

# REAL OPTIONS THEORY IN STRATEGIC MANAGEMENT

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**Research summary:** This article provides a review of real options theory (ROT) in strategic management research. We review the fundamentals of ROT and provide a taxonomy of this research. By synthesizing and critiquing research on real options, we identify a number of important challenges as well as opportunities for ROT if it is to enhance its impact on strategic management and potentially develop into a theoretical pillar in the field. We examine how ROT can inform the key tensions that managers face between commitment versus flexibility as well as between competition versus cooperation, and we show how it can uniquely address the fundamental issues in strategy. We conclude with suggestions on future research directions that could enhance and unify the thus-far distinct main approaches to real options research.

**Managerial summary:** Real options theory (ROT) applies the heuristics and valuation models originally designed for financial securities to the domain of corporate investment decisions (e.g., joint ventures [JVs], foreign direct investment, research and development [R&D], etc.) and strategic decision making under uncertainty. This article provides a synthesis of this body of research in strategic management and related disciplines. We suggest how ROT can address fundamental issues of strategy, including the dilemmas managers face between commitment versus flexibility as well as between competition versus cooperation. We discuss how three distinct approaches to real options analysis can complement each other, and we identify some of the main challenges and opportunities for ROT to become a theoretical pillar in strategy. Copyright © 2016 John Wiley & Sons, Ltd.

## INTRODUCTION

This article provides a critical review and synthesis of real options theory (ROT) in strategic management research. ROT has produced important insights and empirical evidence on various topics in different streams of research in strategic management, such as market entry timing, modes of entry, and organizational forms (e.g., joint ventures

[JVs], acquisitions, etc.), foreign direct investment and MNC performance, cooperation versus competition trade-offs and so on, yet challenges remain in our understanding and application of ROT in the domain of strategic management. Taking stock of this literature and providing a synthesis is also important in light of three distinct approaches to real options research that have emerged over the years, each having its own strengths and limitations, but not as yet building on each other. For readers new to this theory, we cover the fundamentals of ROT by clarifying when real options exist and by highlighting some of their distinctive features and drivers. We also offer a taxonomy of research on real options, highlighting key areas in which

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significant progress has been made as well as identifying areas in which advances have been limited and deserve further attention. Our categorization and synthesis of the relevant strategic management literature on real options also aims to present unifying interpretations and critical assessments to help identify some of the primary challenges and promising future opportunities for this literature.

Another important objective of our review is to consider the potential for extending ROT to engage with and address the fundamental issues of strategy that have occupied the field's attention since its inception. In particular, we submit that ROT can offer new insights into the drivers of firm heterogeneity and competitive advantage (e.g., Peteraf, 1993), organizational form and associated build-borrow-buy decisions (e.g., Capron and Mitchell, 2012), cooperation versus competition trade-offs arising in many market and technology contexts (e.g., Smit and Trigeorgis, 2004), and the role of headquarters in multinational firms (e.g., Rumelt, Schendel, and Teece, 1994). In our review, we articulate ROT's connections to these fundamental strategy issues by noting two trade-offs that often underpin strategic choices: between commitment and flexibility (e.g., Ghemawat, 1991; Smit and Trigeorgis, 2004) and between competition and cooperation (e.g., Teece, 1992). The commitment-flexibility trade-off reflects the importance of "staging" choices as one of the core elements of strategy (Hambrick and Fredrickson, 2001) as well as the classic advantages of a first mover such as preemption. The competition versus cooperation trade-off lies at the heart of competitive strategies and firms' interactions with others (e.g., Chen and Miller, 2015), and relates to strategic choices concerning corporate boundaries as well as technology development and commercialization activities (e.g., Gans and Stern, 2003). Uncertainty, a key driver in ROT, critically informs these tensions, and because it also features centrally in other theories in strategic management, often in different ways, it provides a basis for comparisons as well as potential integration.

We further suggest that novel research opportunities exist to realize ROT's potential through better integration of the three main approaches to conducting real options research, namely, real options reasoning, real options modeling, and behavioral perspectives on real options. These three approaches have largely developed independently and are sometimes presented as rival versions

of ROT in strategic management. We identify a number of opportunities that the field might pursue by marshalling them in combination, and we provide some guidance on what such a research agenda might entail. We also bring up a number of frontier areas for research that hold promise and pathways for strategic management research.

## FUNDAMENTALS OF REAL OPTIONS THEORY

We begin by defining real options, which amounts to describing what makes them "options," and then what makes them "real." The term *option*—as opposed to *alternative* or *possibility*—is of importance in understanding the theory's origins and boundaries and in developing and testing relevant hypotheses. An option is a right, but not an obligation, to take some future specified action at a specified cost. At its core is a fundamental decision asymmetry to take a future decision (e.g., invest) only if it's beneficial to the decision maker, but not otherwise. In some organizational contexts, certain rights might be established through contracts (e.g., patents, JVs) or preferential access to investment opportunities (e.g., in an equity investment); alternatively, they might be established through idiosyncratic knowledge that a firm possesses (e.g., through learning by doing or research and development [R&D])<sup>1</sup>. The fundamental decision asymmetry of options involving the right but not the obligation to act also gives rise to an asymmetry in firm outcomes in the presence of uncertainty. For example, in the case of a call option to invest, the holder is able to access upside opportunities (through exercising the call by investing or expanding) while limiting downside losses (by not exercising it in the event of adverse developments).

Myers (1977) coined the term *real options* and envisioned bringing the theory of financial options to the realm of strategic decision making. Real

<sup>1</sup> This definition of options as rights, or claims on future opportunities, is different from the informal usage of the term options, such as when a firm is said to take an "options approach" by undertaking a number of small and disparate activities, which may not confer clear rights. Moreover, just as a right must exist, it is equally important that the decision maker is not obligated to act in the future for an option to exist. In some contexts, however, firms may be compelled to undertake certain investments due to regulation, competitor actions, prior contractual commitments, or governance inseparabilities (e.g., Argyres and Liebeskind, 1999).

options were seen as “opportunities to purchase real assets on possibly favorable terms” (p. 163). These favorable terms hinge on adjustment costs, market power, or other imperfections in product or factor markets. Connections to strategic management’s focus on firm heterogeneity and competitive advantage are readily appreciated. In the case of financial options, an investor has the right to act to acquire a financial security (e.g., shares of stock) as the underlying asset, yet in real options, the underlying is a “real” asset. Incremental cash flows are tied to the construction or scale up of a plant, the development of a product in an R&D program or the exploitation of a patent, and so forth. ROT has consequently extended options thinking from financial markets, where options are based on traded contracts with specified terms, to real assets, tangible or intangible<sup>2</sup>. As a result, there are many different types of real options.

Table 1 provides a taxonomy of real options (Trigeorgis, 1996). In Panel A, we identify five basic types of stand-alone real options, namely: (1) the option to defer or stage market entry when facing exogenous, market demand uncertainty (e.g., Dixit and Pindyck, 1994; McDonald and Siegel, 1986) (e.g., a firm considering entry into an emerging product market or host country); (2) the option to grow (e.g., Kulatilaka and Perotti, 1998) (e.g., a firm taking a partial equity stake in another company when entering a foreign market with the possibility of expanding at a later date); (3) the option to alter scale (e.g., expand or contract), including the option to expand manufacturing capacity or an outsourcing arrangement (e.g., Leiblein and Miller, 2003); (4) the option to switch inputs, outputs, suppliers, and so on (e.g., a MNC able to reallocate production across foreign subsidiaries in response to changes in exchange rates (e.g., Huchzermeier and Cohen, 1996; Kogut and Kulatilaka, 1994)); and (5) the option to abandon, such as exit a market or sell a technology if conditions deteriorate (Chi, 2000; Dixit, 1989).

Most firms actually possess a portfolio of such options within and across these five categories. This suggests that the real-life decisions firms make regarding the acquisition, maintenance or exercise

of such options can affect the value of other options a firm has, so these interactions need to be accounted for when making these decisions (Anand, Oriani, and Vassolo, 2007; Trigeorgis, 1993b; Vassolo *et al.*, 2004). Moreover, even for single investment decisions, such as timing entry into a market, a firm may possess both deferral and growth options at once (Folta and O’Brien, 2004), and their value can, in turn, be affected by other factors such as network effects and technology evolution (Chintakananda and McIntyre, 2014).

