

THREE CONCEPTUAL ISSUES IN STRATEGIC REAL OPTIONS RESEARCH AND SUGGESTIONS FOR CONCEPTUAL REINFORCEMENT

Abstract

Real options theory has been widely used but often criticized by strategic management scholars. However, even though transferring this theory from financial economics to strategy has inevitably generated non-trivial conceptual ambiguity in real options research, prior studies have given scant attention to resolving the conceptual ambiguity. Reinforcing the theoretical framework, our article points out three conceptual issues in real options research: 1) the lack of a clear conceptual boundary of the possession of real options; 2) the logical contradiction caused by considering the option to defer as a standalone real option; 3) the lack of a definition of uncertainty resolution. Then, we offer suggestions for solving those three problems. Our article emphasizes that, along with taking stock and looking ahead, looking back and fixing the issues in the theoretical framework is also warranted for the advancement of real options research in the strategic management literature.

Key words: real options theory, possession of real options, option to defer, uncertainty, risk

INTRODUCTION

Real options theory has been used by an extensive body of research to examine various strategic decisions under uncertainty. The initial real options theory, which was established in the financial economics discipline, contradicts discounted cash flow (DCF) approaches (notably net present value) by recognizing the flexibility of management to change the course of investment and by emphasizing the need to consider the option value of an asset or a project under uncertainty (Dixit & Pyndick, 1994; Trigeorgis, 1996). Although this initial real options theory focuses on developing quantitative option valuation models, its central tenet that values flexibility under uncertainty has drawn significant attention from strategy scholars because strategic decisions are often made under uncertainty (Mahoney, 2005; Trigeorgis & Reuer, 2017).

In its transfer from financial economics to strategy, real options theory becomes a conceptual framework for interpreting or developing strategies (i.e., real options reasoning) more than for quantitative valuation models (Bowman & Hurry, 1993; McGrath, 1999; McGrath & Nerker, 2004). However, as this transfer and transformation has depended largely on a “simplistic analogy between real and financial options” (Ragozzino et al., 2016, p. 430), conceptual ambiguity has been generated in the theoretical framework. For example, Trigeorgis and Reuer (2017) emphasize that real options should be conceptually distinguished from “mere possibility”. The fact that two prominent real options scholars had to comment even in their 2017 study on the necessity to clarify the conceptual boundary of real options exemplifies the level of conceptual ambiguity in real options research.

Nevertheless, the effort to reinforce the conceptual framework of real options theory has been stalled since early 2000. Instead, prior studies have focused on applying this theory to

various empirical contexts (e.g., O'Brien & Folta, 2009; Reuer & Tong, 2007) or have criticized its low practical usefulness or insufficient considerations of behavioral aspects in option management (e.g., Adner & Levinthal, 2004a; Posen et al., 2018). However, we argue that addressing conceptual ambiguity in the theoretical framework is crucial for properly applying real option theory to strategy research. In this article, we address three important conceptual issues and submit suggestions for addressing those issues.

First, although a real option is defined as a right but not an obligation to take further actions in the future, prior studies have not drawn a clear and coherent conceptual boundary for the possession of real options. Thus, we clarify the conceptual boundary of it, which is a prerequisite to test the validity and usefulness of real options theory and properly apply it to various research contexts. In connection to this first point, we also discuss the problem of recognizing the option to defer as a real option. Given that the flexibility to wait and see is already inherent in real options, considering the option to defer to be a real option generates unintended confusion and even logical contradictions in the theoretical framework. Last, we discuss the lack of a clear definition regarding the resolution of uncertainty. Given that resolution of uncertainty is arguably the most important cue for option holders to move on to the next step in the real options framework (Bowman & Hurry, 1993; Dixit & Pyndick, 1994; Trigeorgis & Reuer, 2017), a clear definition is required to test the validity of the main theoretical prediction. We define the resolution of uncertainty by drawing on the Knightian definitions of risk and uncertainty.

We emphasize that this article does not intend to refute the value of real options theory for strategy research. It is quite the opposite. This article aims to contribute to the conceptual reinforcement of real options theory, which has been stalled for a while. We hope that this article

encourages active discussion about the theoretical framework per se, which is necessary to further develop strategic real options theory.

WHAT DOES IT MEAN TO HAVE REAL OPTIONS?

