing (Song *et al.*, 2015). We operationalize reallocation by the extent to which management clearly specifies an asset's embedded options prior to investment in the said asset (real1), the extent to which circumstances for abandonment (real2), and further capital allocation (real3), are specified ex-ante of option acquisition.

Relative exploration orientation: We apply nine survey items for the exploitation [EXPLOIT] and exploration [EXPLORE] constructs, which were originally developed by Atuahene-Gima (2005) and are focused on product/service innovation. The constructs are recently empirically validated by Bedford *et al.* (2019), who modified the items to reflect ex-ante objectives, which is consistent with He and Wong (2004). We further refine the framing of the questions to fit the context of the current study by asking the respondents to state the extent to which the organization has prioritized capital investment projects in exploration and exploitation. We treat the items as reflective indicators of the two constructs. We compute a balanced dimension, which constitutes our measure of relative exploration orientation [RelExp], which we operationalize with the ratio method used in Jancenelle (2019), Uotila *et al.* (2009), and Wang and Dass (2017), where the level of exploration is divided by the total level of exploration and exploitation[17].

Control variables

We include a number of control variables in the model. McGrath (2001) argues that size may have important implications for measures of innovation and thereby willingness to take on options. Sorensen and Stuart (2000), for example, showed that larger firms tend to put heavier reliance on previous work for innovations. Additionally, larger firms are likely to have more resources available for slack purposes (Lubatkin *et al.*, 2006). We take a measure of size [SIZE] as the logarithm of the number of employees. Multiple scholars have argued that performance effects on exploration and exploitation are affected by environmental factors, such as unpredictability and competitiveness (Birkinshaw and Gibson, 2004; Levinthal and March, 1993; Siggelkow and Levinthal, 2003). To account for the environmental factors, we apply environmental dynamism and environmental hostility. Both measures are previously empirically validated in studies such as Bedford (2015) and Jansen *et al.* (2006). Environmental hostility is a measure of competitiveness and the degree of pressure for market demand, resources, and growth opportunities (Dess and Beard, 1984; Miller and Friesen, 1983). Hostility increases the attractiveness of exploitation while limiting profitability from exploration due to increased risk (Levinthal and March, 1993; Zahra, 1996). Environmental hostility may also have implications for ROR, as it may decrease the managers' focus on venturing into new areas (Wang and Dass, 2017), thus reducing the variance of expected outcomes. While firms may be encouraged to increase innovativeness to compete (Drechsler and Natter, 2012; Weerawardena *et al.*, 2006), tense competition increases the challenges of finding unique opportunities to act on and therefore makes the search, learning, and action more costly (Wang and Dass, 2017). Based on Miller and Friesen (1983) and Tan and Litschert (1994),

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[17] Relative exploration orientation = exploration/(exploration + exploitation).

environmental hostility [HOST] is constructed as an index of three dimensions. A central concept in the ROR literature is the concept of uncertainty, which refers to an inability to anticipate future developments that may have a material impact on the firm (Song *et al.*, 2015). Song *et al.* (2015) argue that the measure chosen for uncertainty should relate to the context in which managers make investment decisions, and measures should be taken to find a measure that represents meaningful sources of uncertainty, which are relevant to decision-makers. As such, for this study, we apply environmental dynamism [DYN] as a proxy for uncertainty, which has been empirically validated in Bedford (2015) and Jansen *et al.* (2006). Environmental dynamism measures the predictability of the firm's environment (Dess and Beard, 1984). Dynamism is measured as an index of five dimensions, as in Chenhall and Morris (1993) and Gordon and Narayanan (1984). The dimensions do not necessarily relate to each other, hence, we measure them as a formative construct. Jahanshahi and Zhang (2015) argue that ROR studies should include firm age [AGE] as an important control variable. Younger firms tend to pursue radical innovations to a higher degree than their older counterparts. Firm age can be measured as the natural logarithm of the number of years that the firm has been in existence (Jahanshahi and Zhang, 2015). We follow this convention. Short-term horizon may impede the firm's benefits from ROR, as it focuses managerial attention on viewing volatility only in terms of its downside (Wright *et al.*, 2007). This can lead to an avoidance of pursuing longer-term payoffs involving greater uncertainty (Hoskisson *et al.*, 1993; Shijun, 2004). Indeed, Alessandri *et al.* (2012) find that short-term incentives impede incentives to pursue valuable growth opportunities. We consequently control short-term horizon and growth opportunities. We measure managerial short-term horizon [SHORT], as in Merchant (1990), by the percentage of resources allocated to activities that will show up in the income statement within one year. We measure growth opportunities [GROWTH] as two item constructs intended to assess the managerially perceived growth opportunities for the organization and within the industry as in Abernethy *et al.* (2004). Organizational slack may be an important determinant of organizational responses, and Miller and Leiblein (1996) argue that any model of downside risk should include a measure of slack. We follow previous conventions and take a measure of organizational slack [SLACK] as SG&A over sales. Last, we control for *Option awareness* [AWARE], which refers managers' awareness of opportunities to acquire option-generating resources (Barnett, 2008). Adner and Levinthal (2004b) argue that the underlying logic of real options is that future opportunities are contingent on past investments and Bowman and Hurry (1993) note that organizations develop as they pursue strategic opportunities, but that these opportunities are contingent on their resources. Bowman and Hurry (1993) argue that such opportunities for change only exist to the degree that managers recognize that investments in resources hold strategic opportunities. Driouchi and Bennett (2011) showed that managerial awareness of real options were important for MNC's ability to reduce their downside risk. They argue that shadowing is the firm's managerial aptitude to actually recognize that its assets hold embedded real options, which can be proxied by the extent to which managers pay attention to option-like opportunities (Barnett, 2005, 2008). Options awareness is operationalized with three items, covering management's consideration of an

investment's options, such as abandonment, expansion, etc. (aware1). We further asked about the importance of acquiring options (aware2), and the degree to which the firm recognize that future opportunities are contingent on prior investments in resources (aware3).

