Dilemmas in Exercise Decisions for Real Options on Core Competencies*

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Abstract

This article explores potential dilemmas for firms applying real options heuristics to guide investments in core competencies. The financial options analogy misses some critical strategic issues faced in exercise decisions. First, unlike financial options where competitive markets constantly provide information about asset value, uncertainty about the value of a core competence may persist even when the exercise decision must be made. This is compounded by a second factor – the asset’s initial state (integrated or isolated) initiates a path-dependent process. When options are initially integrated, firms may be biased to exercise options that should be killed. In contrast, when options are initially isolated, firms may be biased toward killing even promising options. In this way, an options heuristic may lead firms to build large portfolios of options that become locked in, or incur the costs of establishing options that cannot be exercised. We suggest research on ways to structure options and manage the decision process to mitigate these potential problems.

Key words: Real options, Core Competencies, Resource-based view, Knowledge
Real options theory is increasingly touted as a heuristic for making strategic investments in core competencies (Kogut & Kulatilaka, 2001). When required future competencies are unknown, firms may make incremental investments in multiple capabilities and presumably exercise (e.g., leverage) only those that are revealed to be essential over time. However, the focus has been strongly on evaluating decisions to acquire options and not on the subsequent exercise decisions. Our purpose here is to draw attention to potential problems at the exercise stage for the increasing number of firms applying real options models and logic. Might real options theory lead firms down the primrose path?

This problem is underscored by the mixed results some firms have experienced with real options. For example, while 3M was praised for nurturing diverse opportunities (e.g., McGrath & MacMillan, 2000), their failure to weed their garden earned them the moniker “Minnesota Mining & Catchall” when McKinsey suggested breaking up the company (Tatge, 2000). In contrast, Xerox is known for a host of promising opportunities that were dropped (PC, mouse, network, etc.); they pruned branches that were yet to bloom. While the outcomes differed, neither example depicts the ideal envisioned – both firms failed to make effective exercise decisions. These stylized examples prompt us to examine exercise decisions more carefully.

Here, we identify two factors tightly linked to core competencies that may cause dilemmas when making exercise decisions: 1) the value of a core competence depends on whether it can be transferred and integrated, and 2) significant uncertainty about the value of a full-scale commitment may remain when making the exercise decision. When a firm buys an option on a new core competence, it may initially isolate or integrate the capability with respect to the rest of the firm. This choice is the first step in a path dependent process that may ultimately determine

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1We use 3M, Xerox and others as examples of firms that appeared to apply real option heuristics. This approach is increasingly recommended as flaws in quantitative approaches emerge (Bowman & Moskowitz, 2001). Such
the dilemmas faced at the exercise decision. These dilemmas are enabled by persistent uncertainty about the value of exercising an option on a core competence. Neither the isolation versus integration choice nor the existence of uncertainty at the exercise decision is emphasized in standard financial options analysis, upon which the real options literature rests.

We contribute by offering a critical analysis of exercise decisions and arguing for caution when integrating real options logic with the resource-based view. After a brief review of the logic for applying real options to investments in core competencies, we explore the dilemmas faced at the exercise stage and identify an agenda for additional research on real options.

**WHY APPLY REAL OPTIONS HEURISTICS TO INVESTMENTS IN CORE COMPETENCIES?**

Core competencies refer to knowledge that is leveraged in the firm to create a competitive advantage. For example, Prahalad and Hamel (1990) describe how Canon leveraged capabilities in precision mechanics, fine optics, and microelectronics to create an array of products. In this sense, core competence stems from the resource-based view, which focuses on knowledge as a source of sustainable advantage since it may be hard to imitate or acquire in competitive factor markets (Barney, 1991; Hall, 1993). Knowledge is even more critical when firms face dynamic environments (Teece, Pisano & Shuen, 1997).