Although real options theory has been widely applied in research on strategic investments under uncertainty, the conceptual boundary of real options has been continuously questioned (Adner & Levinthal, 2004; Cuypers & Martin, 2010). In response to this criticism, several prominent strategy scholars have elaborated and submitted the definition of real options (Bowman & Hurry, 1993; Kogut & Kulatilaka, 2001; Trigeorgis & Reuer, 2017). However, defining what is a real option is different from what it means to have it. Examining important issues in this theory such as the value to firms of real options, the performance implications of option possession, and how firms treat real options (e.g., whether or not they engage in escalation of commitment), researchers should first know what it means to have a real option.

The most widely accepted definition of a real option is that it is a right but not an obligation to take further actions in the future (Bowman & Hurry, 1993; Kogut & Kulatilaka, 2001; Trigeorgis, 1996; Trigeorgis & Reuer, 2017). This definition has multiple important but less recognized implications for drawing the conceptual boundary of real options. First, the real option is a right. Thus, although some studies define a real option as an opportunity (e.g., Li et al., 2007), we argue that an opportunity is not always equivalent to a real option. According to Merriam Webster, opportunity refers to a “favorable juncture of circumstances or a good chance for advancement or progress” (Merriam-Webster.com). Not all firms that face a good chance for advancement or favorable circumstances can exploit them. Thus, only when firms have the undeterred right to capitalize on the good chance, those firms can be considered as holding an option. When the future value of the target opportunity is uncertain, holding the right to exploit

it—i.e., holding a real option— still has value (Kogut & Kulatilaka, 2001). If there is zero uncertainty about the future value of the target opportunity, holding the right becomes meaningless and the option holder should immediately either exercise or abandon the option.

The definition of real options also implies that if economic actors (e.g., firms) do not have a right to take actions at will in the future, they do not have real options in the first place (Kogut & Kulatilaka, 2001). To have real options, two conditions should be satisfied: 1) possession of underlying resources of the options; and 2) the lack of external restriction for exercising the right in the future.

First, to possess a real option, a firm should have underlying resources that provide it with the right to take actions in the future (Trigeorgis & Reuer, 2017). Suppose that there is an opportunity to generate economic value by developing and producing hydrogen fuel cell vehicles, although the future value of this opportunity is uncertain. However, a small car customization shop may not possess an option to grow through capitalizing on this opportunity due to their lack of underlying resources (e.g., cash and technologies). Thus, the possession of underlying resources that give a firm a real option is the first condition. In other words, when firms without underlying resources are doing nothing, the firms should not be considered as keeping the real option open: the firms simply do not possess the option in the first place.

It is also important to note that the underlying resources of real options include both tangible resources (e.g., goldmines, patents, or lands) and intangible resources (e.g., relationships, innovative ideas, or star scientists). For example, in 1999, David Cowan, who was a partner in Bessemer Ventures, one of the most famous venture capital companies, was asked by his friend, Susan Wojcicki, who is the current CEO of YouTube, to meet the two founders of Google who were working in her garage (Kerr et al., 2014). At that time, although Cowan did

not directly acquire any tangible resource to have the right to meet those Google founders and invest in their company, his long-term relationship with Wojcicki played a role as the underlying resource for this option. Unfortunately, according to Bessemer's webpage, Cowan abandoned this option by saying, "How can I get out of this house without going anywhere near your garage?"¹

This first condition also has an important implication for two competing perspectives regarding the role of a small initial investment (i.e., a toehold investment) in the real option framework. One stream of research based on growth option reasoning argues that, under significant uncertainty over the future value of a growth opportunity, making a small initial investment will grant the focal firm a valuable growth option that can be exercised when uncertainty is resolved in favorable way (McGrath & Nerker, 2004; Smit & Kil, 2017). Thus, firms are encouraged to make a toehold investment under uncertainty because the growth option is more valuable under higher uncertainty (Bowman & Hurry, 1993; Folta & O'Brien, 2004). However, another stream of research has emphasized the value of waiting (i.e., postponing an action) under significant uncertainty (Dixit & Pindyck, 1994; McGrath, 1997).

Folta and O'Brien (2004) reconcile these competing perspectives by showing that firms are likely to enter a new industry under high uncertainty but defer the entry under low uncertainty. We point out that to reconcile those two competing perspectives, it is also necessary to consider the fundamental purpose of a toehold investment. Firms make the toehold investment to acquire underlying resources of a growth option. In other words, before making the toehold investment, those firms did not have access to the target growth opportunities but only had a right to make the toehold investment.