8.3.3. Exploratory and confirmatory factor analyses

Our measures for ROR and perceived downside risk are based on newly developed scales, while the remaining constructs are previously validated. We assess the latent factors for the new measures using exploratory factor analysis (EFA) with maximum likelihood extraction with Varimax rotation.

Table 8-2: Exploratory factor analysis (ROR)

	REAL	**AWARE**	**SLC**	**AUR**
aware1		0.738		
aware2		0.465		
aware3		0.915		
aur1				0.608
aur2				0.651
aur4				0.589
slc1			0.841	
slc2			0.602	
slc3			0.567	
real1	0.570			
real2	0.883			
real3	0.875			
Eigenvalue	4.668	1.520	1.452	1.035
Cum. variance explained	0.390	0.510	0.640	0.720
KMO	0.786			
Bartlett's test of spherecity	0.000			

Note:
[i] Maximum likelihood extraction with Varimax factor rotation. Loadings lower than 0.4 suppressed

Results of the analyses are reported in Tables 8-2 and 8-3. The EFA analysis for ROR, reported in Table 8-2 shows four factors with eigenvalues above 1, and with 72% cumulative variance explained. We obtain a KMO of sampling adequacy of 0.79, and Bartlett's test of sphericity that is significant at $p < 0.000$ which is thus within the generally accepted levels (Hair Jr. *et al.*, 2014). The factors exhibit a Cronbach's α between 0.72 and 0.87, thereby confirming acceptable reliability for all ROR constructs (see Table 8-4). Table 8-3 reports the results of the EFA for the perceived downside risk measures. Cumulative variance explained is 60%, KMO is 0.75, and we obtain Cronbach's α between 0.87 and 0.69.

Table 8-3: Exploratory factor analysis (Downside risk)

	Perceived downside risk, business	Perceived downside risk, financial
bdsr1	0.78	
bdsr2	0.82	
bdsr3	0.90	
fdsr1		0.91
fdsr2		0.41
fdsr3		0.66
Eigenvalue	2.723	1.563
Cum. variance explained	0.360	0.600
KMO	0.751	
Bartlett's test of spherecity	0.000	

Note:
[i] Maximum likelihood extraction with Varimax factor rotation. Loadings lower than 0.4 suppressed

We report the results of a confirmatory factor analysis (CFA) in Table 8-4[18]. As recommended by Kline (2011), we evaluate the model fit with a range of fit indices. We assess the Comparative Fit Index (CFI) (Bentler, 1990), the Tucker Lewis Index (TLI) (Tucker and Lewis, 1973), and Incremental Fit Index (IFI) (Bollen, 1989). All three indices are evaluated based on their closeness to 1 and are all at acceptable levels since all are above 0.9 (Bentler, 1992; Kline, 2011). The root mean square error of approximation (RMSEA), as well as the standardized root mean square residual (SRMR) are both at satisfactory levels as RMSEA is below 0.08, and SRMR is below 0.1 (Browne and Cudeck, 1993; Kline, 2011; Schermelleh-Engel *et al.*, 2003). The χ^2 to degrees of freedom is below 3, and thereby indicating an acceptable fit (Kline, 2011). The model reports composite reliability (CR) levels above 0.6, and can consequently be accepted as reliable (Hair Jr. *et al.*, 2014). Further, all standardized coefficients (factor loadings) are above 0.5 (Bagozzi and Yi, 1988). Discriminant validity is supported, as the square root of the average variance extracted (AVE) is greater than any correlations among the reflective factors (Chin, 1998). We present all correlations in Table 8-6 and descriptive statistics in Table 8-5.

Table 8-4: Confirmatory factor analysis

Latent variable indicators	Standardized loadings	z-value (all sig. at $p < 0.01$)	Composite reliability	Cronbach's alpha	Square root of average variance extracted (AVE)
AWARE			0.777	0.761	0.736
aware1	0.772				

[18] Table 8-4 reports the results of a CFA with DSR$_{business}$ as the only outcome variable. We performed separate CFAs including the other outcome variable, DSR$_{financial}$. The results obtained with the other outcome variables do not alter the conclusions regarding reliability and validity.

aware2	0.928	7.323			
aware3	0.548	5.330			
AUR			0.738	0.742	0.697
aur1	0.688				
aur2	0.656	5.388			
aur3	0.757	5.939			
SLC			0.757	0.717	0.727
slc1	0.91				
slc2	0.626	5.112			
slc3	0.541	4.600			
REAL			0.888	0.864	0.858
real1	0.618				
real2	0.928	7.071			
real3	0.941	7.081			
EXPLOIT			0.782	0.813	0.731
exploit1	0.856				
exploit2	0.671	6.692			
exploit3	0.503	4.694			
exploit4	0.778	7.774			
EXPLORE			0.849	0.880	0.765
explore1	0.693				
explore2	0.818	7.314			
explore3	0.732	8.088			
explore4	0.899	7.942			
explore5	0.646	5.818			
DSR$_{business}$			0.870	0.864	0.832
bdsr1	0.801				
bdsr2	0.822	8.636			
bdsr3	0.884	9.016			

Note:
[i] RMSEA: 0.063, SRMR: 0.076, CFI: 0.925, TLI: 909, IFI: 0.928, Chi-squared to degrees of freedom: 1.39 (314.895/227).
[ii] Blank cells in z-value column indicates loadings fixed to 1.