However, knowledge creation is subject to time compression diseconomies – when the knowledge is vital, it may be too late to begin development (Dierickx & Cool, 1989). Firms must therefore maintain diverse knowledge bases to anticipate future needs (Levinthal & March, 1993). These investments must be initiated when their ultimate value is uncertain. However, decision-makers are often biased against investments in intangible assets for which returns are uncertain and span long time horizons (Bower, 1970; Hayes & Abernathy, 1980; Porter, 1992).

examples illustrate potential pitfalls in applications of real option heuristics to investments in core competencies.
Therefore, investments in core competencies pose a basic dilemma in the strategy literature—the very attributes that make these assets hard to imitate also lead to investment biases (Amit & Schoemaker, 1993). Accordingly, a key to advancing theory is to understand how firms make appropriate investments in core competencies.

**Real Options as a Potential Solution**

There is a great deal of enthusiasm about applying real options heuristics to correct these biases and encourage investments in strategic competencies (Copeland & Antikarov, 2001; Kogut & Kulatilaka, 2001; McGrath, 1997, 1999). This tool has two primary advantages over other investment heuristics: 1) the focus on “follow-on” value and 2) timing flexibility to wait out technological uncertainty. First, real options logic encourages the firm to consider the “follow-on” value that is created by a given project. Smit and Trigeorgis (1999:21) wrote, “Strategic investments such as R&D, exploration drilling for oil, or a pilot project, derive most of their value from the creation of follow-on investment opportunities.” For example, Boeing’s investment in computer-aided design for the 777 created capabilities for designing future aircraft. Kogut and Kulatilaka (1994) describe these as platform investments. Indeed, the essence of a core competency is the notion that the knowledge will be leveraged across the firm.

Second, real options logic allows firms to wait for technological and market-based uncertainty about the investment to diminish before making full-scale commitments. Such an approach may reduce the chance of investing in a poor project (type I error) since the initial investment is small and new information revealed after purchasing an option should promote well-informed exercise decisions to kill under-performing investments (Dixit & Pindyck, 1994; Amran & Kulatilaka, 1999). On the other hand, the chance of missing an opportunity (type II error) could be reduced.

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2 Our analysis does not address strategies (e.g., unrelated diversification or building stand-alone units) in which there is no intention to leverage knowledge across the firm.
error) also is lower because firms can invest in small exploratory projects that create the opportunity, but not the commitment, to pursue profitable projects. Again, new information revealed after purchasing an option should enable the firm to recognize and take advantage of these opportunities. Thus, real options logic may allow firms to realize the upside potential of strategic investments without the downside risk of a full-scale commitment.

A Heuristic Approach to Real Options

Some of the real options literature focuses explicitly on applying financial options pricing models (e.g., Black & Scholes, 1973). However, the values of key parameters are typically unavailable for real options on core competencies (exercise price, time frame for making exercise decisions, variance in the asset’s value, etc.). In the case of financial options, these are either specified ex ante or easily calculated since the assets are traded in competitive markets.

Because of these differences, an options heuristic is often more practical than rigorous pricing models (Bowman & Moskowitz, 2001; Kogut & Kulatilaka, 2001; McGrath & MacMillan, 2000). Our analysis therefore focuses on real options heuristics and the more intuitive approach to considering option value. For example, Brown and Eisenhardt (1997: 1) found that “successful firms rely on a wide variety of low-cost probes into the future.”

EXERCISE DECISIONS FOR OPTIONS ON CORE COMPETENCIES

High profile failures – such as the examples of 3M and Xerox PARC with which we began – are troubling because real options theory is increasingly seen as a solution to investment dilemmas inherent when creating in new capabilities. It should be clear from these examples that

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3Normally, uncertainty increases option value (Dixit & Pindyck, 1994). However, here we distinguish between general or environmental uncertainty and specific uncertainty about the value of a full-scale investment. An option heuristic presumes that uncertainty about the efficacy of further investment is reduced over time.

4Some real options applications (land, oil leases, etc.) draw on formal options models since the assets have well-established markets. This distinguishes real options on core competencies from other real options applications.
the exercise decision is critical. The exercise decision is a natural evaluation point to drop unprofitable projects and fully commit to those with great promise.

Here we examine dilemmas at the exercise decision stemming from uncertainty (the source of option value) and the need to integrate core competencies across the firm. In some cases, we propose an increased likelihood of continued investment (exercising options), even for projects no longer showing promise. In others, we propose an increased likelihood of terminating investment (letting options expire), even with evidence that the project has great merit.