¹ Please see <http://www.bvp.com/portfolio/antiportfolio>

In this light, although the term “toehold” implies the small size of initial commitment, the size of the toehold investment is determined by whether the focal firm can acquire the underlying resources of a growth option. Thus, firms may defer making a toehold investment if acquiring the underlying resources of a growth option requires too big an initial investment and the underlying resources are less reversible (Rivoli & Salorio, 1996). If the size of the toehold investment is trivial to a firm, then irreversibility may be of less concern. If the toehold investment is highly reversible, then its size would be of less concern.

Furthermore, given that the possession of real options requires the possession of corresponding underlying resources, the options a firm has depends on its resources. Suppose that a firm has enough cash to buy the right to exploit an oil field and there is no bidding competition for the right. The eventual opportunity pursued by the firm is to produce economic rent by drilling wells in the oil field and extracting oil. However, at this stage, the firm does not have an option to drill the wells but only an option to buy the right to exploit the oil field.

In this sense, sequential staged investments in growth opportunities can be understood as the sequence of exercising an option to acquire a new option. For example, Apple Inc. recently announced its plan to produce electric vehicles (i.e., the Apple car). However, to achieve this goal, Apple Inc. first needs to exercise the option to acquire (or develop) resources for producing electric vehicles. Its huge pile of cash, status in the market, and/or relational assets would play a role as underlying resources that give Apple Inc. this option. After exercising the option to acquire (or develop) resources for producing electric vehicles, Apple Inc. then will have the option to produce electric vehicles.

Second, we emphasize that even for firms who have underlying resources, the possession of real options can be limited by other factors, such as regulations (Smit, Pennings, & van

Bekkum, 2017). For instance, due to regulations in China, foreign automakers do not have an option to grow in China through a greenfield investment, but only through forming a joint venture with Chinese automakers (Tesla was a rare exception). In this light, the second condition for possessing a real option is that a firm's future action will not be limited by other exogenous factors, such as regulation or competitors' preemption (Smit & Trigeorgis, 2006).

In sum, firms can be considered as having real options when they have underlying resources that enable them to take further actions later on and those actions in the future will not be limited by any restrictions. Thus, we emphasize that examining the validity and usefulness of real option theory requires researchers to carefully check whether firms actually possess real options in the first place. Moreover, applying real options theory in the context of strategy research requires the identification of underlying resources and corresponding options that firms possess.

OPTION TO DEFER: IS THIS REALLY A REAL OPTION?

Based on the definition of a real option discussed above, we also examine the problem of considering the option to defer as a real option. The timing of option exercise or abandonment depends on how long the option holders postpone their subsequent actions. As such, the flexibility to wait and see is already inherent in real options. However, since flexibility to wait and see is the key virtue of the real options investment, previous real options studies have often described this flexibility as a stand-alone real option by labelling it as an option to defer (or deferral option or option to wait) (Folta & O'Brien, 2004; O'Brien et al., 2003; Trigeorgis, 1996; Trigeorgis & Reuer, 2017). For example, the studies of optimal entry timing of multinational corporations (MNCs) to foreign countries focus on the value to those MNCs of the option to defer (Li & Rugman, 2007). Folta and O'Brien (2004) investigate how the option to grow and

the option to defer interactively affect a firm's entry decision under different levels of uncertainty.

However, we point out that recognizing the ability to wait as a standalone real option generates unintended confusion by blurring the causal relationship between uncertainty resolution and the exercise of real options: thereby creating difficulty in defining what the exercise of a real option means. According to the real options theory, the timing of exercising options is determined by the level of uncertainty about the value of the targeted opportunity. Whether or not an option is exercised at the right time should be evaluated based on the level of contemporary uncertainty. If a firm exercises or abandons the option when uncertainty has been sufficiently resolved, either action would be a rational choice. If uncertainty has not been resolved, the firm's actions other than holding the option would be biased or suboptimal ones. This central tenet of the real options theory casts doubts on the conventional recognition of the option to defer as a real option for three reasons.

First, previous research is unclear as to whether firms' inactions should be recognized as the exercise of an option to defer or as holding this deferral option. Adhering to the definition of a real option in the literature, we can define the option to defer as a right but not an obligation to delay subsequent action. Thus, the exercise of an option to defer refers to the actual delay in making a subsequent decision or action. In the same vein, holding an option to defer should be equivalent to taking a subsequent action: either the exercise of or abandonment of a growth option. In other words, an option to defer is continuously exercised during a period when uncertainty exists, while it will be held (i.e., taking a subsequent action) when uncertainty is resolved.

