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ORIGINAL ARTICLE

Strategic and cultural contexts of real options reasoning in innovation portfolios

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Abstract

Decision makers find creating an innovation portfolio challenging, because more innovative projects are associated with a higher degree of uncertainty. In this study, we investigate the potential benefits of applying real options reasoning (ROR) in innovation portfolio management from an attention-based view. Using a sample of 137 innovation portfolios with multiple informants, we investigate ROR's influence on portfolio innovativeness and, ultimately, on portfolio success in a mediated model. Further, we analyze the moderating influence of an innovation portfolio's organizational context—entrepreneurial orientation and innovation climate—on ROR's application. The results support ROR's positive relationship to portfolio innovativeness and portfolio success. The analysis also supports the positive interaction between entrepreneurial orientation and ROR with respect to portfolio innovativeness. This study contributes to the literature by demonstrating the relationship between ROR and portfolio success, mediated by portfolio innovativeness. In addition, the study's analysis offers an explanation of previously mixed findings regarding ROR's benefits by considering the firm's strategic and cultural innovation contexts. The findings underline the relevance of strategic support for ROR's effectiveness in innovation portfolio management. Furthermore, the findings encourage managers to implement ROR, but also stress the essential contribution an entrepreneurial orientation makes when the managers do so.

KEYWORDS

entrepreneurial orientation, innovation portfolio management, portfolio innovativeness, real options reasoning

Practitioner Points

- Portfolios with a higher degree of innovativeness are also more successful.
- Real options reasoning (ROR) refers to portfolio managers implicitly applying real option logic when deciding on innovative projects' funding through sequential investment, low commitment to prior investment decisions, and constant resource reallocation to more promising projects.
- Managers should apply ROR to cope with innovative projects' uncertainty and venture more innovative projects, which increases overall portfolio innovativeness.

- ROR is especially effective for firms with a high entrepreneurial orientation, meaning high proactiveness, innovativeness, and risk-taking.

1 | INTRODUCTION

Innovation projects are associated with a high degree of uncertainty, which makes innovation portfolio management's decisions particularly challenging (Behrens & Ernst, 2014; Criscuolo et al., 2017; Kester et al., 2011; McNally et al., 2013; Schultz et al., 2013). As a behavioral approach to cope with projects' uncertainty, real options reasoning (ROR) has received significant attention in recent research (e.g., Andries & Hünermund, 2020; Klingebiel & Adner, 2015). Comparable to a financial option, a real option allows the holder to delay decisions regarding a project's investment (Myers, 1977). Thus, real options enable decision makers to limit innovative projects' adverse risks, while maintaining future beneficial potential (Bowman & Hurry, 1993). Explicitly calculating option value in practice is highly complex and rarely feasible (Bowman & Moskowitz, 2001). Therefore, with ROR, decision makers implicitly apply real option logic in their portfolio decisions (Adner & Levinthal, 2004b; McGrath et al., 2004).

According to Klingebiel and Adner (2015), three elements jointly define ROR. First, project investment is allocated sequentially over time. Decision makers start out using only a fraction of a project's budget, increasing the investment later if the project progresses as planned. Second, in each portfolio review, decision makers do not necessarily commit to previous investment decisions and can abandon unfavorable projects. Third, in each review, decision makers reallocate resources from unfavorable to more promising project options. Overall, ROR offers an approach to systematically cope with a project's uncertainty, to increase portfolio innovativeness, and eventually, to achieve portfolio success (Salomo et al., 2007; Schultz et al., 2013; Talke et al., 2011).

However, there is an ongoing debate in the literature on the actual performance benefits achieved by applying ROR (Adner & Levinthal, 2004b; Kogut & Kulatilaka, 2004; McGrath et al., 2004; Tong & Reuer, 2007) and empirical evidence on the use of ROR in portfolios is limited (Andries & Hünermund, 2020; Klingebiel & Adner, 2015). Klingebiel and Adner (2015) provide initial evidence for a general positive relationship between ROR and innovation performance. They find that sequential investment and a fit between low commitment and resource reallocation positively affect performance. Andries and Hünermund (2020) find that resource availability moderates the relationship between sequential project funding, one of ROR's elements, and project initiation and abandoning. According to their results, firms initiate and abandon less innovation projects if resource availability is high.

As part of the debate, prior research has strongly suggested investigating the potential influence of organizational context factors on ROR's effectiveness (Adner & Levinthal, 2004b; Li et al., 2007; Miller & Shapira, 2004; Tong & Reuer, 2007). ROR is a behavioral approach that concerns project champions', decision makers', and project employees' individual behavior (Adner & Levinthal, 2004b; Barnett, 2008). Project champions recognize potential opportunities and propose them to decision makers. Decision makers assess each opportunity's potentiality and decide whether to include it as project option in the innovation project portfolio. Over time, they identify the project options that prove to be unfavorable, abandon them, and shift resources to more promising options. During this process, decision makers', project champions', and project employees' behavior is to a large extent shaped by the organizational context (Barnett, 2008; Coff & Laverty, 2007; Kogut & Kulatilaka, 2004). However, while organizational context has been discussed as an important ROR research opportunity, besides the work of Andries and Hünermund (2020), this has not been empirically investigated yet.

Our article addresses this research gap and follows the conceptual work of Barnett (2008), who discussed ROR's behavioral aspects from an attention-based view. According to the attention-based view, "decision-making in organizations is the result of both the limited attentional capacity of humans and the structural influences of organizations on an individual's attention" (Ocasio, 1997, p. 188). Portfolio actors have a limited attention capacity; what they focus their (limited) attention on determines their behavior, and where they focus their attention is determined by a firm's contextual structures (Barnett, 2008). Contextual structures describe those aspects of a portfolio's context which determine what potential influences could come to portfolio actors' attention in general (Ocasio, 1997). Furthermore, contextual structures, for example, a firm's strategic orientation or its organizational climate, continuously shape portfolio actors' attention, behavior, and their decisions (Barnett, 2008).

This study examines the interaction between ROR and an innovation portfolio's contextual structures. We focus on contextual structures since they represent the long-term foundation of innovation portfolios (Barnett, 2008; Coff & Laverty, 2007). A firm's innovation portfolio has a central position in the organization. The portfolio is influenced by

top-down strategic contextual structures (i.e., the firm's strategic direction) and bottom-up cultural contextual structures (i.e., the organization's climate) (Kock et al., 2015). To holistically investigate an innovation portfolio's context, we chose a relevant top-down strategic and bottom-up cultural context structure that influence decision makers', project champions', and project employees' attention and behavior. This choice is supported by Barnett (2008), who suggested that for ROR to be effective, "firms put in place structures that decrease the stigma of failure and make action more attractive than passivity" (Barnett, 2008, p. 612). Furthermore, we think this is a balanced choice since we expect top-down strategic influences to affect decision makers' behavior most strongly, while cultural contextual structures influence project champions' and project team members' behavior most strongly.

As Barnett (2008) proposed, we investigate a firm's entrepreneurial orientation, a highly prominent concept in strategy and innovation literature, as the innovation portfolios' strategic contextual structure (Baker et al., 2016). It describes an organization's strategic orientation toward entrepreneurship (Anderson et al., 2015), meaning that firms with a high entrepreneurial orientation are proactive and favor innovative endeavors with higher expected returns while taking a higher degree of risk (Covin & Slevin, 1991). We anticipate that entrepreneurial orientation directs decision makers' attention when they select and evaluate project options toward favoring innovative options (Barnett, 2008).

As cultural bottom-up contextual structure, we consider an organization's innovation climate. Innovation climate relates to the support, autonomy, and creative feedback employees receive from management that encourage them to pursue innovative tasks (Amabile, 1983; Kock et al., 2015). In the context of ROR, innovation climate represents a strong influence on portfolio actors' attention (Barnett, 2008). Effective ROR requires project champions to discover project opportunities and present them to decision makers. A strong innovation climate should encourage this behavior. Further, if project portfolio processes follow a real option logic, the uncertainty regarding projects' continuation most likely influences the emotions and motivation of employees working in project teams (Shepherd et al., 2013).

Based on real options and portfolio decision-making literature, we hypothesize that a firm's entrepreneurial orientation and innovation climate positively moderate the relationship between ROR and portfolio innovativeness. Since ROR's value stems from its characteristics to cope with options' uncertainty, it should allow decision makers to venture more innovative yet more uncertain projects with higher potential benefits. Thus, we investigate how ROR influences innovativeness and success consecutively in a mediated model (e.g., McGrath et al., 2004). Our research question is: *How do strategic and cultural contextual structures moderate ROR's influence on portfolio innovativeness and, eventually, on portfolio success?*

We tested our hypotheses empirically using a survey of 137 innovation portfolios with multiple informants per portfolio (a decision maker, a coordinator, and several project managers). The results show that ROR is positively related to portfolio innovativeness and that entrepreneurial orientation positively moderates this relationship. We find that a high level of entrepreneurial orientation is necessary for ROR, through high innovativeness, to be positively related to portfolio success. Surprisingly, innovation climate does not significantly moderate ROR's relationships.