Unlike financial options, some real options may not be liquid or traded in organized markets (they sometimes may not yet exist, as in R&D)<sup>3</sup>; they may be asset or firm specific (and hence, partly irreversible), which gives rise to challenges such as information asymmetries, path dependence, and incomplete property rights; and their terms may not always be clearly defined. Inasmuch as earlier activities and prior investments open up or shape particular future investment opportunities, there is a temporal linkage between the firm’s previous and future activities or investments, even though this may not be immediately obvious to some executives. The notion of shadow, or hidden, options (Bowman and Hurry, 1993) suggests that a firm needs to uncover and appreciate these linkages and the opportunities that firm resource endowments and capabilities might create in the future. Firms that lack such early pre-investments, or do not appreciate the particular follow-on opportunities that stem from prior investments, may not be able to access the same future investment opportunity set, or do so on the same terms. Thus, informal labeling of mere possibilities as “options” can miss appreciating the importance of the preferential and heterogeneous access that different firms have to specific investment opportunities.

It also follows that terms of real options may not be clear-cut (e.g., the option maturity, or time to make a commitment, may be fuzzy or uncertain as it may expire on unanticipated rival entry), or they may be influenced by managerial actions and the behavior of external parties such as rivals. Such actions can also influence other parameters of a real option’s value, including the underlying asset value (i.e., the value of the cash flows associated with the investment) or exercise cost (i.e.,

<sup>2</sup> Tangible assets underlying real options might include real estate, natural resources, R&D and patents, physical plants, and strategic acquisitions; intangibles include brands, unique business processes, flexible human capital, and knowledge developed in joint ventures or other cooperative agreements.

<sup>3</sup> For a discussion on incomplete markets or subjective utility-based risk averse entrepreneurial preferences see Henderson (2002, 2007).

Table 1. Strategic investment choices as real options

<b>A. Basic real options</b>	
Type of option	Investment choice/illustration
Defer or stage	Delay or stage market entry when facing demand uncertainty
Grow	Enter new or foreign market (with option to buy partner)
Alter scale (expand/contract)	Expand or contract plant or scale of outsourcing contract
Switch	Switch suppliers or production across foreign subsidiaries
Abandon/exit	Exit market (or sell technology for salvage) if conditions deteriorate
<b>B. Extensions and complications for real options</b>	
Option extensions	Complications
Portfolios of options and interactions	Option <i>substitutability or complementarity</i>
Multiple sources of uncertainty	<i>Different uncertainties</i> favor different investments and might change market timing and entry modes
Competition and preemption versus cooperation	Competitive moves by others <i>erodes the value</i> of a firm's option to defer entry; collaboration (e.g., via joint R&D venture) can instead preserve option to wait
Learning	Value of investing hinges on reduced <i>endogenous uncertainty</i>

Source: adapted from Trigeorgis (1996).

the cost of going forward with the investment). For instance, bargaining costs during negotiation *ex post* may raise the exercise cost, and thereby diminish the net benefits of exercising an option (Chi, 2000). Owners of such real assets might secure related benefits only for a limited duration, and often end up sharing their inherent benefits with other industry participants. Benefits are often remote, diffuse, or difficult to predict and secure. In all these respects, real options differ from financial options. Moreover, unlike financial options whose exercise does not affect the holders of other options, real options exercised in oligopolistic settings can affect (e.g., damage or preempt) other option holders such as rivals, whose reaction must therefore be accounted for in initial strategic decisions (e.g., upfront capacity selection). Real option terms may also differ across firms, driving heterogeneous firm behavior (e.g., a firm facing less firm-specific uncertainty than a rival may enter first, gaining first-mover advantages).

A further complexity inherent to options on real assets is that many different uncertainties can affect their value, and thus, firms' investment behavior (e.g., see Dixit and Pindyck, 1994; Folta, 1998; Trigeorgis, 1996; Vassolo *et al.*, 2004, for a discussion of multiple types of uncertainty affecting the value of real options). These can be broadly classified into exogenous uncertainties (e.g., market demand or some competitive uncertainty such as from

random entry)<sup>4</sup>, endogenous uncertainties (e.g., technological uncertainty that might be resolved through further learning-type investment as in Dixit and Pindyck (1994) and Pindyck (1993), or behavioral uncertainties such as arising from the behavior of a JV partner, or other uncertainties over which the firm may have some, but perhaps limited, influence such as through nonmarket strategies to shape political risk. Some standard models and early applications were well suited for exogenous uncertainties (e.g., market demand) where the classic option models from financial economics readily applied, though more recent research also addresses the role of endogenous or technological uncertainty (e.g., Oriani, 2007; Oriani and Sobrero, 2008). Thus, one key challenge for the formal modeling of real options, compared to basic financial options, is that multiple sources of uncertainty can affect the value of many real options.

As real options involve rights to act on *real* tangible or intangible assets that may not always be clearly defined and those rights might potentially

<sup>4</sup> Some market uncertainty can sometimes be endogenous in that an initial investment can yield information on whether a larger investment is later warranted. For instance, entry into a new geographic market often involves considerable uncertainty about the reaction of potential consumers but the entrant can find out whether the market is receptive to its product by actually selling it on a small scale for a period of time.

be shared with other parties, their (non)proprietary nature needs to be accounted for when applying options theory in the domain of strategic management. Sometimes the rights might be exclusive to one firm (e.g., outputs of R&D), but this is often not the case (Trigeorgis, 1996). Proprietary options are usually firm-specific (e.g., when based on knowledge from learning-by-doing) and the option value goes away at expiration if the firm chooses not to exercise it (Myers, 1977). In some cases, options may be traded on secondary markets that themselves may display certain imperfections (e.g., markets for technology). In the case of shared options held by many firms in a market, the exercise of an option by one firm to invest or enter the market can erode the value of the option to wait by rival firms. In such cases, the claim that a firm has on a future opportunity can be contestable and uncertain, and the risk of competitive erosion or even preemption can lead firms to commit early or in larger scale, rather than be flexible by investing incrementally or waiting to see how a market develops.

The value of waiting hinges not only on the actions of rivals, but also on how irreversible the market entry decision is. If it is easy to resell technology or other assets committed when entering a market, there is less need to wait for additional demand cues. Absent irreversibility, it doesn't pay to wait, and absent uncertainty, there is no value to an option to wait either, so when there is both significant uncertainty and irreversibility, it pays to keep open the option to defer when proprietary (Dixit and Pindyck, 1994). Combined considerations such as competitive threats, the (non)exclusivity of the right, as well as the degree of uncertainty and irreversibility, or new opportunities an investment might open up can therefore jointly determine whether a firm should commit and enter an industry or be flexible to wait or stage entry.

The above discussion illustrates some of the main drivers of strategic investment that are unique to real options, but it also brings into focus the unique contributions of the strategic management field to this literature (e.g., Cuypers and Martin, 2007; Li, 2007; Li *et al.*, 2007; Miller and Folta, 2002; Reuer and Tong, 2007). Panel B of Table 1 summarizes some of the main complications that commonly surround firms' real options and strategic investment decisions. Some of these dimensions complicate formal real options modeling and the articulation of relevant hypotheses, but many of these complications are inherent to the transition from financial

options to the realm of real options. Such complications need to be carefully accounted for in formal models of real options as they require adjustments to the original theory as well as in cases relying on metaphorical use of option theory to analyze corporate investments and strategic decision making under uncertainty. Panel B particularly focuses on four complications that deserve further attention and extensions in the literature: (1) *portfolios* of options and their *interactions* (e.g., substitutability or complementarity effects); (2) impact of multiple sources of *uncertainty*, and how they may change investment timing and entry mode choices; (3) *competition and preemption* versus *cooperation* trade-offs (e.g., how first movers or collaboration might erode or preserve the option to wait); and (4) *learning* effects (resolution of endogenous uncertainties).

## ORGANIZATIONAL STRATEGIC DECISION MAKING UNDER UNCERTAINTY

Having described the fundamental characteristics of real options, we now briefly discuss the three phases of investing in real options in organizations and describe the basic stages of the real options chain or life cycle. This allows us to distinguish three distinct approaches to ROT in strategic management and to develop our taxonomy of the literature.

It is useful to first summarize the process of real options analysis in organizations as it helps classify research and reveal gaps in understanding and new avenues for research:

1. *Problem structuring*. This involves a qualitative, strategic depiction of the problem structure indicating the various managerial decisions or options, their timing and linkages, the main underlying uncertainties, and the key value drivers. An option map can be developed that is analogous to a decision tree representation, but focuses on option characteristics and interlinkages among options.
2. *Valuation and modeling*. At its core, this analysis involves collection of the primary input data to enable a standard discounted cash flow (DCF) estimation and determination of a base-case net present value (NPV) as a base (benchmark). After estimating additional option-driven input estimates, the analysis proceeds with use of

an option valuation model, such as binomial trees (e.g., Cox, Ross, and Rubinstein, 1979) or simulation, to estimate the Expanded-NPV (E-NPV) of an investment. This captures the value of active management represented by the set of embedded options.