However, taking the subsequent action (i.e., the exercise or abandonment of the growth option) also results in foregoing the option to defer (Folta & O'Brien, 2004; Grenadier & Malenko, 2011). Namely, holding an option to defer simultaneously indicates giving up this option. As such, not only is the conceptual boundary of the option to defer unclear, but also the presence of this option in the real options framework engenders a logical contradiction. However, prior real options studies in the strategic management literature generally have not given sufficient attention to this logical contradiction and tend to regard the exercise of the option to defer (i.e., decide to keep waiting) the same as holding this option.

Second, uncertainty resolution is the trigger for the exercise of a real option (Dixit & Pindyck, 1994; McGrath et al., 2004; Trigeorgis, 1996). In other words, the exercise of a real option is an action responding to the real or perceived resolution of uncertainty. In contrast, holding real options means that option holders do not make but postpone any decision or action. This gives rise to an odd conclusion if we consider the option to defer as a standalone real option: the resolution of uncertainty leads option holders to exercise the option to defer (i.e. delay making subsequent action). However, deferring the subsequent action is actually inaction. Given that real options, unlike financial options, do not have a pre-fixed expiration date (Trigeorgis & Reuer, 2017; Zardkoohi, 2004), specific timing of the decision to delay making subsequent action does not exist in the theoretical framework. Thus, the exercise of the option to defer (i.e., keep waiting and seeing) can be recognized as both an action and an inaction at the same time, which should be a logical contradiction. As such, the causal relationship between the level of uncertainty and the exercise of real options becomes equivocal when prior studies carelessly recognize the option to defer as a stand-alone real option.

Third, recognizing the option to defer as a stand-alone option leads researchers to overestimate the number of decision alternatives available to option holders and underestimate the significant role of the abandonment option in the real option investments. Acquisition of underlying resources conferring preferential access to future opportunities gives the focal acquirer a growth option (i.e., a right but not an obligation to make further investment) as well as an abandonment option (i.e., a right but not an obligation to forgo the extant investment) (Dixit & Pindyck, 1994; Folta & O'Brien, 2004; Trigeorgis & Reuer, 2017). In the real options framework, the only rational action under significant uncertainty is for an option holder to keep holding it (i.e., not exercise it). When uncertainty is sufficiently resolved, only two rational choices are available depending on the direction of the uncertainty resolution: further investment (i.e. exercise of a growth option) or abandonment (i.e. exercise of the abandonment option). This is also true for bounded rational option holders in that bounded rationality affects the accuracy of information about the level of uncertainty (Posen et al., 2018), but does not affect the number of alternatives for action under sufficiently resolved uncertainty.

In other words, although the real options investment gives option holders significant flexibility, the value of this flexibility will disappear when uncertainty is resolved. This is even true when an initially unspecified new growth opportunity is recognized during the option holding period. When uncertainty about the relative value of the extant growth opportunity vis-à-vis the new growth opportunity is significant, the option holder should wait and see. If this uncertainty is sufficiently resolved, the option holder may pursue either the new or the extant growth opportunity and abandon the other.

Therefore, when uncertainty is sufficiently resolved, continuously holding an option is not a valid decision in the real options theory's framework, while option holders may make

bounded rational or even biased decisions (Elfenbein & Knott, 2015; Posen et al., 2018; Smit & Kil, 2017). It is important to note that our article does not focus on testing the validity of real options theory's prediction or extending the literature, but on resolving conceptual ambiguity and logical contradiction in real options research.

As such, recognizing the option to defer as a stand-alone option improperly increases theoretical complexity in the real options framework and blurs the boundary of the exercise of real options. Consequently, the flexibility that option holders possess is overestimated, even though deferring the subsequent action (the exercise of the option to defer) is not a valid response under sufficiently resolved uncertainty. This overestimation may distract researchers from focusing on two fundamental action alternatives—i.e. further investment or abandonment of an option.

Therefore, we propose that option holders' inaction under significant uncertainty be recognized as holding growth options, not exercising an option to defer. In the same vein, given that real options are exercised when real or perceived uncertainty is resolved, the exercise or abandonment of real options should not be considered as giving up the option to defer. This theoretical clarification and simplification will not only help future real options research to avoid being trapped by logical contradiction, but also facilitate researchers to explore when option holders wait and why they take a subsequent action.

WHAT DOES RESOLUTION OF UNCERTAINTY MEAN?

The exercise or abandonment of real options depends on option holders' evaluation of the level of uncertainty about the future value of the target opportunities (Trigeorgis & Reuer, 2017). If these firms conclude that the uncertainty has been sufficiently resolved, they will exercise or abandon the real option (McGrath, 1997; Trigeorgis, 1996). Otherwise, these firms can flexibly

postpone the exercise or abandonment of an option until the uncertainty over the value of the target opportunity is sufficiently resolved (McGrath, 1997, 1999; Trigeorgis, 1996).