**Importance of the Exercise Decision**

In the exercise decision, the firm relinquishes its option either by letting it expire or making a full commitment (Dixit & Pindyck, 1994). Either way, the flexibility created by the option ceases. After making a full-scale commitment, a firm cannot easily reverse course if new information casts doubt on the investment. Similarly, once an option is allowed to expire, the opportunity is foregone, even if new information suggests promise. Thus, in the exercise stage, firms may still be vulnerable to both Type I and Type II errors.

While initiating an option creates opportunity, firms realize the value through the exercise decision by fully committing to successful projects or dropping those lacking promise. A real options heuristic may hurt performance if a firm consistently makes poor exercise decisions (e.g., systematic biases to exercise options or let them expire). As McGrath (1999: 23) argues, “Options must be extinguished ruthlessly when they no longer promise high upside potential.”

**Limitations of the Financial Options Analogy**

Despite limitations of formal financial models, the analogy to financial options continues to influence thinking about real options. One aspect of this is the relative lack of emphasis on exercise decisions. If real options closely paralleled financial options, exercise decisions would
be relatively straightforward. For example, if the exercise price of a call option is $10/share and the security is trading at $15 on the exercise date, the option should be exercised to realize a $5/share profit. The potential for erroneous exercise decisions may be understated since the financial options analogy does not capture many of the key concerns of exercise decisions involving core competencies (see Table 1). Accordingly, with few exceptions (e.g., Miller, 2001), exercise decisions for real options have received little attention.

Because the time frame for exercising a real option is rarely specified, managers have considerable discretion about when the exercise decision is made. On one hand, they may schedule the decision as better information emerges. On the other, as we shall see, the ambiguity may allow managers to delay the decision too long. While a firm’s ability to control the timing of investments is a key insight of real options theory (Dixit & Pindyck, 1994), the risk that the ambiguity about timing may create dilemmas is important.

When an exercise decision is considered, managers may choose to continue holding the option – effectively postponing the decision further. In the face of uncertainty, it may seem easy to postpone the decision since this may only require a small resource commitment. Yet, the cost of postponing is complicated by strategic considerations and the nature of investments in core competencies. For example, where first mover advantages are possible, the benefits of waiting for uncertainty to dissipate may be overwhelmed by the cost of moving too slowly (Lint & Pennings, 1999). Firms should make exercise decisions sooner if the value of speed exceeds the value of information that can be gathered by delaying the decision (Kogut & Kulatilaka, 1994).

The other differences between real and financial options form the basis for the analysis in the next sections. We focus at length on persistent uncertainty and path dependence stemming from

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5Here we focus on timing options for which exercise decisions involve large investments. In contrast, some
the investment’s initial integration or isolation. These, in turn, affect the exercise price, disposal cost, and attempts to influence the exercise decision increasingly with the passage of time.

**Persistent Uncertainty when Exercising Options on Core Competencies**

A critical way that exercise decisions for real options differ from financial options is the extent to which uncertainty about the value of a full-scale commitment may persist. As noted, options are particularly useful when there is initial uncertainty about the value of a full investment and postponing the decision would allow better information to surface. For financial options, the asset’s value is generally known at the time the exercise decision is made – the decision rule is simple or even trivial. There is no uncertainty about either the exercise price (established by contract) or the market price (since the stock is traded in a competitive market).

In contrast, for options on knowledge-based assets, persistent uncertainty is driven by the use of imperfect signals of the project’s efficacy. For example, there may be conflicting or ambiguous information about the project – some signals suggest great promise while others cast serious doubt. Alternatively, there may be little or no information – no signal suggesting either a project’s merits or its pitfalls. Finally, there may be signals from sources that lack credibility. Such noisy signals suggest that there is little on which to base a sound exercise decision.