This article contributes to the literature on ROR and innovation portfolio management. First, it adds important insights on ROR's performance influence (Adner & Levinthal, 2004b; Kogut & Kulatilaka, 2004; McGrath et al., 2004; Tong & Reuer, 2007). The results extend the general findings of Klingebiel and Adner (2015) by providing deeper insight into distinctive ROR effects related to portfolio innovativeness on the one hand, and actual success on the other. Second, this article offers new insights into the highly relevant interaction between ROR and innovation portfolios' strategic and cultural context. The article therefore contributes to previous conceptual (Barnett, 2008) and recent empirical (Andries & Hünermund, 2020) work, providing an explanation for mixed findings in previous research on ROR's performance influence (Adner & Levinthal, 2004b; Klingebiel & Adner, 2015). Third, it contributes to research on strategy in innovation portfolio management and responds to the dearth of research on entrepreneurial orientation's moderating role (Wales et al., 2013). The findings highlight the importance of strategic support in general and an entrepreneurial orientation's moderating role in portfolio management in particular (de Brentani, 2001; Kock & Gemünden, 2020). The results encourage managers to use ROR in innovation portfolio management and highlight its relevance for organizational development.

2 | THEORETICAL FRAMEWORK

2.1 | Innovation portfolio management and portfolio success

A firm's innovation portfolio embodies its innovative activities (Kock et al., 2015; Salomo et al., 2008) and comprises its collection of currently running innovation projects that share the same resources (Kester et al., 2014; Roeth et al., 2019). Innovation portfolio management aims to foster conditions that facilitate the generation of creative ideas, establish processes to further evaluate these ideas, and align new

idea initiatives with a firm's strategic future business (Kock et al., 2015; Unger et al., 2012). Further, innovation portfolio management focuses on evaluating, prioritizing, and selecting a portfolio's (potential) projects. In addition, it locates a firm's available resources and evaluates interdependencies between projects regarding risk, revenue, cost, and resources (Blichfeldt & Eskerod, 2008; Jonas et al., 2013).

Innovation portfolio success is commonly defined as a multidimensional construct with four dimensions: average product success, portfolio balance, strategic implementation success, and future preparedness (Cooper et al., 2001; Kester et al., 2014; Kock et al., 2015). *Average product success* refers to maximizing the portfolio's value and thus to the project outcomes' commercial success (Kock et al., 2015). *Portfolio balance* refers to a harmonious portfolio composition with respect to specific parameters such as project types, time horizon, or risk level (Cooper et al., 2001; Kester et al., 2014). This study follows Kock and Gemünden (2016), who find a portfolio to be successfully balanced if it comprises a balanced combination of new and existing product applications, technologies, project competencies, as well as risks and rewards. *Strategic implementation success* describes the extent to which a portfolio's projects reflect the overall business strategy. Portfolio managers should generally focus on supporting projects that fit the firm's strategy well (Kock et al., 2015). In the analysis, we assess how project goals, portfolio resources, and the portfolio overall align with the business strategy. Finally, *future preparedness* adds the highly important aspect of innovation portfolio projects' contribution to the organization's positioning in the longest-term future (Kock et al., 2015). A portfolio high in future preparedness is one that, in the present, builds new skills, competencies, products, and technologies that open up the (longest-term) future opportunities toward shaping the organization's market and gaining a competitive edge.

2.2 | Real options reasoning

Achieving portfolio success requires that portfolio actors identify project opportunities and fund the most promising ones. However, at the time of funding a project, it is difficult for decision makers to estimate future returns on innovative projects (Adner & Levinthal, 2004b). In this regard, ROR has been proposed as a promising solution to this challenge (Myers, 1977). A real option gives its owner the right, but not the obligation, to execute or abandon an underlying asset immediately or at a later point in time. Compared to financial options, real options enable their holder to secure the (unlimited) upside potential of a project's future returns, while simultaneously limiting its downside losses (Trigeorgis, 1993). For managers, to precisely calculate a real option's value and time to maturity is highly complex, and hardly feasible in practice (Bowman & Moskowitz, 2001). Consequently, ROR has been proposed as a behavioral approach. With ROR, decision makers implicitly apply the heuristics and general principles of real option logic in innovation portfolio management. Instead of deciding on definitely funding projects, they place only tentative, structured bets, and successively strive toward reducing various options' uncertainty. Once uncertainty is sufficiently removed, decision makers can execute an option and definitely fund the associated project (McGrath & Nerkar, 2004).

Following Klingebiel and Adner (2015), three elements jointly constitute ROR: First, instead of deciding whether or not to fully finance an option at a certain point in time, the decision makers distribute the investment sequentially over a period of time (Dixit & Pindyck, 1995). Such distribution enables the option owner to decide whether, depending on how the asset develops, to make further investments. Second, when applying ROR, only a low investment is initially made in selected options (McGrath & Nerkar, 2004). Such low initial investment commitment increases the autonomy of future decisions regarding an option's continuation. Third, independent of the option's current phase, all the available options, regardless of their relevant phase, compete against one another for (further) investment. Investments can therefore be efficiently shifted from low-potential options to more promising ones.

Since ROR is a behavioral approach, its actual performance depends on the portfolio actors' behavior (Coff & Laverty, 2007; Kogut & Kulatilaka, 2004). Effective ROR requires portfolio champions to identify and support opportunities and decision makers to formulate consistent option boundary conditions to determine the initiation, refunding, and termination of projects (Adner & Levinthal, 2004b; Bowman & Hurry, 1993). Such behavior is strongly influenced by a portfolio's organizational context (Coff & Laverty, 2007). To investigate the relationship between the organizational context and individuals' behavior, we draw on the attention-based view (Barnett, 2008; Ocasio, 1997). According to the attention-based view, ROR's relevant actors, project champions, and decision makers have only a limited focus of attention, and their behavior depends on where they focus their limited attention. The organization's contextual structures (e.g., organizational climate) determine where actors focus their attention (Barnett, 2008; Ocasio, 1997). Contextual structures place boundaries on which of the unlimited environmental influences can come to the attention of portfolio champions and decision makers (Barnett, 2008).

This article focuses on contextual structures since the long-term foundation they provide for innovation portfolios is highly relevant for new product development success (e.g., de Brentani et al., 2010; Kock et al., 2015). Since an innovation portfolio is centrally positioned in a firm, its contextual

structures are strongly determined by the top-down influence of the organization's upper management (e.g., a strategic orientation toward innovation) and by the bottom-up influence (e.g., an innovation climate) of project team members (Barnett, 2008; Covin & Slevin, 1991; Shepherd et al., 2013). We follow Barnett's (2008) conceptual work and investigate the interaction between ROR and an organization's entrepreneurial orientation and innovation climate, respectively. While previous conceptual work has strongly emphasized the importance of context factors for ROR (Adner & Levinthal, 2004b; Coff & Laverty, 2007; Kogut & Kulatilaka, 2004), no previous study empirically examined strategic or cultural contexts as boundary conditions for ROR's effectiveness. In the following sections, we describe the innovation portfolios' relevant strategic and cultural contexts.

2.3 | Entrepreneurial orientation as portfolio's strategic context

A firm's strategic orientation is an important top-down contextual structure for its innovation portfolio management (Baker et al., 2016; Eisenhardt & Martin, 2000; Kock et al., 2015; Mintzberg, 1973). It provides strong guidance to portfolio actors regarding where they should focus their attention. In terms of ROR, this directs project champions' and decision makers' focus and determines which opportunities they recognize and initiate as options, as well as when they execute these options (Barnett, 2008). In this study, we include entrepreneurial orientation as strategic contextual structure due to its high importance in firms' innovation management (Rauch et al., 2009) and for ROR's effectiveness (Barnett, 2008). Entrepreneurial orientation entails a growth mindset that most likely interacts with ROR (Covin et al., 2006).