3. *Implementation planning.* After arriving at a recommendation for a strategic investment, management can develop a contingent decision plan specifying conditions for the exercise of major options in different circumstances and develop an operating policy and decision milestones across investment stages<sup>5</sup>.

In parallel with the above basic stages of real options analysis practiced in organizations, research on ROT can further be characterized by basic stages in the real option life cycle (e.g., Bowman and Hurry, 1993). Each of these stages identifies a unique set of challenges and opportunities for firms to capture value. Specifically, analogous to product development processes in high-tech firms, Figure 1 identifies four basic life cycle stages: (1) *Identify* or recognize a hidden (shadow) option (i.e., *discovery* of opportunity); (2) *Create (or acquire)* a basic or extended real option via searching, gathering information, and acquiring or organizing needed resources at a cost (*exploration or acquisition*); (3) *Manage*, maintain, and strengthen the real option by incurring necessary preservation or enhancement costs (*development*); (4) *Exercise* the real option (*exploitation*). Like the types of investment analyses mentioned above, these phases need not occur in a linear and rational manner as serendipity plays a role, and the discovery and exploitation of new technological and market opportunities need not progress in such an orderly fashion. However, the fundamental distinct nature of the four stages above helps in characterizing previous real options research in strategy and identifying gaps.

The first two stages involve entrepreneurial-type activities, while the latter two require managerial skills and organizational systems in place. The figure suggests a complementary role for these activities. For example, it is not just the pool

of shadow options that creates firm value alone, but effective managerial decisions to implement and exploit the decision flexibility. This requires adequate organizational systems and management commitment. Broadly speaking, much of the literature has concentrated on Stage 4 (valuing and/or exercising a real option), while some studies have addressed Stage 2 (creation or acquisition of an option at a premium, or valuing the option premium). However, in our view, insufficient attention has been paid to Stage 1, identification of option opportunities through entrepreneurial-type discovery, and to Stage 3, the preservation, strengthening, and management of the firm's real options portfolio. This suggests the need to carry out research across these stages of the real option chain rather than in isolation or using one single approach to ROT.

The above organizational discussion of the common elements and phases of real options analysis naturally allows us to present the complementary roles, contributions, and limitations of each of three prevalent approaches to real options decision making. The most common approaches to real options decision making are: (1) real options reasoning, which relies on logic and heuristics and presents real options as a way of thinking by executives; (2) real options valuation and modeling, which relies on formal analytical (mathematical or simulation) models to value options and derive hypotheses for research; and (3) behavioral perspectives, which focus on the implementation of real options in organizations. Each are reviewed below.

### Real options reasoning (ROR)

Much of the strategy literature views ROT as a strategic and intuitive way of thinking (Folta and O'Brien, 2004; Trigeorgis, 1996), a logical tool or rhetorical device for creating or keeping options open and exploiting them. Essentially, ROR captures the formulation and testing of hypotheses based on verbal theorizing without the aid of analytical modeling. Prevalent use of ROR in strategy is natural given the difficulties of accurately mapping financial options theory into real investment decisions and the many complications of valuing real options highlighted earlier. ROR is most suitable when the key drivers of real option value can be identified and synthesized conceptually (McGrath, 1997), even if options cannot be valued formally. There are several ways that ROR can help organizations better structure their

<sup>5</sup> Management must also consider requirements for realizing the theoretical option value, such as assigning teams to monitor trigger cues and exercise major options, reassess value at future critical milestones and put in place proper information, control, and management reward systems to align managerial incentives and action with the identification, development, and exercise of major real options.

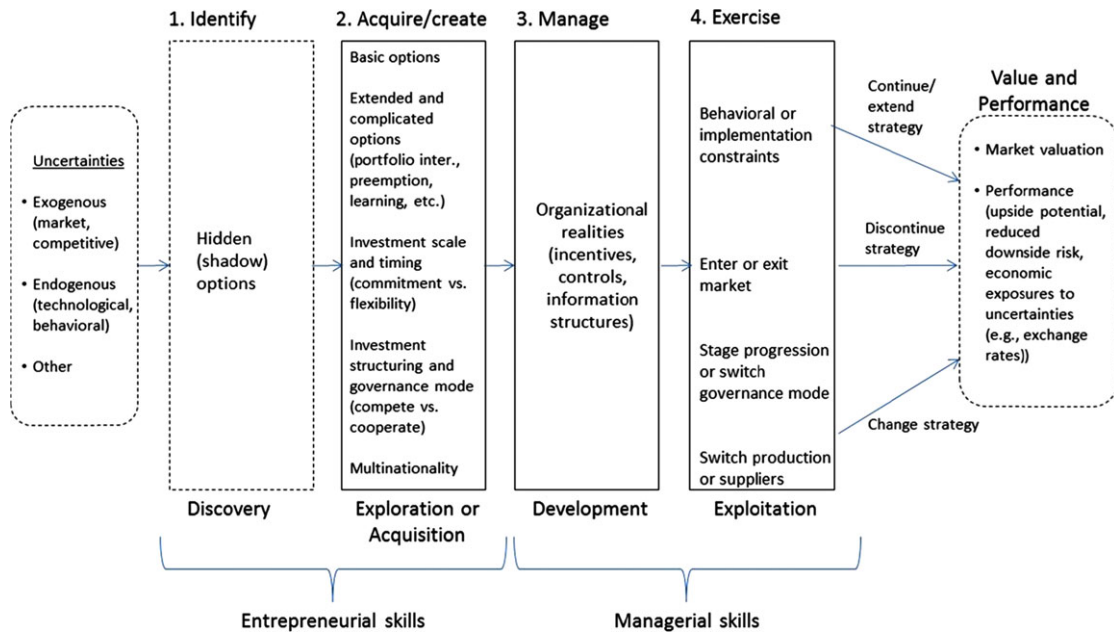


Figure 1. Stages of the real option life cycle

strategic investment decisions under uncertainty. First, ROR generally encourages firms to undertake more uncertain projects since option value rises with uncertainty (McGrath, 1999), and as a rule, firms may have biases against making investments under uncertainty (capital budgeting practices rely on discounted cash flow analyses and NPV, which often undervalue such initiatives). Second, ROR suggests that investments undertaken in the presence of uncertainty be staged to keep open the upside potential while truncating downside losses (e.g., Trigeorgis, 1996). Third, ROR encourages proactive contingent management of investments with flexible decision choices that allow future modification depending on contingent circumstances (e.g., McGrath, Ferrier, and Medelow, 2004). Fourth, ROR encourages a portfolio approach involving many low-cost, staged investment bets (e.g., Trigeorgis, 1996). Research that uses this approach to ROT aims to capitalize on the qualitative insights of options theory, and this research has found applications in technology management, entrepreneurship, and international strategy, among others.

**Real options valuation (ROV) or modeling**

Most of the economics and finance literature, by contrast, focuses on real option valuation (ROV)

and uses formal mathematical models or simulation to value options. Interested readers can consult Trigeorgis (1993a) for a review of this literature, and the books by Dixit and Pindyck (1994) and Trigeorgis (1996). Many of the classical readings and important modeling contributions can be found in Schwartz and Trigeorgis (2001). Formal modeling of real options offers a number of advantages, including being specific and transparent on key assumptions (that are often left implicit or unspecified in ROR), exposing critical boundary conditions or new theoretical relationships through comparative statics and numerical analysis, enabling the simulation of complex and interacting relationships, and often building directly off of original models in option theory. Mathematical or simulation modeling can be useful as a tool for developing propositions and comparative statics insights, and we would encourage more of this research within strategic management. Despite these clear and important strengths, this approach also has a set of drawbacks. For example, for purposes of mathematical tractability, ROV models often rely on restrictive assumptions that are not readily implementable in practice (e.g., Triantis, 2005). Nonetheless this research has shown that ROV can better explain market valuations and many investment decisions than traditional DCF-based approaches in diverse areas (e.g., Moel and Tufano, 2002). But while

ROV models can be rigorous, they can sometimes also become removed from the practical relevance and organizational realities that are of interest to strategic management scholars and practicing firms.