Table 8-5: Descriptive statistics

	Mean	Median	St.dev	Min	Max
Size (log)	5.55	5.22	0.76	4.61	7.38
Age (log)	3.66	3.58	0.62	0.00	4.61
Slack	2.30	1.15	3.72	0.02	27.72
Growth opportunities	5.24	5.50	0.87	2.50	7.00
Short-term horizon	66.54	77.50	29.88	0.00	100.00
Hostility	4.80	5.00	0.72	2.00	6.33
Dynamism	4.34	4.40	0.82	2.20	6.60
Option awareness	5.68	6.00	0.77	3.67	7.00

Reallocation	4.16	4.00	1.31	1.00	7.00
Active uncertainty resolution	4.71	4.67	1.14	1.67	7.00
Sequential low commitment	4.31	4.33	1.10	2.00	6.33
Exploration	4.58	4.80	1.31	1.00	7.00
Exploitation	5.06	5.25	1.06	2.00	7.00
Relative exploration	0.47	0.48	0.07	0.24	0.58
Perceived downside risk, business	2.85	3.00	0.88	1.00	5.33
Perceived downside risk, financial	3.23	3.17	0.87	1.67	5.00
Downside risk, roe	8.27	4.75	12.21	0.00	90.71
Downside risk, roa	3.37	1.90	4.98	0.00	34.32

8.3.4. Regression

We apply two types of cross-sectional regression models to test the hypotheses, depending on the dependent variable in question. For the perceived measures of risk, we apply ordinary least squares (OLS) regression analysis. As such, the OLS analyses pertain to models including $DSR_{business}$ and $DSR_{financial}$. For regressions including the downside risk measures based on ROA and ROE, a large part of the observations are suppressed to a lower level, in this case, zero, which may cause bias in OLS analysis (Wooldridge, 2002). Instead, we apply a Tobit regression model, which is a censored regression model. Such models apply when the dependent variable is partly continuous, but with a positive probability mass at one or more points (Wooldridge, 2002), which in this case would be at zero. The Tobit model was used for the same purpose in Reuer and Leiblein (2000). For our ROR measures, we construct a binary variable, ROR, that takes the value of 1 if [SLC], [AUR], and [REAL] are all above the median value, and 0 otherwise. The reason being that ROR is a system with separate elements that should all be implemented to gain the expected benefits. SLC for example is not unique to ROR and is also descriptive of other path-dependent capital allocation regimes (Adner and Levinthal, 2004a), and due to the behavioral biases of both SLC and AUR, we would not expect our predictions to hold if not in combination with REAL. In a systems view, all design elements are expected to be implemented as a response to optimize some outcome (Grabner and Moers, 2013), here downside risk. The method of defining a binary variable to represent the simultaneous implementation of system elements has previously been applied in accounting studies such as Grabner (2014). The regression model to test H1 takes the form:

$$Outcome_i = \alpha + \beta_1 ROR_i + \beta_2 RelExp_i + \beta_{...}Ctrls_i + \epsilon_i$$

, and the regression model to test H2 takes the form:

$$Outcome_i = \alpha + \beta_1 ROR_i + \beta_2 RelExp_i + \beta_3 ROR_i * RelExp_i + \beta_{...}Ctrls_i + \epsilon_i$$

Table 8-6: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) Size (log)	-																	
(2) Age (log)	0.00	-																
(3) Slack	0.21	0.01	-															
(4) GROWTH	-0.06	-0.1	0.1	-														
(5) SHORT	-0.03	-0.03	0.09	-0.02	-													
(6) HOST	0.08	-0.08	0.1	0.27	0.1	-												
(7) DYN	-0.04	-0.20	-0.01	0.06	0.16	0.54	-											
(8) AWARE	0.12	-0.02	0.15	0.29	0.05	0.23	0.17	-										
(9) REAL	0.24	-0.1	0.06	0.08	-0.12	0.08	0.21	0.39	-									
(10) AUR	0.27	-0.14	0.08	0.26	-0.1	0.28	0.23	0.45	0.35	-								
(11) SLC	0.12	-0.04	0.08	0.01	-0.12	0.13	0.24	0.2	0.51	0.42	-							
(12) EXPLORE	0.21	-0.14	0.1	0.05	-0.15	0.22	0.50	0.29	0.18	0.25	0.22	-						
(13) EXPLOIT	0.16	-0.09	0.16	0.07	-0.04	0.21	0.27	0.33	0.21	0.33	0.18	0.6	-					
(14) RelExp	0.13	-0.06	0.05	0.05	-0.09	0.14	0.41	0.13	0.10	0.20	0.12	0.71	-0.1	-				
(15) DSR_Business	-0.06	0.18	-0.13	-0.29	-0.20	-0.26	-0.07	-0.33	-0.25	-0.33	-0.21	-0.1	-0.23	0.03	-			
(16) DSR_Financial	-0.05	0.13	0.05	0.13	-0.17	0.18	0.23	0.03	0.07	0.09	-0.03	0.19	0.18	0.09	0.23	-		
(17) DSR_ROE	0.04	0.12	-0.1	-0.01	0.05	0.01	-0.05	0.16	-0.03	0.03	0.13	-0.16	-0.21	-0.03	0.01	0.04	-	
(18) DSR_ROA	0.03	0.03	-0.08	-0.1	-0.12	0.03	0.13	-0.06	0.02	-0.01	0.08	0.12	0.08	0.07	0.08	0.1	0.48	-
(19) ROR*	0.22	-0.07	0.01	0.11	-0.08	0.05	0.23	0.28	0.65	0.52	0.49	0.29	0.25	0.06	-0.3	-0.2	-0.1	-0.06