According to Miller (1983), a firm is considered entrepreneurial if it pursues innovation, deliberately enters new markets, and accepts strategic risk. In the analysis, we refer to entrepreneurial orientation as a firm's mindset of "favoring actions with uncertain outcomes" (Anderson et al., 2015, p. 1580). There are different conceptualizations of the entrepreneurial aspect of a firm's strategic orientation (Linton & Kask, 2017; Lumpkin & Dess, 1996). However, according to Rauch et al. (2009) and Rosenbusch et al. (2013), the Miller/Covin and Slevin perspective is by far the most dominant one in the literature. Covin and Slevin (1991) propose a continuum between conservative and entrepreneurial management, with the most entrepreneurial end comprising the characteristics innovativeness, proactiveness, and risk taking. *Innovativeness* refers to a managerial focus on R&D, a constant predisposition to challenge existing products and services, and pursuit of innovation (Mickiewicz et al., 2016). *Proactiveness* refers to actively looking out for opportunities that anticipate future developments and are aimed at the early introduction of new solutions. *Risk taking* refers to an organization's willingness to accept risks related to new ventures (Covin & Slevin, 1989).

2.4 | Innovation climate as a portfolio's cultural context

Following the established definition of organizational climate suggested by Pritchard and Karasick (1973), organizational climate refers to organization members' perceivable behavior and policies that serve "as a basis for interpreting the situation […] and […] act […] as a source of pressure for directing activity" (p. 126). Thus, the organizational climate is a strong contextual structure that shapes the attention of an innovation portfolio's actor (Barnett, 2008).

Innovation climate, in particular, is highly relevant to ROR because it determines the support that project champions, decision makers, and project team members receive when they follow ROR principles (Adner & Levinthal, 2004b; Coff & Laverty, 2007; Schein, 1985). Previous innovation research has considered how an innovation climate generally connects to the innovation portfolio (Kock & Gemünden, 2016). Innovation-oriented values, norms, and artifacts positively affect product program innovativeness and business performance (Stock et al., 2013), and innovation climate improves portfolio management decision-making quality (Kock & Gemünden, 2016). In accordance with Amabile (1983) and Kock and Gemünden (2016), we define innovation climate as the support, autonomy, and creative feedback the management gives its employees, also encouraging them to pursue innovative tasks. A strong innovation climate produces more creative employees (Shalley & Gilson, 2004), increases employees' willingness to take risks related to innovative projects (Baer & Frese, 2003), and results in employees pursuing their innovative ideas (Oldham & Cummings, 1996).

3 | HYPOTHESES

3.1 | Overview

Figure 1 presents this study's research framework. We argue that ROR's value stems from its characteristic ability to cope with the high uncertainty of highly innovative projects. As a direct consequence, ROR enables decision makers to take on innovative options. Therefore, we hypothesize that portfolio innovativeness fully mediates the relationship between ROR and portfolio success. Further, we follow prior research and argue that strategic and cultural contexts, specifically entrepreneurial orientation and innovation climate, moderate ROR's effect on portfolio innovativeness and eventual success.

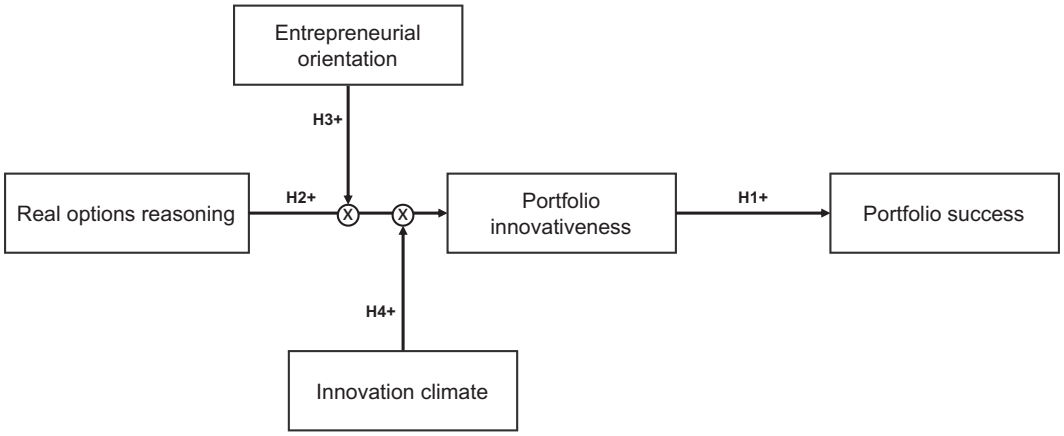

FIGURE 1 Conceptual framework

3.2 | Portfolio innovativeness and portfolio success

We argue that higher portfolio innovativeness positively influences innovation portfolio success. Following Schumpeterian competition, the increased financial gain through a temporary monopoly rent compensates those firms that offer innovative products (Kock et al., 2011). In addition to increased sales through a price premium (Bayus et al., 2003; Saviotti & Pyka, 2004), innovative products' competitive advantage has spillover effects for the firm's image and brand awareness (Pauwels et al., 2004). Innovative projects can also be valuable to the firm's internal knowledge development (Salomo et al., 2008).

Further, higher innovativeness allows firms to improve their strategy implementation. Innovative projects enable firms to maintain their competitive position or empower their technological or market leadership (Talke et al., 2011). Through innovations they can not only decrease the risk of being disrupted by competitors but can also implement their strategy in new ways (Salomo et al., 2008). By pursuing radical innovation, firms can actively shape existing markets and tap into promising new markets, thereby securing their sound future preparedness (Leifer et al., 2000; Nelson & Winter, 1977). Since most firm's innovation portfolios predominantly comprise incremental projects, increasing the share of innovative projects positively contributes to a balanced portfolio (Uotila et al., 2009). Highly innovative projects increase portfolio diversification by offering higher potential returns while simultaneously spreading their raised uncertainty across all portfolio projects.

This hypothesis is also supported by multiple prior studies that empirically found a positive relationship between portfolio innovativeness and overall portfolio success (Hult & Ketchen, 2001; Salomo et al., 2008; Schultz et al., 2013; Talke et al., 2011).

Hypothesis 1 *Portfolio innovativeness is positively related to portfolio success.*

3.3 | Real options reasoning and portfolio innovativeness

Innovative projects are associated with a higher level of uncertainty and risk (Salomo et al., 2008; Schultz et al., 2013), and firms are unsure of the characteristics that determine market's selection of innovative products (Nelson & Winter, 1977). Thus, until a product is fully developed and introduced to the market, its eventual success is not known (Saviotti & Pyka, 2004). In addition, owing to their higher level of complexity (e.g., technological complexity), innovative projects face an increased chance of failing during their early phases (Schultz et al., 2013). This poses a challenge to innovation portfolio management when they decide on innovative projects' funding.

We argue that ROR offers an approach to cope with innovative projects' uncertainty systematically, which enables decision makers to initiate and venture into innovative projects. According to ROR, each project's resource allocation remains flexible throughout its execution (McGrath et al., 2004). Decision makers can integrate promising opportunities in their portfolio quite effortlessly if their resource commitment is low and nonbinding. A project's overall funding is tentative, meaning that it is sequentially spread over time, and remains closely connected to the project developing well (Bowman & Hurry, 1993). Thus, decision makers can incorporate relevant emerging information in their follow-up investment decisions. If a project ceases to be beneficial, decision makers are not bound to previous decisions and can easily shift its funds to more promising options (Klingebiel & Adner, 2015). ROR's overall flexible investment approach which consequently reduces uncertainty and reacts to new

project development, limits innovative projects' adverse risks. This encourages decision makers to initiate and pursue highly innovative projects.

Additionally, across all project options in an innovation portfolio, the structured and tentative type of investment associated with ROR allows decision makers to *simultaneously* advance innovative yet uncertain opportunities. In traditional definitive and static resource allocation regimes, decision makers focus on venturing a selected few, but definitively funded innovative projects (Klingebiel & Adner, 2015). Then, innovative opportunities are tested in serial order. With ROR, however, decision makers allocate resources across multiple tentatively funded project options, which allow them to simultaneously test innovative project options in parallel (Loch et al., 2001). Parallel testing of innovative options increases the portfolio's chances of success overall while decreasing time-to-market, which further encourages decision makers to engage in innovative options.

In summary, ROR enables decision makers to cope with and decrease the uncertainty connected to innovative projects, thus making decision makers more willing to pursue innovative yet risky project options. The higher degree of innovativeness across all projects leads to an increase in overall portfolio innovativeness. We therefore formulate the hypothesis as follows:

Hypothesis 2 *ROR is positively related to portfolio innovativeness.*

3.4 | The moderating influence of the strategic context

An organization's entrepreneurial orientation shapes decision makers' attention when deciding on option investments (Kogut & Kulatilaka, 1994; Tong & Reuer, 2007). Prior literature has established a positive direct effect on innovativeness (e.g., Talke et al., 2011). In this study, we further hypothesize a moderating effect for ROR. Following Barnett (2008), we argue that decision makers in organizations with a stronger entrepreneurial orientation "are more willing to take substantial actions with incomplete information, and […] have greater confidence in their ability to exploit […] opportunities" (Barnett, 2008, p. 620). Thus, we argue that entrepreneurial orientation shapes decision makers' attention and behavior in a way that encourages them to initiate highly innovative options, proactively strive to decrease options' uncertainty, and execute favorable options earlier. Overall, we expect that ROR more strongly leads to higher portfolio innovativeness when coupled with a strong entrepreneurial orientation.