However, prior studies have pointed out that the lack of obligation, including expiration dates, may lead option holders operating under bounded rationality and behavioral biases to exercise growth options prematurely or belatedly instead of at the optimal timing (Adner & Levinthal, 2004a; Bowman & Hurry, 1993; Coff & Laverty, 2007; Smit & Kil, 2017). This point raises one critical question that real option exercise should address: how can the resolution of uncertainty be defined? In other words, under what circumstances can the option-holding firms reasonably conclude that uncertainty regarding the value of a target opportunity has been sufficiently resolved?

Interestingly, prior real options research has rarely discussed this fundamental question. Instead, prior studies have assumed that the arrival of new information will resolve uncertainty. Thus, waiting until new information arrives or making endogenous efforts (e.g., staged investment) will ex post lead option holders to the point at which neither exogenous nor endogenous uncertainty exists (Dixit & Pindyck, 1994; Folta, 1998).

However, given that the resolution of uncertainty is the sole cue for moving on to the next step in the real options framework, the lack of a clear definition of the resolution of uncertainty makes it extremely difficult to evaluate whether or not an option was exercised or abandoned at the right time. As a result, real options theory has been subject to significant criticism. Adner and Levinthal (2004b) argue that the lack of prespecified criteria for moving on to the second stage of option investment will likely result in the escalation of commitment by option holders. Coff and Laverty (2007) and Posen et al. (2018) even point out that making

option exercise decisions can be extremely challenging because the uncertainty may remain, regardless of when the focal option holders consider exercising the options.

Nevertheless, previous studies have found that firms make investment or divestment decisions in a way that is consistent with real options theory (Alessandri et al., 2012; Belderbos & Zou, 2009; Folta & O'Brien, 2004; Kellogg, 2012; Lieberman et al., 2017). From the real options perspective, this finding implies that option holders may be able to perceive the resolution of uncertainty at some point during the period of holding real options. Irrespective of whether this perception is rational or boundedly rational, the option holders' perception regarding the level of uncertainty leads them to exercise their real options. Thus, to enhance the theoretical validity of real options theory, we endeavor to establish a clear definition of the resolution of uncertainty.

The construct of uncertainty has played a pivotal role not only in real options theory, but also in other major economic and organizational theories such as agency theory, transaction cost economics, behavioral theory, and resource dependence theory, to name a few. Frank Knight (1921) proposed the most well-known definition by distinguishing between the concept of risk and that of uncertainty. He defined uncertainty as the lack of information about both future possible outcomes and the probabilities of those future outcomes, while defining risk as the identified probability distribution of identified future outcomes (Bloom, 2014; Knight, 1921).

In this sense, under risk, one may know the distribution of the possible future values of a target opportunity and the likelihood of those values; whereas under uncertainty, one cannot forecast the future value of the opportunity at all (Bloom, 2014). From the real options perspective, option holders may be able to exercise their options under risk, while holding those options under uncertainty. This is because under risk, those option holders may be able to

systematically estimate or calculate the future outcome of their investment by using advanced models (Smit & Trigeorgis, 2017). Thus, drawing on the Knightian definitions of risk and uncertainty, we propose that mitigation of uncertainty to the level of risk would be sufficient resolution of uncertainty, which triggers the exercise or abandonment of a real option.

For example, in their seminal book, Dixit and Pindyck (1994) use a specific example of a new gadget's expected price change to explain the value of delay under uncertainty. In this example, they assign specific numbers to probabilities and future prices: i.e., the current price is \$200 per unit, and there is a 50% chance that it will become \$300 per unit and a 50% chance it will become \$100 per unit.² However, from the Knightian perspective, this example illustrates a decision under risk instead of a decision under uncertainty. As long as the set of possible future prices and the likelihood of those prices are known, the firm in this example can specify the best decision among exercise, abandonment, and hold, and can specify the timing of the decision (in Dixit and Pindyck's example, the next year) with sufficient certainty. This is true even if we keep changing the expected minimum and maximum future prices, as well as the likelihood of each price.