Note:
i Correlation at and above |0.20| significant at $p < 0.05$
* ROR is a dummy variable, taking the value of 1 if REAL, AUR and SLC are all above their median and 0 otherwise

, where $Outcome_i$ refers to the dependent variables, which are the various conceptualizations of downside risk.

8.4. Results

Prior to estimation, we follow traditional conventions and winsorize all financial accounting variables at the 5th and 95th percentile level based on two-digit industry classification[19]. We mean center independent and moderator variables prior to estimating the regression to eliminate issues of multicollinearity (Cohen *et al.*, 2003). Table 7 reports the results of the regression models pertaining to H1. The results in Table 7 provide support for H1 with regard to the perceived measures of downside risk. ROR is significantly negatively associated with $DSR_{business}$ (β = -0.60, t = -3.1, p < 0.01) and $DSR_{financial}$ (β = -0.58, t = -2.86, p < 0.05). However, while the results reported in Table 7 provides coefficients in the predicted direction, the analyses fail to provide a significant association between ROR and the accounting-based measures of DSR, and H1 is thus only partially supported.

In Table 8, we present the results pertaining to H2. We find a significant negative moderation effect (β = -5.66, t = -1.97, p < 0.10) for $DSR_{business}$. Likewise, for $DSR_{financial}$ we observe a negative and significant moderation effect (β = -6.41, t = -2.17, p < 0.05).

Table 8-7: Regression results H1

Dependent variable	Perceived DSR, business		Perceived DSR, financial	
	beta	t value	beta	t value
Intercept	3.053	1.924*	1.105	0.674
Size	0.063	0.491	-0.078	-0.591
Growth opportunities	-0.096	-0.908	0.200	1.828*
Short-termism	-0.007	-2.262**	-0.007	-2.022**
Age	0.259	1.847*	0.343	2.362**
Slack	-0.015	-0.619	-0.007	-0.288
Hostility	-0.335	-2.164**	-0.048	-0.301
Dynamism	0.356	2.178**	0.331	1.963*
Option awareness	-0.145	-1.122	0.013	0.099
Exploitation	-0.207	-0.683	-0.103	-0.330
Exploration	0.091	0.263	0.322	0.901
Relative exploration	-2.288	-0.422	-5.236	-0.934
ROR	-0.602	-3.097***	-0.575	-2.859**
Adj. R-squared		0.227***		0.146**

Dependent variable	DSR_{ROA}		DSR_{ROE}	
	beta	z value	beta	z value
Intercept	0.288	3.441***	-0.396	-1.397
Size	-0.001	-0.138	0.016	0.711
Growth opportunities	-0.005	-0.815	-0.006	-0.336
Short-termism	0.000	-0.142	0.000	0.533

[19] We also test for the alternative specification with winsorization at the 1st and 99th percentile level. The alternative specification does not alter the conclusions of the study.

	beta	t value		Beta	t value
Age	0.006	0.764		0.013	0.514
Slack	-0.002	-1.159		-0.006	-1.143
Hostility	-0.011	-1.396		-0.009	-0.334
Dynamism	0.020	2.308**		0.039	1.323
Option awareness	0.009	1.355		0.059	2.525**
Exploitation	-0.008	-0.487		-0.053	-0.994
Exploration	0.013	0.698		0.020	0.329
Relative exploration	-0.266	-0.935		-0.772	-0.813
ROR	-0.007	-0.710		-0.024	-0.693
Log-likelihood		118			25
Wald		85***			26.81

Note:

i * = p < 0.1, ** = p< 0.05, *** = p< 0.01

We thus find support for H2 based on the perceived measures of downside risk. For DSR_{ROA}, we obtain a significant moderation effect (β = -0.29, t = -1.94, p < 0.10), as predicted. For DSR_{ROE} we also obtain a significantly negative moderation effect (β = -0.89, t = -1.76, p < 0.10), and the Wald statistic borderline significant at p = 0.106.