First, while entrepreneurial orientation relates to a strategic orientation that actively encourages the pursuit of innovative, potentially risky, options (Anderson et al., 2015), ROR offers a suitable approach to turn such pursuit into action. A high level of entrepreneurial orientation indicates a high level of risk taking and proactiveness; we argue that both these factors harmonize well with ROR's approach of accepting more uncertainty due to a low and constantly nonbinding commitment (Tong & Reuer, 2007). We argue that decision makers in a firm with a strong entrepreneurial orientation will be more willing to use ROR's principles to fund unfamiliar, innovative options, thus exploiting more of ROR's potential. Therefore, we conclude that ROR's positive effect on portfolio innovativeness will be higher in firms with decision makers who are encouraged by a strong entrepreneurial orientation.

Second, we expect an organization's strong entrepreneurial orientation to shape decision makers' attention toward more actively decreasing options' uncertainty. Prior research has highlighted the important difference between wait-and-see and act-and-see options (Adner & Levinthal, 2004b). With ROR, decision makers and project options' team members are not compelled to wait for exogenous uncertainty to decrease (i.e., wait-and-see) but can actively reduce uncertainty (i.e., act-and-see) that is endogenous to the firm (e.g., technological uncertainty) (Dixit & Pindyck, 1995). For example, decision makers and project members can use minimum viable products to test technical feasibility and get customer feedback in early project phases. We expect a high entrepreneurial orientation to increase decision makers' attention and behavior toward proactively striving to decrease options' uncertainty. This accelerates organizational learning and increases ROR's effectiveness (Bowman & Hurry, 1993).

Third, we expect decision makers in firms with a strong entrepreneurial orientation to perceive an option has turned profitable sooner and therefore execute it sooner (Barnett, 2008). ROR is a behavioral approach that relies on decision makers assessing an option's value. After initiating an option, decision makers work toward decreasing its uncertainty. Decision makers need to recognize when an option's uncertainty about its future prospects is low enough to venture its execution (Kogut & Kulatilaka, 2004). We argue that an organization's strong entrepreneurial orientation shapes decision makers' attention in such a way that they perceive innovative options to have become favorable earlier, and therefore execute them earlier compared to firms with a low entrepreneurial orientation (Barnett, 2008). This leads to more options with higher innovativeness being integrated as full projects in the innovation portfolio.

Consequently, we hypothesize that entrepreneurial orientation's influence on portfolio decision makers' attention positively moderates ROR's relationship to portfolio innovativeness. We therefore formulate the third hypothesis as follows:

Hypothesis 3 *ROR and entrepreneurial orientation interact to predict a portfolio's innovativeness, such that ROR leads to higher portfolio innovativeness when paired with a higher level of entrepreneurial orientation.*

3.5 | The moderating influence of the cultural context

In addition to entrepreneurial orientation, we extend ROR's context to the firm's innovation climate (Barnett, 2008). We argue that organizations' innovation climate affects portfolio actors' attention and behavior in three ways, and, consequently, positively moderates ROR's relationship with portfolio innovativeness.

First, an innovation climate strongly shapes the attention of project champions in the ROR resource regime who identify future project opportunities and suggest them to decision makers. Depending on the kind of climate, employees might feel encouraged or discouraged to propose and champion project opportunities. As Barnett (2008) mentioned, a high innovation climate serves as supporting "tailwind" (p. 614) for project championing, in contrast to a low innovation climate that serves as "headwind" (p. 614). Since the effectiveness of ROR depends on the intensity of project championing, we argue that ROR's effect on portfolio innovativeness is higher in organizations with a stronger innovation climate since these organizations promote project championing which increases ROR's effects.

Second, innovation climate shapes decision makers' attention when they decide on new project options and continued resource allocation. We expect an organizational climate that strongly supports autonomous innovative initiatives will also shape decision makers' attention toward applying ROR for options with a higher degree of innovativeness (Barnett, 2008; Coff & Laverty, 2007). Since ROR's benefits of limiting downside risk while securing upside potential depend on the innovativeness of options that decision makers select, we argue that the effect of ROR on portfolio innovativeness is higher when decision-makers, encouraged by an innovation-oriented climate, more strongly focus on highly innovative options and apply ROR for them.

Third, ROR's effectiveness relies heavily on decision makers limiting adverse risk by terminating unfavorable options (Adner & Levinthal, 2004a, 2004b). Project option termination, however, mostly results in emotional stress for involved project members and decision makers (Shepherd et al., 2013). Under ROR, projects constantly face the risk of not receiving follow-up investments. We argue that employees in firms with a higher innovation climate will accept this uncertainty more readily, therefore supporting the strict adherence to ROR principles. This should increase ROR's effectiveness and encourage decision makers to initiate innovative options.

Consequently, a high innovation climate provides project champions, decision makers, and project employees with organizational support suitable to following ROR principles, leading to the realization of ROR's full potential. We formulate the hypothesis as follows.

Hypothesis 4 *ROR and innovation climate interact to predict a portfolio's innovativeness, such that ROR leads to higher portfolio innovativeness when paired with a stronger innovation climate.*

4 | METHODOLOGY

4.1 | Sample

We test the hypotheses on a cross-industry sample of innovation project portfolios of firms with on average at least 20 simultaneously running projects. For each portfolio, we targeted three types of informants: (a) a portfolio coordinator with a good overview of the portfolio processes, who was generally the head of the project management office, the portfolio manager, or the innovation manager, (b) a senior management decision maker regarding project initiation and termination, who was generally the head of R&D, a division head, or CEO, and (c) several project managers leading single portfolio projects. We contacted organizations via email and followed-up with phone calls, explaining the study and inviting organizations to participate. After registration, we sent the coordinator individualized links via email to an online survey tool for herself or himself, the decision maker, and multiple project managers. The coordinator then forwarded the links to the relevant portfolio's informants. Subsequent to the survey, we matched the informants' answers to the portfolios. The final sample consists of 137 innovation portfolios with assessments from 137 coordinators, 137 decision makers, and 387 project managers (a median of three per portfolio). The survey's median portfolio has a budget of EUR 32 million and an average of 60 projects simultaneously being executed. We provide the sample characteristics (industry, revenue, number of employees, and portfolio budget) in Table 1.

4.2 | Measurement

In the analysis, we rely on multi-item scales per construct (Hair et al., 2018). The items used in the survey were

TABLE 1 Sample characteristics

Industry		**Revenue**	
Manufacturing	21.17%	<100 million EUR	21.17%
Finance	20.44%	100–500 million EUR	46.72%
Logistics	16.79%	>2000 million EUR	32.12%
Electronics/IT	13.87%		
Pharmaceuticals/chemicals	11.68%		
Utilities	5.84%		
Others	10.22%		
Employees		**Portfolio budget**	
<500	28.47%	<10 million EUR	19.71%
500–2000	28.47%	10–30 million EUR	45.26%
>2000	43.07%	>100 million EUR	35.04%

taken from existing scales or based on conceptual articles. We adjusted the wording of some items to better fit our context. Unless otherwise stated, the items consist of a 7-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"). To assess the scales' validity, we applied confirmatory factor analysis (CFA) and used Cronbach's Alpha to assess their reliability, defining the acceptable value larger than 0.7 (Hair et al., 2018). The multi-informant approach limits potential common-method bias (Podsakoff et al., 2003). We also performed a Harman's single-factor test to further identify potential common-method bias (Podsakoff et al., 2003). The relevant model with all the items loading on one factor had a very poor fit (χ^2 = 3576.12 (df = 1034; p < 0.000); RMSEA = 0.134; SRMR = 0.131; CFI = 0.323), which further decreases possible common-method bias concerns. The correlations and descriptives of all variables used in the analysis are given in Table 2, while items' wording and CFA results (including the loadings and reliability scores) are presented in Tables 3 and 4.

4.2.1 | Dependent variable

We operationalized portfolio success as a four-dimensional, second-order construct, using the following dimensions and items from existing literature (Jonas et al., 2013; Kock et al., 2015; Meskendahl, 2010): strategic implementation success (four items), portfolio balance (four items), average product success (four items), and future preparedness (three items). Similar to previous research (e.g., Jonas et al., 2013; Kock et al., 2015), the portfolio decision makers assessed the final construct of portfolio success.