Thus, we argue that when option holders can identify the highest and lowest future values of opportunities (i.e., identify the boundary of the upside potential) and the probability of each value, they may conclude that the uncertainty is sufficiently resolved. The upside potential of an opportunity is especially relevant to the level of uncertainty because it is theoretically unbound under uncertainty, while the downside risk of option investment is limited to the value of the earlier investment(s) (McGrath et al., 2004; Folta, 1998). Moreover, the size of the future investment is a matter of managerial discretion, while the realization of the value of a growth

² For more information, please see Chapter 2 of Dixit and Pindyck (1994).

opportunity is less controllable. Thus, when an option-holding firm can identify the boundary of the upside potential, it will likely move on to the next step. If the estimated future value of a growth opportunity is smaller than the size of the necessary future investment, the firm may abandon it. On the contrary, if the estimated future value is larger than the size of the necessary future investment, the firm will exercise the real option.

Developing these simple, but theoretically-founded criteria for evaluating the resolution of uncertainty, we categorize the exercise or abandonment of an option as premature if that action happens before the possible set of future values of a growth opportunity and corresponding probabilities are known.

DISCUSSION AND CONCLUSION

After Myers (1997) built the foundation of transferring financial options theory to “the realm of strategic decision making” by coining the term “real option”, real options theory has drawn significant attention from strategy scholars who always seek better answers for the causes and consequences of strategic decisions (more specifically strategic investments) (Trigeorgis & Reuer, 2017: 43). Therefore, this theory has been applied to studying various topics such as business exit, cross-border M&As, international joint ventures, foreign direct investments, entrepreneurship, and innovation projects (Elfenbein, & Knott, 2015; Hartmann & Hassan, 2006; Kogut & Kulatilaka, 1994; McGrath, 1999; O'Brien, & Folta, 2009; Reuer & Leiblein, 2000).

Nonetheless, as the popularity of real options theory among strategy scholars has increased, this theory has been criticized for the failure to address the behavioral aspects of decision making (e.g., cognitive limits or human biases), for the lack of practical usefulness due to the significant differences between financial and real options, and even for the lack of usage in the real world (Adner & Levinthal, 2004; Barnett, 2008; Posen et al., 2018; Ragozzino &

Moschieri, 2014; Ragozzion et al., 2016). These criticisms have been the subjects of scholarly debate, which has contributed to the extension of real options research (Boulding, Guha, & Staelin, 2017; Coff & Laverty, 2001; Denison, 2009; Hartmann & Hassan, 2006; Kogut, & Kulatilka, 2004; Long et al., 2020; Zardkoohi, 2004). As such, prior real options studies primarily focus on applying the theory to various contexts and testing the validity of its theoretical prediction.

However, interestingly, the conceptual framework of real options theory per se has not been revisited or refined for some time, even though transferring this theory from financial economics to strategy has inevitably generated non-trivial conceptual ambiguity in real options research. As an analogy, although people may have used a tool for various purposes and debated over whether it is the right choice for dealing with complicated issues, they have rarely discussed whether the tool is properly designed or has some defects and thus needs refinement.

Given that real option theory has been employed as the way of reasoning in strategy research rather than as a quantitative valuation model, our article emphasizes the necessity to address three conceptual issues (Bowman & Hurry, 1993; Ragozzino et al., 2016; Trigeorgis & Reuer, 2017). We first comment on the unclear conceptual boundary of real options, which makes it difficult for scholars to know whether firms have real options and thereby to know whether real options theory is the proper theoretical lens for studying those firms' strategic decisions. By sticking to the fundamental definition of real options (i.e., a real option is a right but not an obligation to take a subsequent action), we specify two conditions for possessing real options: 1) the possession of underlying resources that give a firm real options; and 2) the absence of external restrictions (e.g., regulations) for exercising or abandoning the options.

Second, we also reveal the logical contradiction caused by recognizing the option to defer as a standalone real option. If the option to defer is a real option, exercising it means postponing a subsequent action whereas holding it means taking that action. However, taking the subsequent action means that the focal option holder gives up the option to defer, which is a logical contradiction. Moreover, real options theory argues that option holders exercise or abandon real options when uncertainty is resolved. However, if the option to defer is a real option, one will reach at an odd conclusion that firms having this option will keep holding it when uncertainty is resolved (i.e., take a subsequent action) rather than exercising it (i.e., postponing a subsequent action). Therefore, the causal relationship between the level of uncertainty and the exercise of real options becomes equivocal. Last, because a real option is a right but not an obligation to take a subsequent action, the flexibility to wait and see is already inherent in real options. Under significant uncertainty, the only rational action is to keep holding a real option (i.e. not exercise it). When uncertainty is sufficiently resolved, only two rational choices are available: exercising or abandoning the option. Thus, we propose to stop recognizing the option to defer as a real option and stop using this term to avoid logical contradictions and unnecessary confusion.