Table 8-8: Regression results H2

Dependent variable	Perceived DSR, business			Perceived DSR, financial	
	beta	t value		Beta	t value
Intercept	2.894	1.858*		0.925	0.577
Size	0.104	0.818		-0.031	-0.240
Growth opportunities	-0.090	-0.865		0.207	1.940*
Short-termism	-0.007	-2.399**		-0.007	-2.176**
Age	0.240	1.741*		0.321	2.264**
Slack	-0.021	-0.854		-0.014	-0.544
Hostility	-0.347	-2.286**		-0.062	-0.398
Dynamism	0.328	2.038**		0.300	1.812*
Option awareness	-0.127	-1.000		0.034	0.258
Exploitation	-0.369	-1.196		-0.287	-0.906
Exploration	0.267	0.761		0.522	1.447
Relative exploration	-3.169	-0.594		-6.234	-1.137
ROR	-0.604	-3.169***		-0.577	-2.943***
ROR * Rel. Exploration	-5.655	-1.970*		-6.411	-2.173**
Adj. R-squared		0.252***			0.188**

Dependent variable	DSR_{ROA}			DSR_{ROE}	
	beta	z value		Beta	z value
Intercept	0.284	3.450***		-0.406	-1.46
Size	0.001	0.163		0.023	1.002
Growth opportunities	-0.004	-0.769		-0.005	-0.293
Short-termism	0.000	-0.252		0.000	0.445
Age	0.004	0.611		0.009	0.356
Slack	-0.002	-1.372		-0.007	-1.344
Hostility	-0.012	-1.511		-0.011	-0.42
Dynamism	0.018	2.117**		0.032	1.122
Option awareness	0.010	1.534		0.062	2.683**
Exploitation	-0.017	-1.015		-0.080	-1.466
Exploration	0.023	1.214		0.051	0.815
Relative exploration	-0.319	-1.139		-0.938	-1.001
ROR	-0.008	-0.777		-0.026	-0.777

ROR * Rel. Exploration	-0.293	-1.935*	-0.890	-1.762*
Log-likelihood		119.9		26.54
Wald		91.87***		30.55

Note:

[i] * = p < 0.1, ** = p< 0.05, *** = p< 0.01

The results are in partial support of H1, where the results show that higher levels of ROR is significantly associated with lower levels of perceived $DSR_{business}$ and $DSR_{financial}$. While we do obtain coefficients in the predicted direction, the results are insignificant for the association between ROR and DSR_{ROA} and DSR_{ROE}. For H2, we find support across all measures of downside risk, though the regression model including DSR_{ROE} is only borderline significant at $p = 0.106$[20].

Figure 1 illustrates the moderation effects obtained from the regressions in Table 8. Figure 1 illustrates that the interaction effect in the models with perceived DSR measures is monotonic (Burkert *et al.*, 2014), meaning that the effect of ROR on DSR is negative across all levels of relative exploration, but more so when relative exploration is high. The moderation effect for the ROA and ROE based measured of DSR shows a symmetrical non-monotonic interaction (Gerdin and Greve, 2008), meaning that ROR is actually increasing DSR at low levels of relative exploration while decreasing at high levels of relative exploration. As such, for all the obtained moderation fits, the moderator variable alters the form of the relationship between ROR and downside risk in the expected direction.

Alternative specification

Since we have collapsed our ROR measure into a binary variable, we report a second set of regressions, where we include the individual effects of each part of the ROR system to show that the model is robust. As such, Tables 9 and 10 report results where we include the individual measures of SLC, AUR, and REAL to show the incremental effect of the ROR variable.
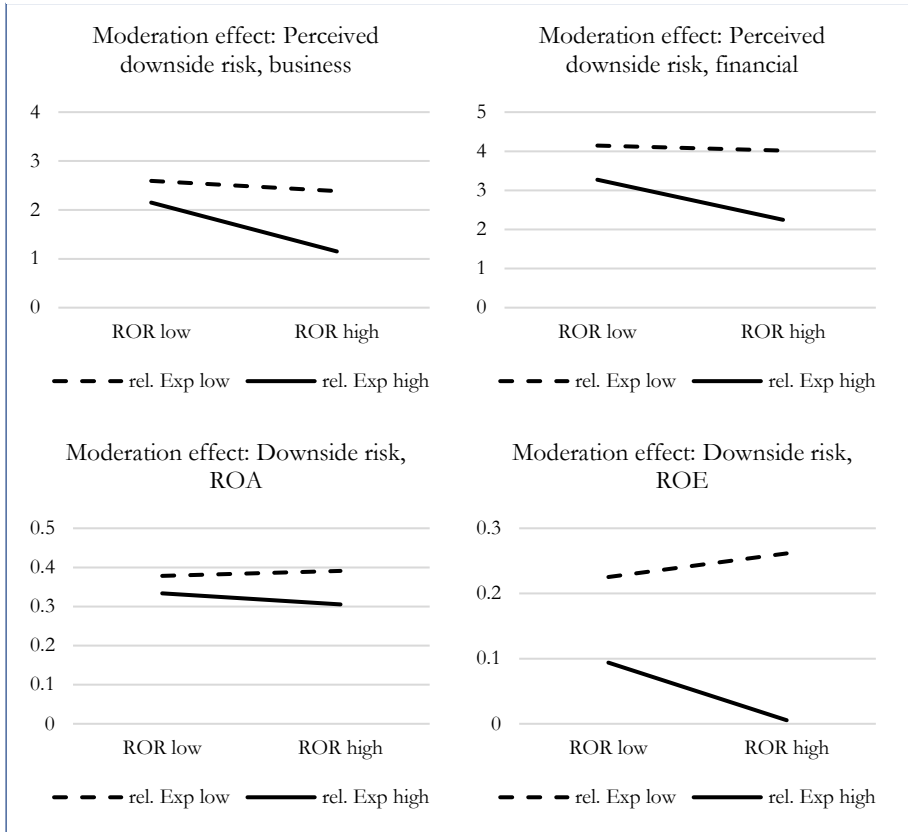
The model is robust to the inclusion of the individual effects. While we do observe an increase in the strength of significance levels, the results do not alter the conclusions