4.2.2 | Mediator

In the analysis, we operationalized portfolio innovativeness by using established measures from literature, including innovativeness's market and technology aspects (Kock et al., 2011; Schultz et al., 2013; Talke et al., 2011; Zhou et al., 2005). For a comprehensive evaluation of the portfolio's innovativeness, we used the equally weighted average of the coordinators' and decision makers' assessments of innovativeness (six items).[1]

4.2.3 | Independent variables

We operationalized *ROR* based on Klingebiel and Adner's (2015) investigation of the ROR elements and further literature on ROR (McGrath et al., 2004). We investigated the ROR elements jointly, thus following Klingebiel and Adner's (2015) argumentation that a combination of sequencing, low commitment, and resource reallocation constitutes ROR. However, in contrast to Klingebiel and Adner's (2015) dichotomous operationalization, we also acknowledge the broader view on ROR's definition by Bowman and Hurry (1993) and McGrath et al. (2004), who find that ROR encompasses a wider range of behavioral approaches which share their aim of decreasing projects' present uncertainty to secure future profits. Consequently, we operationalized ROR as a composite formative

[1]We also tested models in which innovativeness was only assessed by coordinators or decision makers. The results were comparable to those reported below, except for the direct effect of ROR on innovativeness, which was narrowly insignificant (p = 0.14) when innovativeness was solely assessed by the decision maker.

TABLE 2 Descriptives and correlations

	Variables	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Success	4.68	0.84	1									
(2)	Portfolio innovativeness	3.94	1.00	0.46	1								
(3)	Firm size (ln)	7.33	1.97	−0.09	−0.04	1							
(4)	Portfolio budget (ln)	3.50	1.60	0.04	0.04	0.43	1						
(5)	Number projects (ln)	4.05	1.31	−0.09	−0.08	0.41	0.55	1					
(6)	Formalization PPM	4.98	1.66	0.17	0.10	0.15	0.13	0.04	1				
(7)	Market turbulence	3.80	1.15	0.10	0.25	−0.03	−0.03	−0.12	0.07	1			
(8)	Technology turbulence	4.95	1.32	0.24	0.43	−0.14	0.04	−0.08	0.06	0.43	1		
(9)	Real options reasoning	4.11	1.35	0.14	0.20	0.01	0.08	−0.05	0.12	−0.06	0.06	1	
(10)	Entrepreneurial orientation	4.11	0.89	0.45	0.58	−0.09	−0.01	−0.02	0.00	0.19	0.43	0.10	1
(11)	Innovation climate	4.85	0.83	0.14	0.27	0.05	0.01	0.05	0.16	0.04	−0.04	0.17	0.08

Note: $n = 137$, M = mean, SD = standard deviation, all correlations above 0.17 are significant at the 5%-level.

construct, using three items in total, with each item covering one of the three ROR dimensions: (1) Project budgets are approved for each project phase separately instead of for the whole project; (2) In highly uncertain environments, the goal of projects is often to demonstrate feasibility or to develop a prototype before we decide whether to fully pursue an opportunity; (3) In each prioritization cycle, new and ongoing projects compete for resources. This choice not only reflects the dimensions Klingebiel and Adner (2015) put forward but also allows us to measure the intensity of ROR applied. Portfolio coordinators assessed the construct since they have a good overview of the portfolio processes.

We chose a composite formative rather than a reflective construct for ROR based on recommendations in prior literature (Bollen, 2011; Diamantopoulos et al., 2008; Jarvis et al., 2003). According to Jarvis et al. (2003), a construct should be modeled as formative if the following requirements, which we argue apply to ROR, hold true: (a) the items are considered the construct's defining elements, (b) changes in the items should lead to changes in the construct, (c) changes in the construct are not necessarily linked to changes in all the items, (d) the items do not necessarily cover the same content, (e) excluding one item might change the construct's conceptual domain, (f) a change in one of the items' value does not necessarily result in a change in all the other items, and (g) the items do not need to share the same antecedents and consequences (Jarvis et al., 2003).

In the case of ROR, its three elements—investing sequentially, low initial investment, and reallocation of investment—determine the overall construct (Klingebiel & Adner, 2015). A change in one of the items would therefore indeed have an influence on the degree to which ROR is applied, but this is not necessarily associated with a change in one of the other two items. For instance, if a firm decides to cease sequential investment, this decision affects the degree of ROR but does not necessarily result in the firm terminating other ROR elements, such as investment reallocation. Since each of the ROR items covers one of its elements, the three items we used are not interchangeable. In addition, different considerations could motivate each of the three items; therefore, they do not necessarily have the same antecedents and consequences. Thus, we conclude that, for this article's empirical analysis, ROR should be modeled as a linear combination of its three items, and therefore as a composite formative construct (Bollen, 2011). We used the equally weighted average of the three items to determine the ROR construct. Furthermore, we followed recommendations of established literature and validated the construct using partial least squares (Hair et al., 2017; Sarstedt et al., 2016). The results support the construct's definition (weights 0.15, 0.40, and 0.24), while showing no indication of multicollinearity (condition index = 8.22). We also calculated the ROR construct using the weighted average as a robustness check and achieved similar results as the ones reported below.

Last, we measured *entrepreneurial orientation* as a three-dimensional, second-order construct, using Covin and Slevin's (1989) widely used scales. For each entrepreneurial orientation dimension—innovativeness, proactiveness, and risk-taking—we used a three-item scale and aggregated the nine items into one construct. We used an aggregation to measure the overall impact entrepreneurial orientation has,

TABLE 3 Confirmatory factor analysis of second-order constructs

Construct/Item	Loading
Project portfolio success (second-order construct)	
Strategic implementation success (Cronbach's alpha = 0.85; AVE = 0.62; CR = 0.87)	0.80
The project portfolio is consistently aligned with the future of the company	0.87
The corporate strategy is ideally implemented through our project portfolio	0.90
Our project resource allocation reflects our strategic objectives	0.70
The implementation of the strategy is considered a great success in the organization	0.66
Portfolio balance (Alpha = 0.89; AVE = 0.67; CR = 0.89)	0.78
There is a good balance in our project portfolio…	
… between new and existing areas of application	0.87
… between new and existing technologies	0.85
… between projects that develop new competences and projects that utilize existing competences	0.79
… between risk and returns	0.74
Future preparedness (Alpha = 0.88; AVE = 0.72; CR = 0.88)	0.70
We develop new technologies and/ or competences in our projects to succeed in the future	0.80
Our projects for new products, technologies, or services take us a step ahead of our competition	0.86
Our projects enable us to shape the future of our industry	0.89
Average product success (Alpha = 0.86; AVE = 0.66; CR = 0.88)	0.63
Our products/project results achieve the target costs defined in the project	0.61
Our products/project results of the project achieve the planned market goals (e.g., market share)	0.70
Our products/project results achieve the planned profitability goals (e.g., ROI)	0.95
Our products/project results achieve the planned payback period	0.93
Entrepreneurial orientation (second-order construct)	
Innovativeness (Alpha = 0.69; AVE = 0.49; CR = 0.74)	0.73
In general, the top managers of my business unit favor…	0.57
… a strong emphasis on the marketing of tried and true products or services. –… a strong emphasis on R&D, technological leadership, and innovations	
How many new lines of products or services has your business unit marketed during the past three years? No new lines of products or services. – Many new lines of products or services	0.71
Changes in product or service lines have been mostly of a minor nature. – Changes in product or service lines have usually been quite dramatic	0.81
Proactiveness (Alpha = 0.70; AVE = 0.48; CR = 0.73)	0.72
In dealing with its competitors, my business unit…	
… typically responds to actions which competitors initiate. –… typically initiates actions to which competitors respond	0.78
… is seldom the first business to introduce new products/services, administrative techniques, operating technologies, etc. –… is very often the first business to introduce new products/services, administrative techniques, operating technologies, etc.	0.77
… typically seeks to avoid competitive clashes, preferring a "live-and-let-live" posture. –… typically adopts a very competitive "undo-the-competitors" posture	0.48
Risk-acceptance (Alpha = 0.76; AVE = 0.52; CR = 0.76)	0.89
In general, the top managers of my business unit have …	0.67
… a strong proclivity for low risk projects (with predictable and moderate rates of return)	
–… a strong proclivity for high risk projects (with chances for very high returns)	
Due to the nature of the environment …	0.74
… it is best to explore it gradually via cautious, incremental behavior. –	
… bold, wide-ranging acts are necessary to achieve the firm's objectives	
When confronted with decision-making situations involving uncertainty, my business unit…	0.74
… typically adopts a cautious "wait and see" posture in order to minimize the probability of making costly decisions. –	
… typically adopts a bold, aggressive posture in order to maximize the probability of exploiting potential opportunities	

Note: Model fit $\chi^2[244] = 397.622$; comparative fit index [CFI] = 0.916; root mean square error of approximation [RMSEA] = 0.068; standardized root mean square residual [SRMR] = 0.082.