Consider the decision to commercialize a new technology (i.e., exercise option) at \( t_1 \) after having invested in a pilot manufacturing capability at \( t_0 \). Market prospects and the firm’s manufacturing capabilities may be better known at \( t_1 \) than at \( t_0 \), but considerable uncertainty remains. Managers must interpret ambiguous signals about external conditions such as market size, rivals’ actions, or emerging technologies. Similarly, implementation issues such as the options require a sequence of small investments. We explore these “compound options” in the discussion section.

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6In financial options models, uncertainty is defined as the variance in the underlying asset’s value. This variance (and therefore the option value) can be calculated readily since the assets are traded in competitive markets. Since the markets for core competencies are incomplete, the variance is almost impossible to determine. Consistent with how McGrath (1997) and others address uncertainty, we use the term “persistent uncertainty” to refer to the degree to which the value of the underlying asset is unknown as opposed to the variance concept used in financial models.
magnitude and timing of expenditures (exercise price) may remain uncertain. Managers may require more experience to gain a full understanding of knowledge needed to implement.

Much of the persistent uncertainty is due to new knowledge rather than tangible assets. For example, implementing a new manufacturing process or gaining new marketing expertise may be harder to master than acquiring the associated tangible assets for which factor markets provide reliable prices. Uncertainty about whether knowledge can be absorbed and applied may only be reduced through direct experience (Cohen & Levinthal, 1990; Kogut & Kulatilaka, 1994).

Thus, while uncertainty about a full commitment may decrease over time (e.g., signals become more reliable), it may never dissipate. Accordingly, McGrath’s (1997) condition that uncertainty is “temporally truncated” may not be met when applying a real options heuristic to core competencies. Such persistent uncertainty may make exercise decisions treacherous for managers. First, persistent uncertainty may put pressure on managers to push back the exercise decision (e.g., hold the option longer). Second, the lack of reliable information about the value of a full-scale commitment allows social and political processes to play a greater role in influencing the exercise decision. We explore these problems in depth below.

Postponing exercise decisions due to uncertainty. As stated, the value of purchasing an option depends on the initial uncertainty about the efficacy of a full-scale commitment along with the extent to which this uncertainty will dissipate over time. This also holds for how long an option should be held once purchased (McGrath, 1997). That is, if uncertainty persists and the decision-maker believes that time and additional information gathering may remedy the situation, it may be best to maintain the option until a better-informed decision can be made. In this way, the option is neither relinquished nor exercised until managers have a clearer picture.

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7The uncertainty associated with the decision to hold the stock after the option is exercised is a distinct issue.
Persistent uncertainty makes it attractive to continue holding the option because an exercise decision cannot effectively maximize upside potential while limiting downside risk – the primary motivation for using an options approach. Downside risk can be limited by killing the option. However, since uncertainty about a full-scale commitment is unresolved, this would also eliminate the upside potential. Similarly, a decision to exercise the option in the face of persistent uncertainty would preserve the upside potential while exposing the firm to considerable downside risk. Accordingly, postponing the exercise decision seems especially appealing.

Nonetheless, such uncertainty never fully dissipates and it may be reduced at an unpredictable rate. Thus, specific information about when and if uncertainty will dissipate may be unavailable and there may be pressure to push the exercise decision back indefinitely until better information is available. As we shall see, this may have serious consequences.

 Proposition 1: The greater the persistent uncertainty about the value of a full-scale investment in a core competency, the more likely are managers to postpone the exercise decision (i.e., maintain the option).

Uncertainty and the role of social capital in exercise decisions. In some cases, it may be apparent that the decision cannot be postponed. If uncertainty about the value of a full-scale investment persists, on what basis will exercise decisions be made?

Research on capital budgeting suggests that when firms must invest under conditions of uncertainty, the project champion’s reputation and ability to influence others serve as signals of a project’s efficacy (Bower, 1970; Pfeffer & Salancik, 1974). Reputational signals are most influential when clear evidence of project performance is lacking. Thus, firms tend to invest in projects sponsored by high reputation or well-networked managers while low reputation managers may be unable to get funding for very promising projects absent strong evidence. These same dynamics may apply when exercise decisions are made under conditions of persistent uncertainty about the value of a full-scale investment.
Such reputational signals may be efficient if they reflect managerial experience and ability. That is, it puts a weight on a given manager’s judgment based on his or her past performance. If one’s past performance results from investment expertise, the fact that a high reputation manager undertook a project may be important information. In the absence of other, more direct, information sources, this may be the best available signal of a project’s efficacy.