### Behavioral perspectives (BP) on real options

This approach aims to come to terms with these organizational realities and give more attention to the human or behavioral nature of management and the constraints on the adaptive capabilities of organizations. Adner and Levinthal (2004) cautioned that the domain of applicability of ROT is limited when necessary conditions such as decision flexibility and information accuracy are not met due to real-life frictions, organizational realities, and implementation weaknesses. If information about the value of an asset at the decision time is imprecise, managers may underinvest in good opportunities or overinvest in bad projects (e.g., Coff and Laverty, 2007; Trigeorgis, 2014). As a matter of implementation, it is often difficult to identify latent or shadow options (Bowman and Hurry, 1993) or to value many real options when the terms of the option such as expiration are not so clear-cut (McGrath, 1999) or the valuation is project specific (Bowman and Moskowitz, 2001). Such constraints naturally lead to practical difficulties in the effective management of real options (McGrath *et al.*, 2004). Managers are further constrained by bounded rationality (Trigeorgis, 2014), so ROT might embrace this behavioral assumption to better connect with existing streams of strategy research. Differences exist across organizations in their information processing and belief updating, contributing to differential effectiveness in executing real options (Leiblein, Chen, and Posen, 2015). While the promise is to bring real options to real-world organizations, a need exists to be clear about the challenges in doing so, including integrating theories with different starting assumptions. Working out the implications of bounded rationality, information imperfection, and behavioral biases is one such opportunity, just as research on real options implementation needs to be concerned about separating behavior compatible with rational real option-based decisions from other path-dependent behavior (e.g., Klingebiel and Adner, 2015).

### A TAXONOMY OF REAL OPTION STUDIES

Based on the above three approaches to real options research, we classify studies according to whether they use a real options reasoning approach or formal modeling and specific analytical valuation methodologies (see Table 2). The top part of Table 2 provides representative articles on the five basic types of real options (reviewed in Table 1, Panel A). Our taxonomy of the literature leads us to draw out several broad conclusions about real options research. First, while theoretical and conceptual articles outpace empirical papers, there is a growing empirical literature on real options, and in this regard, the strategic management field has made important contributions to the broader real options literature. These studies examine the antecedents of strategic investments involving the purchase or exercise of various options as well as their valuation and performance consequences. The articles in Table 2 establish how real options are embedded in a broad range of firms' strategic investments and activities, and as we discuss, often challenge received wisdom in important ways<sup>6</sup>. The table further highlights the many complications that arise for ROT in the realm of strategic decision making (e.g., portfolios of options and interactions across options, uncertainty affecting the value of different options at once, and multiple sources of uncertainty, competitive erosion, and preemption, learning, etc.). For instance, strategy research considers search and the role of learning in the context of corporate diversification as firms sequentially enter or exit industries (Chang, 1995, 1996), and other research features endogenous uncertainty as being central to firms' corporate investment decisions. Additionally, strategy research has devoted attention to the implications of options in firms' portfolios being super- or sub-additive rather than being independent of one another (e.g., Anand *et al.*, 2007; Trigeorgis, 1993b; Vassolo *et al.*, 2004).

Second, a prevalent theme in real options research is the classic trade-off between firm commitment and flexibility (Ghemawat and del

<sup>6</sup> For instance, joint ventures were long viewed as "marriages" between organizations, and in this view stability, longevity, and harmony were markers of effective collaborations. By contrast, ROT suggests that firms can partner in an uncertain domain and then be in a position to buy out a partner if uncertainty is resolved favorably, suggesting a new role for transitory collaborations in uncertain market contexts to capture value (Kogut, 1991).



Table 2. Main research themes and literature categorization

Main research theme	Representative studies		
	RO reasoning	Valuation/modeling	Empirical
<i>Mapping to basic options</i>			
Defer or stage	Trigeorgis (1996) and McGrath (1997)	McDonald and Siegel (1986) and Dixit and Pindyck (1994)	Campa (1994)
Grow	Kester (1984) Kogut (1991), and Malos and Campion (1995)	Kulatilaka and Perotti (1998)	Trigeorgis and Lambertides (2014), Malos and Campion (2000)
Alter scale (expand/contract)	Trigeorgis (1996)	Pindyck,(1998)	Damaraju, Barney, and Makhija (2015) and Hurry, Miller, and Bowman, (1992)
Switch	Trigeorgis (1996)	Kogut and Kulatilaka (1994) and Sakhartov and Folta (2014)	Allen and Pantzalis (1996) and Rangan (1998)
Abandon/exit	Adner and Levinthal (2004) and Lee, Peng, and Barney (2007)	Dixit (1989) and Chi (2000)	Elfenbein and Knott (2015) and Arend and Seale (2005)
<i>Extensions and complications</i>			
Portfolios and option interactions	Trigeorgis (1996)	Trigeorgis (1993b)	Vassolo, Anand, and Folta (2004) and Anand <i>et al.</i> (2007)
Uncertainty and investment	Dixit and Pindyck (1994)		Folta and O'Brien (2004) and Li and Chi (2013)
Competition and preemption versus cooperation	Smit and Trigeorgis (2004)	Chevalier-Roignant and Trigeorgis (2011)	
Learning	Kogut and Kulatilaka (2001)	Pindyck (1993)	Li (2008)
Investment (market entry) timing and scale (commitment versus flexibility)	Dixit and Pindyck (1994), Trigeorgis (1996), Rivoli and Salorio (1996), McGrath (1997) and Chintakananda and McIntyre (2014)	Dixit (1989, 1992); Kulatilaka and Perotti (1998), Pindyck (1998), Sadanand and Sadanand (1996) and Ghemawat and del Sol (1998)	Folta (1998) and Quinn and Rivoli (1991)
Investment structuring, organizational form (market entry mode), and contract/deal design	Buckley and Casson (1998), Leiblein (2003) and Cuypers and Martin (2006)	Chi and McGuire (1996), Chang and Rosenzweig (2001) and Chi and Seth (2009)	Kouvelis, Axarloglou, and Sinha (2001), Reuer and Tong (2005), Ziedonis (2007), Tong and Li (2011), Lukas, Reuer, and Welling (2012), and Tong and Li (2013)
Multinationality (international networks)	Kogut (1983) and Trigeorgis (1996)	Kogut and Kulatilaka (1994) and Huchzermeier and Cohen (1996)	Allen and Pantzalis (1996), Miller and Reuer (1998a), Reuer and Leiblein (2000), Tong and Reuer (2007), Belderbos and Zou (2009), Fisch and Zschoche (2012), Lee and Song (2012) and Tong and Belderbos (2014)
Organization realities and implementation issues	Bowman and Hurry (1993), Bowman and Moskowitz (2001), Zardhooki (2004), Adner and Levinthal (2004), McGrath <i>et al.</i> (2004), Barnett (2008) and Klingebiel (2012)	Trigeorgis (2014)	Moel and Tufano (2002), Miller and Shapira (2004) and Alessandri, Tong, and Reuer (2012)
<i>Valuation and performance</i>			
Market valuation	Kester (1984) and Folta and O'Brien (2007)	Oriani (2007) and Trigeorgis and Ioulianou (2013)	Allen and Pantzalis (1996) and Trigeorgis and Lambertides (2014)
Performance measures	Hurry <i>et al.</i> (1992), Kim, Hwang, and Burgers (1993) and Klingebiel and Adner (2015)	Abel, Dixit, and Eberly (1996), Miller and Reuer (1996), Berk, Green, and Naik (1999) and Bloom and Van Reenen (2002)	Miller and Reuer (1998a, b), Tong and Reuer (2006, 2007), Tong, Reuer, and Peng, (2008) and Driouchi and Bennett (2011)

Sol, 1998; Sadanand and Sadanand, 1996; Smit and Trigeorgis, 2004). This part of the literature typically focuses on issues dealing with investment timing, such as market entry and exit timing (Dixit, 1989) and decision delays or hysteresis (Dixit, 1992) as well as investment scale or capacity choices, such as investment contraction or expansion (Pindyck, 1998). A related literature focuses on the structuring of strategic investments, covering topics such as staging commitments (Baldwin, 1982), deal structuring, and contract design, including the terms of JVs and acquisitions (Lukas, *et al.* 2012; Reuer and Tong, 2005; Tong and Li, 2013), and how different types of uncertainty and their resolution shape market entry modes at the formation of deals and over time (e.g., Folta, 1998; Folta and Miller, 2002).