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[20] We specified the regressions in Table 8-7 and Table 8-8 with the inclusion of the exploration and exploitation variable, while we did not hypothesize on their direct effects. We included the variables to ensure that it is the ratio between them that drives the results and to control for the level of exploration and exploitation. For robustness, we also specified regressions excluding the exploration and exploitation measures. The results did not alter the conclusions, but the interaction term ROR * Relative exploration in Table 8-8 for the insignificant model with DSR_{ROE} as dependent variable becomes insignificant, which highlights the importance of controlling for the level of exploration and exploitation.

obtained in the section above, with the exception that for H2, the model including DSR_{ROE} is now significant at $p < 0.10$ rather than only borderline significant[21].

Figure 8-1

Moderation effect: Perceived downside risk, business

Moderation effect: Perceived downside risk, financial

Moderation effect: Downside risk, ROA

Moderation effect: Downside risk, ROE

Table 8-9: Alternative regression results H1

Dependent variable	Perceived DSR, business		Perceived DSR, financial	
	beta	t value	beta	t value
Intercept	3.325	1.996**	0.826	0.497
Size	0.060	0.453	-0.118	-0.897
Growth opportunities	-0.109	-0.986	0.194	1.762*
Short-termism	-0.008	-2.298**	-0.006	-1.784*
Age	0.257	1.785*	0.370	2.585**
Slack	-0.012	-0.489	-0.006	-0.237
Hostility	-0.332	-2.082**	-0.063	-0.394
Dynamism	0.368	2.19**	0.316	1.888*
Option awareness	-0.128	-0.890	-0.119	-0.832
Exploitation	-0.199	-0.642	-0.063	-0.203
Exploration	0.076	0.215	0.298	0.843
Relative exploration	-2.048	-0.369	-4.863	-0.880
ROR	-0.503	-1.853*	-0.924	-3.417***
Reallocation	-0.030	-0.320	0.181	1.922*
Active uncertainty resolution	0.008	0.075	0.110	1.047
Sequential low commitment	-0.058	-0.610	-0.038	-0.398
Adj. R-squared		0.193**		0.176**

Dependent variable	DSR_{ROA}		DSR_{ROE}	
	beta	z value	beta	z value
Intercept	0.257	3.028***	-0.507	-1.777*
Size	0.000	0.018	0.020	0.870
Growth opportunities	-0.003	-0.560	-0.002	-0.123
Short-termism	0.000	0.009	0.000	0.699
Age	0.005	0.750	0.012	0.487
Slack	-0.002	-1.462	-0.008	-1.467
Hostility	-0.013	-1.537	-0.015	-0.562
Dynamism	0.020	2.282**	0.038	1.312
Option awareness	0.010	1.391	0.064	2.548**
Exploitation	-0.009	-0.570	-0.058	-1.126
Exploration	0.014	0.763	0.025	0.421
Relative exploration	-0.292	-1.047	-0.888	-0.961
ROR	-0.012	-0.854	-0.039	-0.849
Reallocation	-0.002	-0.437	-0.013	-0.773
Active uncertainty resolution	-0.001	-0.209	0.001	0.066
Sequential low commitment	0.009	1.892*	0.034	2.079**
Log-likelihood		119.9		27.49
Wald		91.34***		32.31

Note:
[i] * = p < 0.1, ** = p< 0.05, *** = p< 0.01

Table 8-10: Alternative regression results H2

Dependent variable	Perceived DSR, business		Perceived DSR, financial	
	beta	t value	beta	t value
Intercept	3.209	1.967*	0.718	0.440
Size	0.109	0.823	-0.073	-0.556
Growth opportunities	-0.102	-0.938	0.201	1.855*
Short-termism	-0.008	-2.473**	-0.006	-1.933*
Age	0.233	1.648	0.348	2.465**
Slack	-0.018	-0.728	-0.011	-0.455
Hostility	-0.342	-2.188**	-0.072	-0.458
Dynamism	0.340	2.061**	0.290	1.758*
Option awareness	-0.092	-0.646	-0.085	-0.602
Exploitation	-0.373	-1.182	-0.225	-0.711
Exploration	0.264	0.734	0.472	1.312
Relative exploration	-3.015	-0.553	-5.761	-1.057
ROR	-0.457	-1.714*	-0.882	-3.304***
Reallocation	-0.051	-0.548	0.161	1.737*
Active uncertainty resolution	-0.010	-0.095	0.093	0.902
Sequential low commitment	-0.057	-0.610	-0.037	-0.393
ROR * Rel. Exploration	-5.902	-1.999**	-5.479	-1.855*
Adj. R-squared		0.227***		0.205**