Abbreviations: AVE, average variance extracted; CR, composite reliability.

TABLE 4 Confirmatory factor analysis of first-order reflective constructs

Construct/Item	Loading
Innovation climate (Alpha = 0.90; AVE = 0.57; CR = 0.84)	
In our organization, …	
… employees are given sufficient responsibility, resources, and freedom to work independently	0.66
… communication is open, meaning that we share information and appreciate debates and diverse opinions	0.63
… we emphasize creativity and innovativeness	0.93
… unconventional ideas are encouraged by management	0.76
Formalization (Alpha = 0.93; AVE = 0.76; CR = 0.92)	
Please evaluate the portfolio management process	
Essential project decisions are made within clearly defined portfolio meetings	0.78
Our project portfolio management process is divided in clearly defined phases	0.81
Our process for project portfolio management is clearly specified	0.92
Overall, we execute our project portfolio management process in a well-structured manner	0.95
Technology Turbulence (Alpha = 0.83; AVE = 0.64; CR = 0.84)	
The technology in our industry is changing rapidly	0.82
There are frequent technological breakthroughs in our industry	0.93
Technological changes provide big opportunities in our industry	0.63
Market Turbulence (Alpha = 0.70; AVE = 0.45; CR = 0.71)	
In our industry, it is difficult to predict how customers' needs and requirements will evolve	0.62
In our kind of business, customers' product preferences change quite a bit over time	0.78
In our industry, it is difficult to forecast competitive actions	0.59
Portfolio innovativeness (Alpha = 0.89; AVE = 0.53; CR = 0.87)	
Our products/project results…	
… offer new customer benefits which were not previously provided by any other products	0.61
… create a completely new market	0.57
… completely change the way our market functions	0.65
… are based on new technological principles	0.85
… use new technologies that make older technologies obsolete	0.87
… use technologies that enable leaps in performance	0.77

Note: Model fit $\chi^2[158] = 270.803$; comparative fit index [CFI] = 0.929; root mean square error of approximation [RMSEA] = 0.072; standardized root mean square residual [SRMR] = 0.067.

Abbreviations: AVE, average variance extracted; CR, composite reliability.

arguing that it comprises the three dimensions' joint application. In the survey, decision makers assessed organization's entrepreneurial orientation since this construct relates to the overall strategic posture of the firm. *Innovation climate* relates to the creative encouragement a firm's employee experience. We assessed the construct by using established items from Kock and Gemünden (2016) and Kock et al. (2015). To achieve a comprehensive innovation climate evaluation, we used the equally weighted average of portfolio coordinators' and multiple project managers' assessment. This aggregation is justified, since the variance across the portfolios is significantly larger than that within the portfolios ($F = 1.60$; $p = 0.030$).

4.2.4 | Control variables

In the analysis, we controlled for multiple variables that might affect portfolio innovativeness or portfolio success. First, we controlled for *firm size*, measured as the natural logarithm of the respective firm's number of employees (Kopmann et al., 2017). Second, we controlled for the *portfolio size*'s potential influence, which we measured with the natural logarithm of the portfolio's annual budget in euro millions. Third, we included the natural logarithm of the *number of portfolio projects* running simultaneously. Finally, we also included *portfolio management formalization* that we measured with a five-item scale by Teller et al. (2012). Further, we controlled for

the portfolio environment's *external turbulence*. We included both market and technology turbulence in the analysis, since evolutionary initiatives and dynamic capabilities are dependent on the external environment (Eisenhardt & Martin, 2000). We used Sethi and Iqbal's (2008) scales for market turbulence (three items) and technology turbulence (three items).

The variables' correlations strengthen the confidence in the overall model and provide first indications of supporting the hypothesized relationships. Portfolio innovativeness highly correlates with portfolio success. As can be expected, entrepreneurial orientation and innovation climate are each positively correlated with portfolio innovativeness. In addition, entrepreneurial orientation is positively correlated with portfolio success. ROR's correlation with entrepreneurial orientation and innovation climate is rather weak. This is in line with the assumption that although organizational context can moderate the ROR effects on innovativeness it does not determine the degree of ROR.

5 | RESULTS

We tested the hypotheses with hierarchical ordinary least squares regression analysis and present the results in Table 5. Model 1 shows the direct relationships between the control variables and the mediator portfolio innovativeness. The environment's technology turbulence is positively related to portfolio innovativeness ($b = 0.28$; $p = 0.00$); the other control variables are not significant. Model 2 tests ROR and portfolio innovativeness's direct relationship as formulated in Hypothesis 2. The results support the hypothesis ($b = 0.13$; $p = 0.03$). The interaction effect between entrepreneurial orientation and ROR, tested in Model 3, is also significantly positive ($b = 0.15$; $p = 0.01$), which supports Hypothesis 3. The interaction between innovation climate and ROR is, however, not significant ($b = -0.06$; $p = 0.26$). Consequently, we can neither confirm nor reject Hypothesis 4. To further investigate the interaction effects, we plotted ROR's marginal effects with respect to different entrepreneurial orientation levels with 90% confidence bands (see Figure 2).

Models 4, 5, and 6 in Table 5 show the relationships between the independent variables, the mediator, and the dependent variable portfolio success. In Model 4, we investigate the relationship between the control variables, ROR, and portfolio success. ROR's direct relationship with portfolio success is not significant ($b = 0.06$; $p = 0.22$). However, the relationship between a project portfolio's innovativeness and portfolio success is positive (Model 5: $b = 0.34$; $p = 0.00$; Model 6: $b = 0.19$; $p = 0.03$), which supports Hypothesis 1.

To identify ROR's indirect effect on portfolio success through its influence on portfolio innovativeness, we followed the Hayes and Preacher (2014) approach. Since the mediated influence's standard errors are biased, we bootstrapped the results with 5000 repetitions. We show the test results in Figure 3 and also plot the interaction between ROR and entrepreneurial orientation's indirect marginal effect, through portfolio innovativeness, on portfolio success with respect to different levels of entrepreneurial orientation with 90% confidence intervals. The mediated relationship of ROR and portfolio success becomes positive, when entrepreneurial orientation exceeds the value of 4.55.

Since ROR's benefits are based on its characteristics to cope with options' uncertainty, ROR's positive effect on innovativeness should increase with higher levels of uncertainty. Consequently, this should also be true for external uncertainty. We conducted a supplementary regression analysis and tested the interaction effect between ROR and both market and technological turbulence on portfolio innovativeness in two separate models. The interaction effect between ROR and technology turbulence was positive ($b = 0.12$, $p = 0.004$) as well as the interaction effect between ROR and market turbulence ($b = 0.08$, $p = 0.072$). Overall, these results support the models' robustness and demonstrate that ROR's benefits for innovativeness increase for higher levels of external turbulence, as well.

6 | DISCUSSION

ROR is an approach designed to cope with innovative projects' uncertainty by splitting investment over time, maintaining low commitment, and shifting investment to the more promising options (Klingebiel & Adner, 2015). In this article, we empirically investigated the relationship between ROR and innovation portfolio success, mediated by portfolio innovativeness and considering innovation portfolios' strategic and cultural contexts.

The results confirm the positive relationship between portfolio innovativeness and portfolio success as previous research has shown (Schultz et al., 2013). But more importantly, we can show a positive relationship between ROR and portfolio innovativeness. This conforms to prior conceptual (e.g., Bowman & Hurry, 1993) and empirical (e.g., Klingebiel & Adner, 2015) work on ROR and underlines ROR's advantages compared to traditional definitive project investment approaches. ROR allows organizations to limit innovative endeavors' downside risk while maintaining their