Third, we separately highlight the stream of research that has examined the value of multinational operations, not only because of the attention this topic has received and its breadth of coverage across the various approaches to ROT, but also because this is a paradigmatic area in which ROT has fundamentally challenged the received wisdom in an established literature. A long-standing body of work in international business (IB) has emphasized the static efficiency gains associated with internalizing exchanges rather than using licensing agreements in the presence of transaction costs (e.g., Caves, 2007). ROT instead portrays the multinational corporation (MNC) as a coordinated network straddling multiple host country environments, positioned to dynamically shift sourcing, production, and other value-chain activities across countries in response to exchange rate movements or other environmental uncertainties (e.g., Kogut and Kulatilaka, 1994). As a result of within-country growth options and across-country switching options that MNCs possess, they are in a position to both take advantage of upside growth opportunities in their multinational network as well as reduce exposure to adverse movements (e.g., in exchange rates) and limit downside risks (e.g., Miller and Reuer, 1998a, 1998b; Reuer and Leiblein, 2000). Recent research considers the conditions that enable MNCs to exercise switching options to contain downside losses, including coordination and control of foreign subsidiaries (Tong and Belderbos, 2014; Tong and Reuer, 2007). The multinational network hypothesis received extensive attention in terms of both ROR (e.g., Buckley and Casson, 1998; Kogut, 1983; Trigeorgis, 1996)

and formal modeling (Huchzermeier and Cohen, 1996; Kogut and Kulatilaka, 1994).

Fourth, the studies in the table indicate that strategic management research is unique in addressing many organizational realities, constraints, and implementation issues that can inform ROT. These include implementation stages and plans (e.g., Bowman and Hurry, 1993; Klingebiel, 2012), managerial limitations and the suboptimal exercise of options (e.g., Moel and Tufano, 2002), agency conflicts and managerial incentives (e.g., Alessandri *et al.*, 2012), management quality and real options awareness (e.g., Bowman and Hurry, 1993; Driouchi and Bennett, 2011), and various cognitive biases in decision making (e.g., Trigeorgis, 2014; Zardhooki, 2004).

Finally, a set of studies listed at the bottom of Table 2 have addressed market valuation challenges and examined traditional as well as new measures of firm performance. Given the critical importance of an asymmetric payoff profile for real options that results from firms having the right but not the obligation to act in the presence of uncertainty, much empirical research on real options has focused on whether and when firms can indeed access upside opportunities while containing downside risk. Research has developed better-suited performance and risk measures for testing these asymmetric predictions from ROT (e.g., Reuer and Leiblein, 2000; Tong *et al.*, 2008). Literature examining the firm value and performance implications of real options has extended our knowledge in assessing market valuation (e.g., Kester, 1984; Oriani, 2007; Oriani and Sobrero, 2008; Trigeorgis and Ioulianou, 2013) and firm performance beyond standard measures such as Tobin's  $q$  and abnormal returns (Abel *et al.*, 1996; Allen and Pantzalis, 1996; Berk *et al.*, 1999; Bloom and van Reenen, 2002) to more direct option-based or asymmetric measures such as market-implied growth option value (e.g., Alessandri *et al.*, 2012; Tong *et al.*, 2008; Trigeorgis and Lambertides, 2014) or downside risk and economic exposures to foreign exchange rate movements (Miller and Reuer, 1996, 1998a, 1998b; Tong and Reuer, 2007). The main advantage of such option-based or asymmetric measures is that they are more closely tailored to testing the predictions of ROT and helping better ascertain if firms are able to derive specific asymmetric benefits as predicted by the theory, helping differentiate ROT from alternative theories in strategy and management.

## REAL OPTIONS THEORY AND CORE STRATEGY ISSUES

For ROT to develop into one of the field's theoretical pillars and to further enhance its contributions to strategic management, ROT needs to engage more deeply with the fundamental issues in strategy that have set out the field's boundaries and research agenda (e.g., Rumelt *et al.*, 1994). We believe that ROT holds such promise for strategy scholarship by tackling the core issues of corporate and competitive strategy. Our intent is not to develop each of these issues in an exhaustive manner, but rather to highlight some of the key insights of ROT in core strategy domains, and provide illustrations that convey the challenges and promise of the theory for the strategic management field.

### Firm heterogeneity and the nature of competitive advantage

At its core, strategy is fundamentally about heterogeneity in firm behavior, organizational performance outcomes and competitive advantage. Barney (1991) identified heterogeneity in resources as the main reason why firms differ in profitability and survival. Knowledge, competencies and learning are at the base of capabilities that allow the firm to exploit new opportunities (e.g., Prahalad and Hamel, 1990). By focusing on firms' investment opportunities and related firm-specific knowledge, ROT can enhance our understanding of why firms differ and what drives sustainable competitive advantage under uncertainty. For instance, in the knowledge-based view of the firm (e.g., Grant, 1996), connections can be seen between knowledge and real options, yet this linkage has not been carried forward as it might. In Kogut and Zander (1992: 385), knowledge is itself "considered as owning a portfolio of options, or platforms, on future developments." Combinative capabilities developed through internal learning (experiments and investments in trial and error knowledge acquisition) and external learning (e.g., via collaborations) provide unique organizational and technological opportunities to firms. Inter-firm differences in knowledge acquisition and learning capabilities can therefore create different options for firms, or result in differential recognition of the options that firms already possess based on their capabilities. In addition, proprietary options that firms take out through internal and external initiatives can lead to

enduring capability differences across firms due to the unique knowledge they acquire when entering new markets or pursuing internal initiatives<sup>7</sup>. Thus, real options can inform firm heterogeneity and competitive advantage by identifying critical bi-directional linkages: Real options both emerge from firm heterogeneity (e.g., unique resource accumulation schemes provide unique options to firms), and when pursued successfully, they enhance firm heterogeneity (as when a firm decides to enter a particular area without competition and the unique experience there provides novel knowledge).

Firm performance was presumed early on to be shaped by firms' market power and competitive behavior (e.g., Peteraf, 1993), and the potential role of inter-firm cooperation was generally underappreciated in the competitive strategy literature. As cooperative relationships among firms gained in importance, strategy scholars began to appreciate the value in switching from competitive strategies to cooperative relationships in the face of uncertainty (e.g., Kumar, 2005). Consideration of these alternative sources of firm heterogeneity leads to multiple pathways to competitive advantage, straddling the dilemmas between commitment versus flexibility as well as cooperation versus competition. In a dynamic environment, firm competitive advantage rests increasingly on an adaptive organizational capability to simultaneously manage these two intertwined trade-offs at once. These two dimensions are naturally related since firms will often implement flexibility through cooperative agreements and commitment through competitive strategies, though this need not always be the case. In fact, one can find a basis for competitive advantage in each of the scenarios in Figure 2, and ROT provides an overall framework and set of modeling tools for an integrated analysis of the intertwined tensions of commitment versus flexibility and of cooperation versus competition in firms' individual strategic investment decisions. Moreover, firms are heterogeneous in the adaptability of their structures and systems (Kogut, 1984; Rangan, 1998; Trigeorgis,

<sup>7</sup> The work of Kogut and Zander (1992), and Penrose (1959) on unique knowledge and internal opportunities suggested that firms will differ in the options they possess based on the resources and knowledge that they uniquely have. Penrose (1959) described how "services" or alternatives in the use of various resources provide the basis for firm growth, and she emphasizes the importance of slack managerial resources in the pursuit of growth. Firms may also differ in their recognition of potential options (or shadow options) based on their unique knowledge and prior resource endowments (see also Bowman and Hurry, 1993).

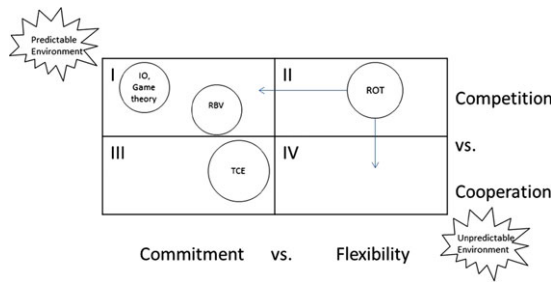


Figure 2. ROT positioning in strategic management relative to key strategy dilemmas. (Source: adapted from Trigeorgis and Baldi (2014))

1996), and in their ability to effectively manage these twin dilemmas (e.g., Chen and Miller, 2015). This heterogeneity to manage effectively these core dilemmas under uncertainty can ultimately lead to differential long-term firm performance.