Third, we point out that even though the resolution of uncertainty has been considered as the key cue for exercising or abandoning a real option, prior studies have not established a clear definition of the resolution of uncertainty. By depending on Knightian definitions of risk (i.e., the potential future outcomes and probability of each of those outcomes is known) and uncertainty (i.e., both future outcomes and the probability of those outcomes is unknown), we propose that reduction of uncertainty to the level of risk can be considered as a sufficient resolution of uncertainty.

Our article discusses three conceptual issues in real options research, not to refute the value of real options theory for strategy research but to reinforce its theoretical framework. As we easily can observe how sudden and unexpected changes (e.g., the pandemic) affects firms' strategy, performance, and even survival, it is no wonder that maintaining flexibility is always one of the most crucial strategic issues for firms. Thus, real options theory that prescribes firms to maintain flexibility under uncertainty should be a significant addition to the strategy literature (Bowman & Hurry, 1993; Trigeorgis & Reuer, 2017). However, to extend this theory's contributions to the literature, real options researchers should address the conceptual ambiguity revealed in prior studies. We believe that along with taking stock and looking ahead, looking back and fixing the problem is also clearly warranted.

REFERENCES

- Adner, R., & Levinthal, D. (2004a). What is not a real option, Considering boundaries for the application of real options to business strategy. *Academy of Management Review*, 29, 74-85.
- Adner, R., & Levinthal, D. (2004b). Real options & real tradeoffs. *Academy of Management Review*, 29, 120-12.
- Alessandri, T., Tong, T., & Reuer, J. (2012). Firm heterogeneity in growth option value, The role of managerial incentives. *Strategic Management Journal*, 33, 1557-1566.
- Barnett, M. L. (2008). An attention-based view of real options reasoning. *Academy of Management Review*, 33, 606-628.
- Belderbos, R., & Zou, J. (2009). Real options & firm affiliate divestments, A portfolio perspective. *Journal of International Business Studies*, 40, 600-620.
- Bloom, N. (2014). Fluctuations in uncertainty. *Journal of Economic Perspectives*, 28, 153-176.
- Boulding, W., Guha, A., & Staelin, R. (2016). Do we really need to change the decision maker? Counterintuitive escalation of commitment results in real options contexts. *Management Science*, 63, 3459-3472.
- Bowman, E. H., & Hurry, D. (1993). Strategy through the options lens, An integrated view of resource investments and the incremental-choice process. *Academy of Management Review*, 18, 760-782.
- Coff, R. W., & Laverty, K. J. (2001). Real options on knowledge assets, Panacea or Pandora's box? *Business Horizons*, 44(6), 73-79.
- Coff, R. W., & Laverty, K. J. (2007). Real options meet organizational theory, Coping with path dependencies, agency costs, and organizational form. *Advances in Strategic Management*, 24, 333-361.
- Cuyper, I., & Martin, X. (2010). What makes & what does not make a real option? A study of