However, reputational signals may be dubious for several reasons. First, reputation is not built entirely on the ability to judge investment opportunities. It also reflects one’s personal influence, communication skills, and social capital. These may not be strongly correlated with sound investment judgment or a willingness to admit failure if a project lacks promise.

Furthermore, individuals may ply their political skills to advance personal agendas even if these are not in the firm’s interests. Managers have strong incentives to seek funding for their projects to enhance their power. In general, as managers secure resources for their unit and their unit grows in size, they garner greater status (Pfeffer & Salancik, 1974). Even if a manager felt a project might ultimately fail, the time horizon might be long enough that he or she would have moved on and so avoid direct blame. Given the long time horizons often associated with core competencies and sustained competitive advantage, this may be especially relevant.

Finally, even if project champions do not act opportunistically, there is reason to doubt their judgment. Individuals who are immersed in a project may be especially prone to escalation problems. That is, a manager’s personal need to justify an initial decision may lead to irrational support for continued investment (Brockner, 1992). Uncertainty may exacerbate the risk of escalation, as a necessary condition for self-justification to produce irrational support for continued investment (McLean Parks & Conlon, 1990; Staw, 1981; Staw & Ross, 1987). For example, Hantula and Bragger (1999) found evidence of a positive association between “feedback equivocality” (unpredictability of feedback about performance) led to escalation.
In sum, while a manager’s reputation may be the best available signal of a project’s efficacy, it is far from perfect and may lead the firm astray. Nevertheless, in the face of persistent uncertainty, reputation and social capital may take on greater significance.

Proposition 2: The greater the persistent uncertainty about the value of a full-scale investment in a core competency, the more likely that managers will use social capital to influence the exercise decision.

We will build on propositions 1 and 2 in the next section as we explore specific biases that may result when persistent uncertainty interacts with the path dependence stemming from the initial integration or isolation of the asset.

Initial Integration v. Isolation of Real Options

The other key factor differentiating exercise decisions for real and financial options is the degree and nature of interdependency with other assets (Trigeorgis, 1993). The interdependencies present in a portfolio of financial options are limited. For example, financial options may be used to hedge against performance of different firms or economic sectors. In this sense, exercising one may suggest that others should not be exercised.

In contrast, core competencies must be integrated to leverage and realize their full value. The notion that value is created when knowledge is transferred and integrated is a strong theme in the knowledge literature (Kogut & Zander, 1992; Grant, 1996). Thus, we assume that in order to exercise an option on a competency (e.g., transform it into a core competency), the knowledge must ultimately be combined and integrated with other organizational resources.

However, an option on a competency may be established either as an isolated subunit or integrated with other divisions. Sometimes an incompatible culture, routine or technology must be kept isolated in order to thrive (Christensen, 1995). In others, knowledge must be integrated initially to evaluate its potential (Mosakowski, 1997). Either situation may lead to problems at
the exercise decision. We explore these, in turn, below. We argue that the initial state, integration or isolation, may set path dependencies in motion that ultimately bias exercise decisions.

**Options that are integrated initially.** In some cases, information about the efficacy of a full-scale investment can be obtained only by integrating the option initially. For example, a key source of uncertainty might be whether the firm has absorptive capacity to transfer and apply the knowledge (Cohen & Levinthal, 1990). Here, initial integration may help the firm learn about ease of implementation and, accordingly, both the cost and value of exercising the option.

However, as we shall see, integration creates disposal costs that may become an important factor in the exercise decision. Routines in the new unit become increasingly co-specialized with those of other units. This is part of a process by which internal consistency is maintained while accommodating specialized skills (Doty, Glick & Huber, 1993). For example, unless the units are somewhat isolated from each other (as will be explored), conflicting cultures in different units may seem hypocritical, eroding each value set or converging on one set of values (Schein, 1996). In this way, specialized skills and routines necessitate other co-specialized routines to form a sort of co-specialization machine (Poppo & Zenger, 1998).