Figure 2 also is useful in positioning ROT applications and describing how the theory has evolved and differs from other mainstream theories used in strategic management research. Early applications of ROT (Cell II) considered how firms flexibly time their entries into product markets (e.g., Dixit and Pindyck, 1994), in contrast to traditional economics (IO and game theory) emphasizing the value of commitment in Cell I (e.g., Ghemawat, 1991). More recently, ROT has been extended to new applications in other cells of the matrix, including combining ROT with game theory (at the interface of Cells I and II) and applications to cooperative strategies such as JVs (extending into Cell IV). Moreover, initial applications of ROT in Cell II have been deepened and extended in recent years by a focus on the strategies of multinational firms, as noted earlier. These developments have expanded the strategy research domains to which ROT can be applied and the set of theories that potentially can be juxtaposed or integrated with ROT.

### The theory of the firm

According to Transaction Cost Economics (TCE), when the costs of transacting in the marketplace are high due to market inefficiencies arising from the threat of opportunism, market-mediated exchanges will be displaced by hierarchy within the firm (Williamson, 1991). The scope and growth of the firm are therefore set at the margin where the benefits of reduced opportunism exceed the administrative and control costs of internalized

operations. For example, the MNC internalizes markets across borders and grows organically or expands its international network of subsidiaries through acquisitions to reduce transaction costs in licensing agreements due to market uncertainty and behavioral uncertainty concerning technology transfers (e.g., Caves, 2007). Control over intangible assets and monitoring of foreign operations therefore promote efficiency (Buckley and Casson, 1998). However, while the focus on commitment and administrative control contains transaction costs, this can be at the expense of flexibility owing to the largely irreversible commitments involved.

By contrast, ROT emphasizes the role of uncertainty and asymmetry in payoffs arising from decision flexibility and shifting value-chain activities across borders. Kogut and Kulatilaka (1994) argued that a MNC holds a set of strategic and operating real options in its multinational network that allow it to exploit uncertainty and take advantage of heterogeneous opportunities across foreign countries and reduce downside losses owing to exchange rate movements and other risks. ROT thus identifies international flexibility and the dynamic advantages afforded by coordinated multinational networks as a source of value in a dynamic global environment. Focusing on the MNC's growth options in emerging economies, Li and Li (2010) suggested that ROT complements existing views on MNC ownership strategies such as TCE by emphasizing the importance of flexibility in responding to future opportunities, which rises as uncertainty increases. Focus on the multinational firm was thus an important source of advances for ROT in Cell II of Figure 2 as this helped expand the domain of the theory beyond its traditional focus on investment timing (e.g., market entry) by considering global strategy applications and the multiple environments in which MNCs compete. Extensions of ROT to other organizational forms such as partnerships enabled expansion of real options applications from Cell II to Cell IV of Figure 2 and opened up additional ways to connect with new, cooperative streams in corporate strategy research (whereas early real options applications focused more on competitive strategy).

### The role of uncertainty in firms' choices and the uncertainty-investment relation

The role of uncertainty in management and strategy has been recognized early on as being fundamental

(Cyert and March, 1963; Lippman and Rumelt, 1982; Rumelt *et al.*, 1994; Wernerfelt and Karnani, 1987). Strategic decisions involve impactful choices about future resource commitments, potentially involving follow-on opportunities, technological threats, and rivals' moves, all inherently made under uncertain conditions. Uncertainty thus shapes the tensions between flexibility versus commitment as well as competition versus cooperation.

Unlike the traditional view that uncertainty depresses investment, ROT presents decision makers with a more proactive response to uncertainty. Specifically, real options allow the firm to delay investment commitments, stage them, or alter future decisions when market conditions change, enabling the firm to contain losses and benefit from uncertainty under favorable developments (Bowman and Hurry, 1993; McGrath, 1997; Trigeorgis, 1996). It is this inherent managerial discretion under uncertainty and resulting asymmetry in firm payoffs that drives option value, reduces downside losses, and improves firm performance. Uncertainty leverages the impact of decision flexibility and opens a window of opportunity that can be a source of value rather than a penalty *per se* (McGrath, 1999; Trigeorgis, 1996). As a consequence, uncertainty and decision flexibility can be a source of value creation if real options are properly recognized, developed, and exercised (Triantis, 2005). The firm thus manages a portfolio of strategic growth and operating options, and the degree of its adaptive capability will condition its ability to exploit upside opportunities or limit downside risk (Trigeorgis, 1996). If properly designed and effectively integrated within the firm's strategic plans and organizational structure, real options should enable making better strategic choices, enhancing firm value and providing valuable management of risk. This, of course, requires proper organizational systems, managerial attention, and efficient organizational use of limited resources (Barnett, 2008).

### **The commitment versus flexibility dilemma**

Each firm faces a dynamic trade-off between commitment (e.g., making an irreversible or specific investment) and flexibility (Li and Li, 2010; Smit and Trigeorgis, 2004). Proper management of this trade-off can determine firm competitive advantage, capitalizing on the opportunity set created by

uncertainty and decision flexibility (Chi, 2000). The intensity of this trade-off depends on both exogenous and endogenous uncertainties (e.g., Cuypers and Martin, 2010). For instance, a flexible growth strategy may not be as valuable in an industry with clear first-mover advantages (or shared industry growth opportunities) and learning-by-doing. First-mover advantages and strategic commitment involving early or larger-scale investment may preempt rivals or strategically influence their behavior (Smit and Trigeorgis, 2007). First movers may also acquire proprietary rights such as patents and licenses to protect or appropriate future growth options (Folta and O'Brien, 2004; Smit and Trigeorgis, 2004). This underscores that early commitment may sometimes actually enhance future flexibility (preserving or creating future growth options), making the impact of uncertainty on investment non-monotonic (e.g., Abel and Eberly, 1994; Folta and O'Brien, 2004)<sup>8</sup>.

For instance, securing patents and property rights through early commitment might provide first-mover advantages in some industries, though not all R&D-related investments make sense under uncertain conditions. In product development, for example, it may sometimes be more beneficial to structure processes more flexibly to lower the cost of future product changes and defer making commitments on more uncertain aspects<sup>9</sup>. The option to defer must generally be traded off against the learning and strategic benefits of commitment, including the value of embedded follow-on options to abandon, grow, or switch. Because uncertainty increases the value of these options resulting from commitment itself, higher

<sup>8</sup> Uncertainty makes investment and commitment detrimental in the case of a single, irreversible, proprietary investment with negligible early-exercise benefits (dividend-like effects), other follow-on (e.g., growth or switch) options, learning effects, preemption effects, or other strategic first-mover advantages. However, commitment under uncertainty can benefit the firm when the investment: (1) is staged; (2) opens up or creates follow-on options; (3) is reversible or the asset is of a general purpose nature, is not protected by property rights or is shared with industry rivals, leading to value dissipation; (4) has steep learning curve effects where part of the uncertainty is endogenous and can be resolved through further investment; or (5) results in rival preemption or in other first mover advantages (e.g., network effects).

<sup>9</sup> Sometimes, therefore, it is wise to wait in uncertain conditions, while in other contexts commitment (sometimes even disinvestment) benefits firm value. This is particularly so when there are nonlinearities arising from convex adjustment costs of committed capital, fixed costs, and partial reversibility of capital (Abel and Eberly, 1994).

uncertainty would not necessarily discourage commitment. Various benefits of commitment may also be impacted differentially by different kinds of uncertainty. For the above reasons, the impact of uncertainty on investment is not monotonic (e.g., Folta and O'Brien (2004)). Uncertainty, asymmetric information (involving uncertainty for one party such as a rival about the success of R&D efforts by an incumbent who knows their own costs), and learning effects may also interact and differentially affect the trade-off between flexibility and commitment (Smit and Trigeorgis, 2004).

### Trade-offs between competition and cooperation

Not only does a commitment versus flexibility trade-off run through many strategic investment contexts, but there is usually also a trade-off between competition and cooperation. In the strategy literature, competitive rivalry and cooperation have often been viewed as opposing or mutually exclusive strategy paths (Lado, Boyd, and Hanlon, 1997). However, firms increasingly engage in both competition and cooperation at once or alternate among these modes at different development stages or market circumstances. For instance, some firms cooperate in one sphere of activity, such as in R&D or the strategic use of their patents, while competing in end markets. Others might attempt to enhance market share by collaborating to strengthen their positions against substitutes, governmental interference, or newcomers, or to share upstream resources cost effectively.