- equity shares in international joint ventures. *Journal of International Business Studies*, 41(1), 47-69.
- Denison, C. A. (2009). Real options and escalation of commitment, A behavioral analysis of capital investment decisions. *The Accounting Review*, 84, 133–55.
- Dixit, A.K., & Pindyck, R. S. (1994). *Investment under uncertainty*. Princeton, New Jersey, Princeton University Press.
- Elfenbein, D., & Knott, A. M. (2015). Time to exit, Rational, behavioral, and organizational delays. *Strategic Management Journal*, 36, 959-975.
- Folta, T. B. (1998). Governance and uncertainty, The tradeoff between administrative control and commitment. *Strategic Management Journal*, 19, 1007– 1028.
- Folta, T. B., & O'Brien, J. P. (2004). Entry in the presence of dueling options. *Strategic Management Journal*, 25, 121–138.
- Grenadier, S. R., & Malenko, A. (2011). Real options signaling games with applications to corporate finance. *Review of Financial Studies*, 24, 3993–4036.
- Hartmann, M., & Hassan, A. (2006) Application of real options analysis for pharmaceutical R&D project evaluation, empirical results from a survey. *Research Policy*, 35, 343–354.
- Kellogg, R. (2014). The effect of uncertainty on investment, Evidence from Texas oil drilling. *The American Economic Review*, 104(6), 1698–1734.
- Kerr, W., Nanda, R., & Rhodes-Kropf, M. (2014). Entrepreneurship as experimentation. *The Journal of Economic Perspectives*, 28, 25–48.
- Knight, F. H. (1921). *Risk, uncertainty, and profit*. Boston, MA, Hart, Schaffner & Marx; Houghton Mifflin Company.
- Kogut, B., & Kulatilaka, N. (1994). Operating flexibility, global manufacturing, and the option value of a multinational network. *Management Science*, 40, 123–139.
- Kogut, B., & Kulatilaka, N. (2001). Capabilities as real options. *Organization Science*, 12(6), 744-758.
- Kogut, B., & Kulatilka, N. (2004). Real options pricing and organizations, The contingent risk of extended theoretical domains. *Academy of Management Review*, 29, 102-110.
- Li, Y., James, B., Madhavan, R., & Mahoney, J. T. (2007). Real options, Taking stock and looking ahead. *Advances in Strategic Management*, 24, 31-6.
- Li, J. & Rugman, A.M. (2007). Real options and the theory of foreign direct investment. *International Business Review*, 16, 687–712.
- Lieberman, M. B., Lee, G. K., & Folta, T. B. (2017). Entry, exit, and the potential for resource redeployment. *Strategic Management Journal*, 38, 526–544.
- Long, X., Nasiry, J., & Wu, Y. (2016). A behavioral study on abandonment decisions in multi-stage projects. *Management Science*, 66 (5), 1999-2016.
- Mahoney, J. T. (2005). *Economic foundations of strategy*. Thousand Oaks, CA, Sage.
- McGrath, R.G. (1997). A real options logic for initiating technology positioning investments. *Academy of Management Review*, 22, 974–996.
- McGrath, R. G. (1999). Falling forward, Real options reasoning and entrepreneurial failure. *Academy of Management Review*, 24, 13–30.
- McGrath, R. G., Ferner, W. J., & Mendelow, A. (2004). Real options as engines of choice and heterogeneity. *Academy of Management Review*, 29, 86-101.
- McGrath, R. G., & Nerker, A. (2004). Real options reasoning and a new look at the R&D investment strategies of pharmaceutical firms. *Strategic Management Journal*, 25, 1-21.
- Myers, S. C. (1977). Determinants of corporate borrowing. *Journal of Financial Economics*, 5,

147–175.

- O'Brien, J., & Folta, T. (2009). Sunk costs, uncertainty and market exit, A real options perspective. *Industrial & Corporate Change*, 18, 807
- O'Brien, J. P., Folta, T. B., & Johnson, D. R. (2003). A real options perspective on entrepreneurial entry in the face of uncertainty. *Managerial & Decision Economics*, 24, 515-533.
- Posen, H. E., Leiblein, M. J., & Chen, J. S. (2018). Toward a behavioral theory of real options, Noisy signals, bias, & learning. *Strategic Management Journal*, 39(4), 1112–1138.
- Ragozzino, R., & Moschieri, C. (2014). When theory doesn't meet practice, Do firms really stage their investments? *Academy of Management Perspectives*, 28(1), 22–37.
- Ragozzino, R., Reuer, J., & Trigeorgis, L. (2016), Real options in strategy and finance, Current gaps and future linkages. *Academy of Management Perspectives*, 30, 428–440.
- Reuer, J. J., & Leiblein, M. J. (2000). Downside risk implications of multinationality and international joint ventures. *Academy of Management Journal*, 43, 203-214.
- Reuer J. J., & Tong, T. W. (2007). Corporate investments and growth options. *Managerial and Decision Economics*, 28, 863–877.
- Rivoli, P., & Salorio, E. (1996). Foreign direct investment & investment under uncertainty. *Journal of International Business Studies*, 27, 335-357.
- Smit, H. T. J., & Kil, J. C. M. (2017). Toehold acquisitions as behavioral real options. *California Management Review*, 59(3), 42–73.
- Smit, H. T. J., Pennings, E., & van Bakkum, S. (2017). Real options and institutions. *Journal of International Business Studies*, 48(5), 620–644.
- Smit, H., & Trigeorgis, L., (2006). Real Options and Games, Competition, Alliances and Other Applications of Valuation and Strategy. *Review of Financial Economics*, 15, 95-112.
- Smit, H. T. J., & Trigeorgis, L. (2017). Strategic NPV, Real options & strategic games under different information structures. *Strategic Management Journal*, 38, 2555–2578.
- Trigeorgis, L. (1996). *Real options, Managerial flexibility and strategy in resource allocation*. Cambridge, MA, MIT Press.
- Trigeorgis, L., & Reuer, J. J. (2017). Real options theory in strategic management. *Strategic Management Journal*, 38, 42–63.
- Zardkoohi, A. (2004). Do real options lead to escalation of commitment? *Academy of Management Review*, 29, 111 119.