Dependent variable	DSR_{ROA}		DSR_{ROE}	
	beta	z value	beta	z value
Intercept	0.255	3.075***	-0.508	-1.831*
Size	0.002	0.375	0.027	1.233
Growth opportunities	-0.003	-0.504	-0.001	-0.073
Short-termism	0.000	-0.146	0.000	0.566
Age	0.004	0.549	0.006	0.272
Slack	-0.003	-1.668*	-0.009	-1.681*
Hostility	-0.013	-1.670*	-0.018	-0.681
Dynamism	0.018	2.105**	0.031	1.114
Option awareness	0.013	1.704*	0.071	2.851***
Exploitation	-0.018	-1.147	-0.089	-1.68*
Exploration	0.024	1.318	0.060	0.977
Relative exploration	-0.348	-1.27	-1.076	-1.186
ROR	-0.010	-0.713	-0.032	-0.724
Reallocation	-0.003	-0.712	-0.018	-1.087
Active uncertainty resolution	-0.002	-0.337	0.000	-0.015
Sequential low commitment	0.009	1.926*	0.034	2.15**
ROR * Rel. Exploration	-0.309	-2.061**	-0.983	-1.986**
Log-likelihood		122		29.43
Wald		99.38***		37.01*

Note:
ⁱ* = p < 0.1, ** = p< 0.05, *** = p< 0.01

8.5. Conclusion

In this study, we show that firms with a high degree of ROR experience lower levels of downside risk. We also studied how this relationship is affected by other choice variables related to the characteristics of the capital investment portfolio, as measured by relative

exploration orientation. We show that the negative association between ROR and downside risk is moderated by the level of relative exploration orientation. Table 11 summarizes our findings.

Table 8-11: Results

	H1	H2
DSR$_{Business}$	+	+
DSR$_{Financial}$	+	+
DSR$_{ROA}$	%	+
DSR$_{ROE}$	%	(+)

Our findings extend the literature on ROR and downside risk, by confirming that the relationship is robust outside the scope of research on multinationality (Andersen, 2011, 2012; Driouchi and Bennett, 2011; Elango, 2010; Ioulianou *et al.*, 2020; Reuer and Leiblein, 2000; Reuer and Tong, 2007). We extend the literature by showing that the relationship is robust in the context of ROR as a multidimensional construct of firm action (Cuypers and Martin, 2010; Klingebiel and Adner, 2015). We also contribute to the literature on portfolio correlation and subadditivity in the ROR literature (Belderbos and Zou, 2009; Ioulianou *et al.*, 2020; Li and Chi, 2013; McGrath and Nerkar, 2004; Vassolo *et al.*, 2004; Ziedonis, 2007). By applying March's (1991) exploration and exploitation framework, we extend this literature into the context of product/service innovation (Cuypers and Martin, 2010; Klingebiel and Adner, 2015; Verdu *et al.*, 2012). In doing so, we also respond to some calls for research in the ROR literature. Trigeorgis and Reuer (2017) promote the collection of more primary data in order to examine the managerial decision-making aspects of ROR. Similarly, Ipsmiller *et al.* (2019) call for increased focus on perceptual measures in the ROR literature. We respond to such calls with the development of a survey-based instrument to assess the multidimensionality of ROR, and we adopt alternative risk outcome measures based on managerial perception. Our study also contributes with practical implications that inform managers about the potential benefits of implementing a ROR investment approach. Our study informs managers that the outcome of ROR depends on the portfolio of capital investment activities and that the portfolio, optimal for ROR, reflects one of high relative exploration orientation. The allocation of resources among alternative capital investment projects is one of the most pressing top management priorities when implementing strategy (Bowman and Hurry, 1993; McGrath *et al.*, 2004). Long-term survival will likely be dependent on an efficient capital allocation among both exploration and exploitation activities. However, each such activity introduces risk, and strong financial management is a crucial element for long-term survival and success (Bennouna *et al.*, 2010). In this paper, we show that ROR can be a key element for managers to reduce the downside element of risk, with important implications as to how managers can balance their exploration and exploitation activities when implementing ROR.

There are several limitations to the study, and the results should be interpreted in terms of these limitations. We apply several new survey instruments in this study, and while they exhibited satisfactory properties, future research should further develop and validate both the perceived risk measures and the ROR instruments. We apply cross-sectional data to test the hypotheses, which has implications for the causal inference. Though we let prior empirical studies, as well as theory, inform our choice of control variables, we cannot rule out that variables not included in the model drive the evidence. We conduct the study on a small sample size with a relatively low response rate, and while tests of non-response bias indicate a representative sample, the size and response rate is a limitation to the study. Additionally, some paths in our statistical models show only weak levels of statistical significance. While the determination of significance can be somewhat arbitrary, Chenhall *et al.* (2011) argue that results in the range of p-value 0.05-0.10 should at least be acknowledged as indicators of interest that are not completely due to chance[22].

Our study builds on the idea that exploratory activities have a lower correlation among projects. Theoretically, each such project should all be experimenting with new alternatives (March, 1991), and exploration only has a certain depth before it turns into exploration (Zollo and Winter, 2002). However, the breadth and depth of exploration and exploitation are not directly observable from our survey measures, and future studies could explore the implications of these concepts when studying ROR in combination with exploration and exploitation. Readers may have noticed from the correlation matrix in Table 6, that ROR correlates positively with exploitation, which may seem counterintuitive to our hypotheses. Prior literature has shown that exploitation and exploration are complementary in enhancing firm performance (Raisch and Birkinshaw, 2008), and we also observe a correlation in our data. Our results should not be seen as a promotion to abandon exploitation activities, but that ROR firms will benefit increasingly from exploring well beyond current activities. Exploration and exploitation are both important activities for firms' long-term survival (March, 1991), and future studies may examine the role of exploitation activities for ROR firms.

8.6. Appendix: List of survey items

Table A 1: Real options reasoning

Please rate the extent to which your organization's investment behavior is in accordance with the following statements
Option awareness
Prior to an investment, we consider the potential future trajectories of its inherent opportunities (e.g. deferment, expansion, flexibility, redeployment, etc.)