TABLE 5 Regression results

	Portfolio innovativeness			Portfolio success		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Firm size (ln)	−0.03	−0.02	−0.04	−0.02	−0.01	−0.02
	[0.05]	[0.05]	[0.04]	[0.04]	[0.04]	[0.04]
	{0.53}	{0.61}	{0.34}	{0.64}	{0.77}	{0.63}
Portfolio budget (ln)	0.02	0.00	0.01	0.04	0.04	0.05
	[0.06]	[0.06]	[0.05]	[0.05]	[0.05]	[0.05]
	{0.76}	{0.95}	{0.79}	{0.42}	{0.40}	{0.36}
Number projects (ln)	−0.06	−0.05	−0.07	−0.08	−0.06	−0.08
	[0.07]	[0.07]	[0.06]	[0.06]	[0.06]	[0.06]
	{0.41}	{0.48}	{0.28}	{0.24}	{0.32}	{0.21}
Formalization PPM	0.06	0.05	0.04	0.07	0.05	0.06
	[0.05]	[0.05]	[0.04]	[0.04]	[0.04]	[0.04]
	{0.18}	{0.28}	{0.29}	{0.13}	{0.24}	{0.14}
Market turbulence	0.04	0.05	0.01	−0.03	−0.04	−0.05
	[0.08]	[0.07]	[0.06]	[0.07]	[0.06]	[0.06]
	{0.62}	{0.47}	{0.82}	{0.70}	{0.48}	{0.44}
Technology turbulence	0.28***	0.27***	0.17***	0.14**	0.04	0.01
	[0.07]	[0.07]	[0.06]	[0.06]	[0.06]	[0.06]
	{0.00}	{0.00}	{0.01}	{0.02}	{0.46}	{0.93}
Real options reasoning		0.13**	0.09*	0.06	0.02	0.03
		[0.06]	[0.05]	[0.05]	[0.05]	[0.05]
		{0.03}	{0.09}	{0.22}	{0.67}	{0.59}
Entrepreneurial orientation			0.44***			0.29***
			[0.08]			[0.09]
			{0.00}			{0.00}
Entrepreneurial orientation × real options reasoning			0.15**			0.06
			[0.06]			[0.06]
			{0.01}			{0.33}
Innovation climate			0.27***			0.03
			[0.08]			[0.08]
			{0.00}			{0.72}
Innovation climate × real options reasoning			−0.06			−0.02
			[0.06]			[0.05]
			{0.26}			{0.72}
Portfolio innovativeness					0.34***	0.19**
					[0.07]	[0.09]
					{0.00}	{0.03}
Constant	2.47***	2.50***	3.34***	4.08***	3.23***	4.05***
	[0.53]	[0.52]	[0.46]	[0.47]	[0.47]	[0.53]
	{0.00}	{0.00}	{0.00}	{0.00}	{0.00}	{0.00}
R^2	0.195	0.224	0.461	0.102	0.228	0.294
R^2 adjusted	0.157	0.182	0.413	0.053	0.179	0.225
F	5.24***	5.33***	9.71***	2.09**	4.71***	4.29***

Note: Standard errors in square brackets, p-values in curly brackets; $n = 137$.

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

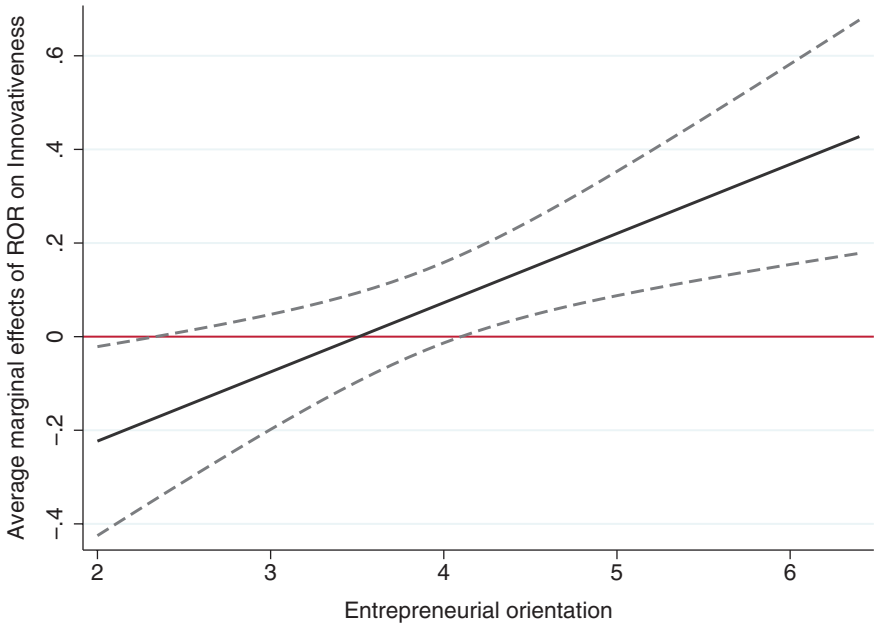

FIGURE 2 Marginal effects of real options reasoning (ROR) on portfolio innovativeness with respect to different levels of entrepreneurial orientation (dashed lines represent 90% confidence bands)

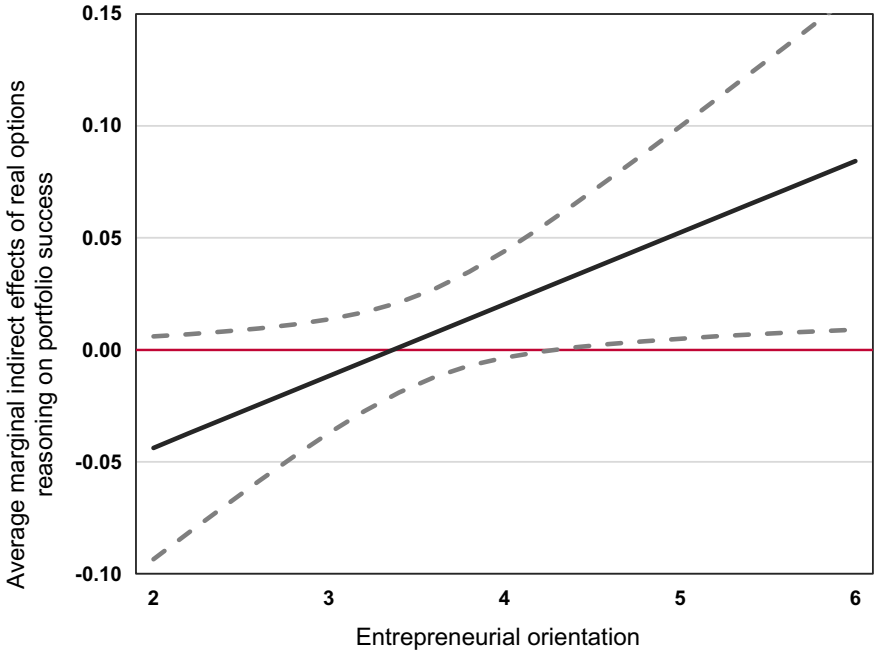

FIGURE 3 Average marginal indirect effects of real options reasoning (ROR) on portfolio success with respect to different levels of entrepreneurial orientation (dashed lines represent 90% confidence bands)

full upside potential. This enables decision makers to venture projects that are more innovative yet also more uncertain (Dixit & Pindyck, 1995).

With ROR's sequential form of investment and overall low commitment, decision makers are able to consider new information in future resource allocation decisions. In

this regard, ROR is an act-and-see instead of a wait-and-see approach (Adner & Levinthal, 2004b). So, decision makers and project members can act toward decreasing uncertainty during project execution to better adapt to external (e.g., market developments) or internal (e.g., technological) changes (Huchzermeier & Loch, 2001; Sońta-Drączkowska & Mrożewski, 2020). Further, decision makers are able to venture into multiple innovative project options simultaneously, which allows them to test options in parallel instead of doing serial tests for definitive project investment (Loch et al., 2001). Coupled with ROR's characteristic of constant resource reallocation to more promising options, this should establish stronger competition and selection of more lucrative options across the portfolio. Decision makers can advance highly innovative projects and abandon the lowest performing projects with limited losses. The actual number of initiated and abandoned projects is however contingent on other organizational factors, for example, resource availability (Andries & Hünermund, 2020).

Still, ROR's effect on portfolio innovativeness and success is highly contingent on portfolio actors' behavior. Owing to the aforementioned ROR advantages, decision makers are more likely to engage in innovative projects. However, to reap ROR's full potential, decision makers need to select promising options and consequently abandon those project options that have turned unfavorable (Adner & Levinthal, 2004b). Since ROR constitutes a heuristic approach, its effect ultimately depends on portfolio actors' individual assessment and behavior (McGrath et al., 2004; Tong & Reuer, 2007). Their behavior in turn is highly shaped by the organizational context (Adner & Levinthal, 2004b; Coff & Laverty, 2007).

In this regard, we followed Barnett's (2008) conceptual work and investigated the interaction between an organization's strategic contextual structure and ROR. The results show that through ROR, coupled with a sufficiently high level of entrepreneurial orientation, firms can increase portfolio value, balance their portfolio toward higher innovativeness, increase their strategic fit, and prepare their portfolio for the future (Cooper et al., 2001). We conclude that with sufficient evidence of future potential, a strong entrepreneurial orientation is conducive to managers relying more on high option values and being willing to take considerable risk to use these options. The general entrepreneurial orientation characteristics, such as proactiveness, innovativeness, and risk taking (Anderson et al., 2015), therefore shape decision makers' attention toward venturing innovative projects, executing favorable options earlier, and acting on options to reduce their uncertainty. This increases ROR's positive effects. Furthermore, the supplementary analysis shows that external turbulences increase the positive effect of ROR on portfolio innovativeness, as well. Faced with external uncertainties, project champions and decision makers might thus be more willing apply ROR and venture into innovative yet risky project options. This also conforms to prior findings on issue selling (Dutton et al., 1997).