Even though competitive strategy implications figured prominently in the early research on collaboration, more recently, attention has focused on the corporate implications of collaboration, and this recent research is often not integrated into strategy research on competition. As a consequence, the interplay of cooperation and competition remains a distinct and currently-unfilled research gap in the field. The competitive rivalry and cooperation interplay has been fundamental in strategic planning and business strategy, even though scholars have not devoted adequate attention to addressing this complex interplay under conditions of uncertainty (Wernerfelt and Karnani, 1987). The competition-cooperation dilemma needs to deal with the why, how, and under what circumstances

firms are better off cooperating rather than competing in the marketplace in uncertain and dynamic environments. ROT combined with game theory has the potential to extend the notion of dynamic strategy to incorporate endogenous strategic responses among firms in an industry, quantifying not only the trade-off between commitment and flexibility, but also potential shifts between competitive and cooperative modes in a dynamic environment over time. For instance, in the case of strategic patenting, firms might attempt to build a patent wall or bracket a rival's patent in a competitive mode, or may engage in cooperation via licensing or cross-licensing a patent. Hybrid strategies are also possible, such as when a firm switches from competition to cooperation as demand changes. The ability to switch between competitive and cooperative modes will be more valuable in volatile environments, and when the firm has a small innovation or cost advantage from the patent (Trigeorgis and Baldi, 2014).

### Organization and governance mode choices

Management scholars identify four main ways of obtaining access to or deploying a resource as part of a firm's growth strategy: (1) buy (sell) or acquire (divest), (2) build/develop internally, (3) rent/lease/contract, or (4) share/ally. Traditionally, streams of research using the resource-based view (RBV) emphasized forms of commitment (buy/acquire or build) to secure proprietary use of scarce resources in a competing mode. Acquisition transactions might take place on both the buy or sell sides. Other modes (lease/contract or share/ally) involve more flexibility in the strategic use of external resources, often through cooperation with other firms. For example, a firm that possesses proprietary assets complementary to those of another firm can sell or rent its assets to the other firm or buy or rent the other's assets (Chen, 2010). Just as an acquisition might be considered from either the buy or sell side, a firm may contract for complementary technologies (e.g., license in) to fill in gaps in its own technology portfolio or further develop its own resources, or it might license out or otherwise contract for its own assets with another company. Sequential market entry and collaborative investments provide flexibility that commitment strategies such as an upfront acquisition and/or expanding permanent workforce do not allow. Kogut (1991) provided evidence that JVs

provide options to expand sequentially into new and uncertain markets, while firms can potentially expand and buy out a partner if conditions develop favorably. According to ROT, JVs may serve as a transitional organizational form by design, calling into question the conventional presumption that JVs are, or should be, stable, equilibrium-based organizational forms.

Collaborative ventures generally serve as flexible arrangements for dealing with uncertainty concerning market entry, technology transfer, and partner competence development (Estrada, de la Fuente, and Martin-Cruz, 2010). Chi and McGuire (1996), and Chi (2000) analyzed how transaction costs and real options influence collaborative ventures, market entry alliances, or acquisition modes and divestment. Reuer and Tong (2010) found that growth opportunities are a key determinant of equity alliance formation with IPO firms. Kouvelis *et al.*, (2001) showed that the choice of ownership structure in a multinational context (e.g., wholly owned subsidiaries, export operations or minority IJVs) depends on exchange rate uncertainty, which favors more flexible or low-commitment production modes.

## CHALLENGES FOR REAL OPTIONS RESEARCH IN STRATEGY

In this section, we consider a set of research directions that may serve as frontiers for future developments in strategic management, and we pose a number of related challenges for theory development for real options in the field.

### Real options and the foundations of strategy

While ROT is ultimately a theory of investment that can properly guide resource allocation decisions in firms, for ROT to become one of the theoretical pillars in the strategy field, more attention is needed on how ROT can help address the fundamental issues of strategy, such as the sources of competitive advantage and firm heterogeneity. Along these lines: What are the implications of viewing the firm as a portfolio of staged interacting options or as a repository of adaptive organizational capabilities and options to learn, rather than as a bundle of resources and capabilities? Why do firms differ in the creation, recognition or exploitation of options, sometimes fail in the presence of valuable

growth options that go unexploited, or at times succeed even when such opportunities are limited? How can the distribution of authority rights and internal resource allocation within organizations be made more efficient to capitalize on such growth options? What are the defining features of a real options-based view of the firm and how can existing theories complement one another more effectively?

### Differences and potential integration with other strategy theories

Unlike traditional industrial organizational (IO) economics and game theory approaches that presume the business environment and firm reactions are predictable, various theories used in strategic management recognize that the business environment is uncertain and unpredictable (Figure 2) and that boundedly-rational managers are limited in their ability to predict and plan for various future contingencies. Uncertainty is a key driver that both brings together and differentiates alternative views of the firm and their implications concerning strategic investment. Uncertainty is at the root of the dilemmas created by commitment versus flexibility and between competition versus cooperation, giving rise to important differences between ROT and alternative theories such as IO, TCE, and RBV as a result of their different treatment of the role and types of uncertainty considered. They also differ in terms of their focus on cost efficiency as well as the role of knowledge, learning, and decision flexibility. We submit that ROT draws on all these factors in a comprehensive way, and hence, carries considerable integration potential with other theories focusing on aspects of firm investment and decision making under uncertainty.

Traditional IO and game theory focus on external market structure factors and *ex post* barriers to competition (e.g., capacity or contractual preemption) in a rather predictable environment, modeling mainly strategic uncertainty but essentially ignoring market and other uncertainties that decision makers routinely encounter. Recent progress on option games has been achieved in integrating ROT with IO and game theory to account for both stochastic demand and strategic or competitive uncertainty (e.g., Chevalier-Roignant and Trigeorgis, 2011; Smit and Trigeorgis, 2004). This integration, essentially achieved by overlaying real option binomial trees onto  $2 \times 2$  payoff matrices

from game theory, has allowed the quantification of the important trade-off between commitment and flexibility under uncertainty and has also brought out analytically the potential benefits of collaboration strategies (Trigeorgis and Baldi, 2014).

Under TCE, limitations in predicting and planning for future contingencies make market contracting incomplete, necessitating costly mechanisms to monitor and enforce contractual performance (Williamson, 1991). Opportunistic behavior gets amplified in environments of high uncertainty and specific investment. Uncertainty is detrimental as it raises the risk of opportunistic behavior and the costs of writing and enforcing contingent contracts as well as the need for hierarchical control. It also increases the risk of unanticipated contingencies and need for contract renegotiation, and hence, of market failure when asset specificity is high (Leiblein, 2003). This shifts the balance more toward commitment and control (favoring internal growth rather than market-based exchange) under high uncertainty and asset specificity. In a multinational context, there is also significant endogenous behavioral uncertainty arising from potential partner opportunism, raising the need for control. According to TCE, the MNC handles such behavioral uncertainty (which leads to higher transaction costs when asset specificity is high) through strict control and monitoring of subsidiaries and specific investments. However, in a business environment with high exogenous market uncertainty as well as endogenous behavioral partner uncertainty, firms must consider both upside growth opportunities and substantial market risks that must be contained. In such dynamic and unpredictable environments, ROT suggests that a MNC should maintain flexibility to benefit from uncertain opportunities (while containing risks) even when asset specificity is high. Just as TCE and ROT hold different implications for commitment (control) versus flexibility due to their different treatments of uncertainty as being detrimental or beneficial, and focus on governance versus investment, respectively, the same is true for the dilemma between competition and cooperation. Whereas ROT suggests hybrid organizational forms are important instruments for achieving decision flexibility and beneficial asymmetric payoffs, TCE implies that hybrids are not viable under conditions of uncertainty due to problems associated with contractual incompleteness, lack of well-developed administrative

controls, and imperfections associated with reliance on third parties to adjudicate disputes (Williamson, 1991).

Like TCE, RBV also recognizes that boundedly-rational managers lack the knowledge and ability to predict and plan for future contingencies. It further emphasizes that firms must make an up-front investment commitment (an early bet) to create new resources and capabilities raising heterogeneity, ambiguity, and imitation difficulty that form the basis for sustainable competitive advantage (Leiblein, 2003). Lippman and Rumelt (1982) indicated that the persistence of resource heterogeneity across firms is enhanced with proprietary rights for the exclusive use of a resource or causal ambiguity regarding its application. By contrast, ROT emphasizes that when uncertainty and ambiguity are high, firms should stay flexible and adapt their plans to future contingencies. There is room, however, for ROT to improve its integration potential by joining TCE and RBV in recognizing the boundedly-rational reality of organizational decision making, including human behavioral biases.