Interdependent subsystems of this type may create pressure to invest further in co-specialized routines. Like a wave that sweeps through the firm, co-specialization raises the cost of cutting off further investment. Put another way, the disposal costs for letting the option expire may be spread throughout the firm reflecting the interdependencies that develop over time. Thus, allowing an option to expire first requires derailing the co-specialization machine.

These costs are very difficult to anticipate when the option is initiated since they depend on ties and routines that evolve over time. Furthermore, estimating and monitoring these costs may not get much easier since they are embedded in routines and social ties that must be broken.
such, these disposal costs may turn out to be much larger than could be foreseen when the option was established or even when the exercise decision is postponed.

In sum, the unforeseen disposal costs should increase with the length of time that the option is held, as the assets become integrated. While these creeping costs suggest that the exercise decision should be moved forward in time, managers may be unaware of changes in these costs.

**Proposition 3:** The longer an option on a core competency is allowed to become integrated before the exercise decision, the greater will be the (initially) unforeseen disposal costs.

This situation creates a management dilemma that has not been fully addressed in the real options literature. A real options approach may support purchasing an option, and that nature of a particular asset may require its initial integration. By the time the exercise decision is considered, the disposal cost may be sufficiently high that it makes sense to exercise the option. Still, it is possible that the firm would have been better off if it had not purchased the option at all. Thus, both decisions – to purchase the option and to exercise the option – can be rational when viewed separately. Nevertheless, the firm might have been better off not to have invested at all than to be swayed into purchasing an option. This arises since many parameters of the option (e.g., disposal cost, exercise price, expiration date) are unanticipated ex-ante.

This problem may be exacerbated when juxtaposed with the effect of persistent uncertainty on timing (see proposition 1). Specifically, this may put pressure on managers to postpone exercise decisions in anticipation that uncertainty about the value of a full-scale commitment will dissipate. If managers succumb, unforeseen disposal costs may accumulate – in the extreme case, the option may be exercised, de facto, as managers wait for uncertainty to disperse.

**A bias to exercise options.** Beyond the problems created by disposal costs, persistent uncertainty about the value of a full commitment amplifies the role of social capital in exercise decisions (proposition 2). In this case, the effect is to elevate the influence of well-connected
managers in the experimental subunit. Through the increased influence of social capital, the effect of persistent uncertainty may be to create a systematic bias – beyond the rational consideration of disposal costs – toward exercising options that are initially integrated.

If a great deal of uncertainty about the efficacy of a full-scale investment persists, bias may arise from three key sources: employees in the experimental subunit (i.e., the option), employees in the rest of the firm, and managers who make the exercise decision. First, integration helps managers in the experimental unit use social capital to influence the decision. Social capital is often explored as a factor that enhances firm performance as it helps build and transfer knowledge (Nahapiet & Ghoshal, 1998; Leana & Van Buren, 1999). However, more broadly, social capital is the “ability to secure benefits through membership in networks and other social structures” (Portes, 1998: 8). Here, integration creates social networks for managers in the affected unit; enhancing their influence and helping them push for continued investment.

Second, employees in other departments and divisions may lobby on their own for continued investment. Aside from the social capital effect cited above, there might be broad support for continued investment to avoid change. As suggested earlier, co-specialization may mean that change would be felt throughout the firm if the option were killed. Thus, managers in other departments may not oppose exercising the option and may even push for further investment.

Finally, managers who are directly responsible for the exercise decision might have to sever ties or break implicit contracts. It has been noted that managers are often reluctant to break such contracts and external forces, such as hostile acquisitions, are required to sever inefficient implied contracts (Shleifer & Summers, 1988). These contracts might be even stronger if the unit is integrated and its managers well connected. Ultimately, a new management team may be needed to avoid escalation in such settings (Staw, Barsade & Koput, 1997).
In this way, persistent uncertainty and integration may interact; creating pressure to escalate commitment even in the face of evidence that further investment is unwise. The structural determinants leading to escalation of commitment mirror the co-specialization machine in the form of “side bets” made that promote continued investment. Staw and Ross (1987: 60) wrote:

Organizations create economic, technical, and political side bets as a project is installed and developed over time. These side bets are incurred to support and implement a given project over its lifespan … [but] are serious considerations in decisions whether to persist or withdraw from a project if it does not appear to be succeeding. … [E]conomic and technical side bets may both inhibit the reexamination of a current course of action as well as contribute added costs to a withdrawal decision.