Regarding the firm's cultural context, we hypothesized a positive interaction between innovation climate and ROR. We confirmed innovation climate's importance for innovation portfolio management by showing its direct relationship to portfolio innovativeness (Kock et al., 2015). However, in terms of the innovation climate as a contextual structure that interacts with ROR, we find surprising results. We initially presumed that a higher level of innovation climate should provide a suitable environment for ROR in terms of project champions, decision makers, and employees involved in or affected by the innovation portfolio decision making. However, while a high level of entrepreneurial orientation is necessary for the relationship between ROR and portfolio innovativeness to become positive, the interaction effect between ROR and innovation climate is not significant. Nonetheless, the finding's insignificance does not prove the nonexistence of the interaction effect, especially since the likelihood of a type II error with respect to detecting smaller effects is considerable. The data simply cannot confirm the interaction effect.

Nevertheless, there might be factors that inhibit a positive interaction effect. Innovation climate generally relates to a high degree of autonomy and employees' freedom to pursue innovative tasks (Kock & Gemünden, 2016; Kock et al., 2015). A strong innovation climate also promotes innovative, out-of-the-box ideas (Stock et al., 2013). ROR, however, requires strict principles and boundary conditions (Adner & Levinthal, 2004b). Consequently, in keeping with the ROR elements, decision makers' attention in portfolio decisions should be more strongly focused on facts, such as trackable progress or meeting targets (Adner & Levinthal, 2004b). However, if decision makers are too strict in deciding on a project's future, they could also prevent potential stimulating benefits of a high innovation climate.

Additionally, a strong innovation climate supports autonomy for decision makers and project champions (Stock et al., 2013). This could also have negative effects if coupled with ROR. Empowering more project champions most likely brings about more diverse opportunities and projects. Further, a strong innovation climate leads to higher autonomy for decision makers (Coff & Laverty, 2007). Different contextual structures, coupled with a generally higher number of decision makers, increase variability of decision makers' focus, assessment, and behavior (Barnett, 2008; Kogut & Kulatilaka, 2004). A broader portfolio is generally regarded

to have positive effects on portfolio adaptability and future success (Rothaermel et al., 2006). Yet, diverse projects and autonomous decision makers might also alter organizations' strategic path in such a way that they lose their overall strategic focus and get stuck in opportunity exploration (Adner & Levinthal, 2004b). That is one of the reasons why Adner and Levinthal (2004b) strongly recommend that decision makers set clear boundary conditions for option execution and abandonment in advance and strictly adhere to them.

Consequently, on the one hand, the interaction between the innovation climate and ROR could be positive, since a stronger innovation climate leads to stronger decision support, better coping with a project termination, and championing innovative opportunities (Barnett, 2008). On the other hand, innovation climate's freedom and ROR's strict focus could lead to a negative interaction between innovation climate and ROR. While the empirical analysis did not distinguish this, positive and negative effects of innovation climate could potentially compensate each other, resulting in the overall insignificant interaction effect we observed in the data. In this regard, we need more research on how a strict approach, such as ROR, could harmonize with a climate focused on innovation and personal fulfillment.

7 | IMPLICATIONS

7.1 | Theoretical implications

This article offers multiple contributions to the literature on ROR and innovation portfolio management. First, focusing on innovation influence, it adds to the debate on ROR's general performance influence (e.g., Adner & Levinthal, 2004b; Kogut & Kulatilaka, 2004; McGrath et al., 2004; Tong & Reuer, 2007). With the mediated model, it offers detailed insight into the consequences of ROR for portfolio innovativeness and portfolio success. The findings are in line with prior argumentation on the advantages ROR has for innovative, yet uncertain options (Adner & Levinthal, 2004b; Tong & Reuer, 2007). By demonstrating the mediated relationship between ROR and portfolio success, this article specifically extends the recent findings of Klingebiel and Adner (2015), whose research focused on ROR's dimensions and their influence on innovation performance. We also add empirical insight on ROR's beneficial influence in innovation management (McGrath et al., 2004). This is relevant, since prior literature noted that because innovative endeavors are highly unpredictable, they might conflict with establishing strict, in advance boundary conditions for abandoning certain options (Adner & Levinthal, 2004b). Our study shows that through a suitable organizational context, ROR can be very beneficial for innovation portfolios.

Second, our study demonstrates that organizational contexts play an important role in shaping portfolio actors' attention and behavior. Previous research was inconclusive regarding whether ROR generally benefits firms (e.g., Li et al., 2007). Our article follows the conceptual work of Barnett (2008), who describes ROR's interaction with contextual structures from an attention-based view. By including top-down strategic entrepreneurial orientation and bottom-up innovation climate, we directly respond to the call for additional research on the interaction between ROR and organizational contexts (Adner & Levinthal, 2004b; Coff & Laverty, 2007; Li et al., 2007). We provide relevant empirical evidence for the interaction between ROR and a firm's strategic and cultural context. This also adds to prior studies on decision-making in innovation management (Behrens & Ernst, 2014).

Third, our article contributes to recent literature on strategy and adaptiveness in innovation portfolio management (Baker et al., 2016; de Brentani, 2001; de Brentani et al., 2010). The findings highlight entrepreneurial orientation's positive influence on portfolio innovativeness and portfolio success, also underlining its importance as a moderator in relation to applying ROR. While previous strategic literature on entrepreneurial orientation has mainly considered its direct influence (Wales et al., 2013), this article offers additional insight into entrepreneurial orientation's organizational support. Further, we add to recent literature on adaptiveness in new product development (Cooper & Sommer, 2016; Kock & Gemünden, 2016, 2019). In combination with frequent portfolio reviews, ROR constitutes a suitable approach for firms to increase their innovativeness, which enables them to better adapt to future challenges (Kogut & Kulatilaka, 2004).

7.2 | Managerial implications

This study's results are highly relevant for innovation portfolio managers. In general, we encourage project champions and portfolio decision makers to propose and venture innovative yet uncertain projects, since higher portfolio innovativeness translates to greater success. Further, we advocate that managers apply ROR to cope with innovative projects' higher degree of uncertainty. However, we also highlight ROR's behavioral character in emphasizing that ROR's positive contribution depends on project champions' and decision makers' behavior. Decision makers particularly, should be aware that the organizational context influences their attention and behavior. According to the empirical results, an organization's entrepreneurial orientation provides a strong supporting context for ROR, leading to both higher portfolio innovativeness and higher success. Furthermore,

we generally support a strong innovation climate due to its positive influence on innovativeness. However, we also remind decision makers of ROR's challenges, as ROR requires decision makers to formulate strict boundary conditions for option abandonment.

7.3 | Limitations and future research

Our empirical analysis is associated with certain characteristics that need to be considered when interpreting its implications. Since we relied on correlation-based methods of analysis, there can only be a limited direct causal interpretation of the findings. Nevertheless, we mitigate endogeneity concerns, such as common-method variance, by using multiple types of informants (decision makers, coordinators, and multiple project managers) and applying statistical measures to test for common-method bias.

The findings provide valuable quantitative insights for ROR and its interaction with contextual structures in innovation portfolio management. However, they also open up avenues for future research. ROR conceptually covers a range of different options types available to decision makers (e.g., abandon, switch, and expand). We, therefore, could not differentiate the impact of specific types, which is a potential issue for future research. Further, adding to the findings of Klingebiel and Adner (2015), future research could investigate how contextual structures interact with comparable resource regimes (e.g., sequential but definitive project investment). Furthermore, additional factors which might potentially facilitate or hinder successful implementation of ROR in the portfolio decision process could be investigated. In particular, we encourage future research on decision makers' personality traits (McNally et al., 2009), their cognitive load (Killen et al., 2020), and influences of status reporting (Hopmere et al., 2020) in relation to ROR. Finally, we see great potential in exploring the organizational change process ROR could support over time (Midler et al., 2019). Depending on the actual selection of executed options, projects could either contribute to the originally intended strategy or support the development of new emerging strategies (Bowman & Hurry, 1993). Through its impact on strategy development and opportunity recognition, ROR could thus be a relevant part of a firm's search processes (March, 1981). Similar to a self-reinforcing cycle, we would expect ROR's interaction with entrepreneurial orientation to also shape a firm's overall strategic orientation toward enhancing its entrepreneurial orientation (March, 1981). Accordingly, future studies could provide additional insight into the interaction between ROR's dynamics and emerging strategy, and on how firms can apply ROR in adapting to changing environments.

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CONFLICT OF INTEREST

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