The above observations lead naturally to the challenge of the interplay between ROT and other, more established perspectives in strategic management. How can ROT better connect to and be integrated with other theories in strategy, beyond extending its own stand-alone unique contributions in existing and new strategic decision contexts? How can research more effectively separate out ROT's predictions from those of alternative theories that also feature uncertainty or specific investments as key variables, either via appropriate empirical horse races, or by extending and enriching those predictions through more integrated theoretical frameworks (e.g., Elfenbein and Knott, 2015)? For example, what is the relation between behavioral theory's escalation of commitment under failure (Brockner, 1992) and ROT's predictions concerning delayed exit?

### **Role of management and organizational realities**

In a closely-related vein, what are the roles of management and organizational considerations in ROT (e.g., Cyert and March, 1963)? Many streams of strategic management research can uniquely enrich the practical application of ROT by considering human characteristics and cognitive biases,



managerial incentives, reward structures, control systems, operational routines, and entrepreneurial culture, all of which might influence the success of firms' strategic investments and their appropriated value. For instance, how should organizations assess and reward the creation, maintenance and proper exercise of real options across the option life cycle (i.e., option identification, creation, maintenance, exercise)? How can research best address agency conflicts and behavioral biases in the maintenance and option exercise stages, or how best to deal with *ex ante* contracting (under uncertainty and asymmetric information) in earlier stages versus *ex post* negotiation?

How can ROT be adjusted to account for management and organizational realities such as bounded rationality, organizational structures, and control systems? We believe it would be particularly valuable to incorporate subjective judgment (see Tversky and Kahneman, 1974), inflicted with cognitive limitations or behavioral biases, such as clinging to prior beliefs or habits, confirmation bias, myopia, escalation of commitment, pessimism and ambiguity, or overconfidence and narcissism, into research on the various stages of the option chain. How can organizations better address creativity and ambiguity, accounting for the possible but currently unthinkable? What types of managers or CEOs are appropriate for different organizations, in different industries, and stages in the option life cycle for proper risk taking, innovation, and option encouragement in order to more effectively identify, create, and properly exercise real options in the firm's portfolio? How can we better explain, conceptually and empirically, the behavioral and organizational as well as rational implications of real options decision making in organizations?

### **Integration among real options approaches**

How can the real options literature itself go beyond sectarian divisions and move forward stronger? More specifically, how can alternative ROT approaches become more integrated and mutually reinforcing as opposed to remaining disjointed? In particular, how can prevalent approaches such as ROR and formal modeling/valuation work more effectively in tandem rather than as distinct or even rival ROT approaches? Since flexibility creation or acquisition usually comes at a cost (explicit or

organizational), it is often necessary to value the option to ascertain if the flexibility benefit exceeds the overall associated cost. Consideration of an individual project's value within the broader strategic and organizational context is also necessary. Hence, it is desirable to go beyond the qualitative versus quantitative debate and enlist the combined contributions of the different ROT approaches. What is the proper balance among more strategic (or sometimes metaphoric) usage of ROR as a framing device, formalism as an analytic valuation/modeling methodology, and explicit treatment of organizational realities, constraints, and implementation considerations? More research is needed to examine the complementary usage of all these ROT approaches in practice within real organizations to assess gaps between theory and practice, identify the sources of these gaps, and appraise the descriptive and normative value of a more integrated ROT.

As the field matures, we need a more unified approach for better integration of qualitative and quantitative approaches while accounting for important organizational realities. It would further help the integration efforts if researchers focus on application contexts where these approaches come closer together contextually, such as in M&As, divestitures or spin-offs, the sale of a patent or license, or franchising of a brand. Not only are there untapped opportunities and challenges to jointly apply the different ROT approaches to these problems, but these organizational decision contexts also afford opportunities to combine them. In such contexts, we need to think concurrently about future strategic plans and the current market worth of an investment.

Finally, how can organizational realities, capital rationing, bounded rationality, and other organizational constraints and strategic considerations be incorporated into strategic analysis and valuation models? What is the role of heuristics (Bowman and Moskowitz, 2001) in reducing complexity and bridging these approaches in achieving this balance? Can proper heuristics be identified, calibrated, and tested against formal analytical ROT models? If options in a portfolio are not redundant or substitutes, should we add them up? How can organizations expand their cognitive frames and knowledge platforms as part of an adaptive capability and a real options heuristic?

### Future research designs

Finally, we would encourage the use of new methodologies, a greater focus on the business unit and the individual project level of analysis from a strategic perspective, and the collection of more primary data on individual real options cases<sup>10</sup>. To begin with, new methodologies such as lab experiments, simulations, fieldwork, and surveys would provide a useful complement to existing evidence derived from secondary or large-scale empirical data involving investments by firms. Such methodologies might be more suitable to gather particular information on managerial decision making and rich details of an actual investment decision and its path-dependent historical context. Simulations can further help address multiple uncertainties or interacting portfolio options as well as incorporate behavioral or managerial considerations that might affect decisions with embedded options in more complex ways (e.g., Cuypers and Martin, 2010).

Reconsidering the unit of analysis in real options studies might also help advance strategy research on real options. In particular, to bring the ROR and valuation/analytical perspectives closer together, we encourage strategy scholars to focus more on the individual project and the business unit as the unit of analysis. Since the valuation/modeling focus is more applicable for individual projects, future strategy work that focuses on individual projects or business units would facilitate the above integration. This also implies more case-focused research and an ability to consider strategy issues (e.g., heterogeneous capabilities, competitive advantage, etc.) at this more granular level to match with the valuation focus. So far in strategy research, much of the empirical work has been at the corporate level or has involved aggregation that has made links with the valuation models more difficult. In this same vein, research at the project level where there is usually more precise and project-specific information could more readily develop empirical measures for key option constructs (e.g., irreversibility) that are more difficult to assess in large-scale empirical

studies relying on aggregated information from secondary sources at the corporate level. Moreover, longitudinal case studies and applications focusing on the project or business unit level could explicitly tackle organizational processes and implementation issues that have not been possible in existing empirical research focusing mostly on the timing and structuring of investments or aggregated data on investment and performance at the corporate level.

More fine-grained empirical work might also examine some of the unique aspects of real options, such as gauging managerial real option awareness, unique knowledge, training and learning (Kogut and Zander, 1992), or differentiating shared from proprietary options. We also believe it is critical to devote attention to the costs involved in identifying, acquiring, developing, preserving, and exercising real options by organizations in order to better assess the net value-added of flexibility and help integrate the reasoning, valuation/analytical, and behavioral perspectives. Empirical research should also account for the multiple and interdependent sources of uncertainty, both exogenous and endogenous, the opportunity costs of holding a real option alive (e.g., “dividend-type” effects such as competitive erosion) as well as interacting portfolio effects. Addressing organizational implementation concerns and behavioral considerations further holds the potential to integrate ROT with other streams in management, and close prevailing gaps between theory and organizational reality.

### CONCLUSION

We have developed a framework for organizing extant research on ROT along several dimensions. These include (1) types of real options, (2) stages of the real option chain, (3) types of strategic decisions, (4) core strategy trade-offs or dilemmas cast in a two dimensional space (i.e., flexibility versus commitment and cooperation versus competition), and (5) various approaches to real options research (i.e., real option reasoning, real option modeling, and behavioral perspective). We have also critically examined key challenges for real options research in strategic management. We see a pressing need to integrate related managerial disciplines and perspectives into an integrated organizational approach. We suggest more work

<sup>10</sup> There are many opportunities to broaden the domains of application of ROT, such as by analyzing brands, licensing terms, outsourcing deals, corporate spin-offs, corporate venture capital, or flexible human capital. ROT in strategic management would also benefit from grappling with some more fundamental research design issues that could enhance the theory's value in strategic management.

and adoption of suitable integrated methodologies for bringing strategic considerations down to individual case projects and business unit levels. Increased attention by future researchers should also be devoted to application contexts involving both strategic as well as valuation components concurrently, while paying due attention to behavioral and organizational realities and constraints. Future research should focus more on the role of management and organizations in further refining and extending the domain of applicability of ROT, while addressing critical implementation issues along the various stages of the real option life cycle in organizations. Future research should thus take more of an organizational and implementation perspective, rather than a detached valuation or purely strategic reasoning one. This requires thinking more deeply about organizational processes, managerial incentives, and control systems as well as agency conflicts and behavioral biases. Finally, we need to think more not only about valuation, but also its mirror image, the optimal management and contingent exercise of key real options. The organizational/implementation side should focus more on this twin aspect of option management and exercise, and link it with the path-dependent unfolding of strategic direction, thus helping bring valuation and strategic reasoning for option exercise decisions closer within a real organizational context.

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