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[22] Reporting findings at the p < 0.10 significance level is not uncommon in management accounting research (see e.g. Chapman and Kihn (2009), Ittner, Larcker and Meyer (2003) and Ittner, Larcker and Randall (2003)).

Future opportunities are important for the decision to make an initial investment

The firm's future opportunities are contingent on our prior investments

Active uncertainty resolution

We observe our environment on a continual basis to assess if an opportunity has become profitable

We observe our environment on a continual basis to assess if an opportunity is about to expire (e.g. patent expiration, competitive entry, etc.)

We put continual effort into creating value from the opportunities that are embedded in our investments

Sequential low commitment

When the uncertainty about an investment's outcome is resolved/low, we commit larger sums of capital

When the uncertainty about an investment's outcome is high, we commit smaller sums of capital

We realize our opportunities when we feel certain that we have resolved the uncertainty about its outcome

Reallocation

We clearly define which opportunities are inherent in an investment before committing capital to the initial investment

We clearly define under which circumstances an opportunity should be deferred or abandoned before committing capital to the initial investment

We clearly define under which circumstances an opportunity can be allocated further capital prior to the initial investment

Note:
[i] Scale: 1 = Very low extent; 2 = Low extent; 3 = Somewhat low extent; 4 = Neither low/high extent; 5 = Somewhat high extent; 6 = High extent; 7 = Very high extent

Table A 2: Environmental hostility

Over the past two years…

How intense you rate the competition for your primary products/services (1 = very low intensity, 7 = very high intensity)

How difficult has it been to acquire the necessary input for your business (1 = very low difficulty, 7 = very high difficulty)

How many strategic opportunities have been available for your business (1 = extremely few, 7 extremely many)

Table A 3: Environmental dynamism

Over the past two years, how predicable or unpredictable have important changes in your external environment been with regard to the following?

Customer (e.g. demand, preferences)

Suppliers (e.g. key markets, quality of resources)

Competitors (e.g. competitors entering/exiting, tactics, strategies)

Technology (e.g. R&D, process innovations)

Regulations (e.g. economics, processes)

Note:
ⁱ Scale: 1 = Very predictable; 2 = Predictable; 3 = Somewhat predictable; 4 = Neither predictable/unpredictable; 5 = Somewhat unpredictable; 6 = Unpredictable; 7 = Very unpredictable

Table A 4: Growth opportunities

What are your expectations of the growth opportunities that exist in the industry that you compete in?
What are your expectations of the growth opportunities that your organization has?

Note:
i Scale: 1 = Strong decrease, 2 = Decrease, 3 = Somewhat decrease, 4 = Neither decrease/increase, 5 = Somewhat increase, 6 = Increase, 7 = Strong Increase

Table A 5: Short-term horizon

Please rate the percentage of time used on activities that will show in the income statement within... (Sum must be 100)
1 month or less
1 month to 1 quarter
1 quarter to 1 year
1 year to 3 years
3 years to 5 years
More than 5 years

Table A 6: Exploration and exploitation

Please indicate the extent to which the following have been prioritized investments of the organization that you lead over the last 2 years:

Exploration

Acquiring entirely new skills that are important for product/service innovation (such as identifying emerging markets and technologies; coordinating and integrating R&D, marketing, manufacturing, and other functions; managing the product development process)

Learning product/service development skills and processes entirely new to your industry (such as product design, prototyping new products, timing of new product introductions)

Acquiring product/service technologies and skills entirely new to the organization

Learning new skills in key product/service innovation-related areas (such as funding new technology, staffing R&D function, training and development of R&D, and engineering personnel for the first time)

Strengthening product/service innovation skills in areas where it had no prior experience

Exploitation

Upgrading current knowledge and skills for familiar products/services and technologies *

Investing in enhancing skills in exploiting mature technologies in your industry that improve productivity of current product/service innovation operations

Enhancing competencies in searching for solutions to customer problems that are near to existing solutions

Upgrading skills in product/service development processes in which the firm already possesses significant experience

Strengthening knowledge and skills for projects that improve efficiency of existing product/service innovation activities.

Note:
[i] Scale: 1 = Very low extent; 2 = Low extent; 3 = Somewhat low extent; 4 = Neither low/high extent; 5 = Somewhat high extent; 6 = High extent; 7 = Very high extent
[ii] * Dropped items

Table A 7: Perceived downside risk, business

How do you rate the chance that an average investment project will in your organization…
Reaches the performance expectations set at the time of the investment
Has the functionality expected at the time of the investment
Will overall function as expected at the time of the investment

Note:
[i] Scale: 1 = Very low chance; 2 = Low chance; 3 = Somewhat low chance; 4 = Neither low/high chance; 5 = Somewhat high chance; 6 = High chance; 7 = Very high chance
[ii] All items are reverse coded

Table A 8: Perceived downside risk, financial

How much overall risk is associated with allocating capital to an average investment project in your organization? (1 = very low risk, 7 = very high risk)
Please rate how likely you find the following statements (1 = very unlikely, 7 = very likely)
A capital allocation to an average investment project in your organization will lead to higher risk due to events that will lead to higher than expected operational costs?
A capital allocation to an average investment project in your organization will lead to higher risk due to events that will lead to higher than expected financial costs?

8.7. References

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