For example, let us return to 3M, a company praised for fostering creativity and fully backing projects that show merit, was also lauded for business units that were integrated with corporate R&D around a series of core competences such as adhesives, abrasives, and data storage (Peters & Waterman, 1982). However, recent poor performance has sparked a closer look and stark recommendations to break up the firm (Tatge, 2000). If 3M had killed options that lacked promise all along, they would not have been left with a poorly performing portfolio. Their new CEO, the first outsider to run the firm in 99 years, has eliminated 800 of 3M’s 1,500 R&D projects to focus on those that have the greatest potential (Merrick, 2001). Apparently, it took a new CEO with few pre-existing ties to kill options that had been nurtured far too long.

In sum, the interaction of persistent uncertainty and integration enhances the risk of biased exercise decisions as managers deploy social capital to lobby for more funds. Such options create constituencies in favor of further continued investment (Staw & Ross, 1987; Drummond, 1994). When a project is institutionalized, its termination requires costly adjustments and clear evidence of failure (Goodman, Bazerman, & Conlon, 1980). Thus, this bias is distinct from the rational consideration of unanticipated disposal costs (proposition 3).

*Note that this article focuses on the structural or organizational antecedents to escalation rather than the psychological attributes associated with a given decision-maker’s tendencies to escalate commitment.*
Proposition 4: For options on core competencies that have been integrated initially, greater persistent uncertainty about the value of a full-scale investment increases the likelihood of a bias to exercise the option.

The key distinction between propositions 3 and 4 is whether there is a bias toward continued investment at the exercise decision. Although both propositions address a sub-optimal outcome (i.e., overinvestment), the causes differ. The discussion leading to Proposition 4 emphasizes how the initial integration of the asset may result in a bias to exercise the option. Camerer and Weber remind us, however, that there are poor outcomes for which “… the blame should be pinned on optimistic initial cost forecasts, not on sub-optimal escalation” (1999: 75). We thus emphasize in the discussion preceding Proposition 3 that a poor outcome may result from a rational exercise decision, given the unanticipated disposal costs arising from integration. Proposition 4 extends this to consider an irrational bias that may emerge as stakeholders advocate personal agendas.

Options that are initially isolated. It is possible to limit co-specialization and social ties by keeping options as isolated subunits. This should reduce the bias to exercise options described above. For instance, we began with the example of how Xerox created a flurry of innovation in their Palo Alto Research Center (PARC). This isolated subunit developed unique skills and routines that flourished apart from the rest of the company.

However, if the required degree of isolation is achieved, the resulting routines may be incompatible with the rest of the firm. In effect, PARC Xerox also illustrates an inability to fully exercise options kept in isolation. While PARC has fostered creativity and innovation, Xerox is famous for failing to take advantage of the options created (e.g., personal computers, networks, and the mouse interface were developed in the 1970s). Here, the innovations did not build on the firm’s core knowledge and skills (e.g., marketing and xerography). As a result, management could not exploit the emerging innovations. More recently, Xerox has considered selling all or parts of its “golden goose” to spare it from deep cost cutting efforts (Rae-Dupree, 2001).
GM had a similar experience with its Saturn division. Saturn was isolated from the rest of the firm, creating a unique team-based culture – effectively an option on cultural change. Once the experiment succeeded, it turned out that the isolated option was very difficult and costly to exercise. GM could not implement the changes more broadly since they were incompatible with existing routines and values. In order to exercise the Saturn option fully, GM might have to allow the existing divisions to wither while creating new divisions that espouse the desired culture.

Of course, eliminating the core business is a hard decision. Yet, as the Saturn example illustrates, it may be required to take full advantage of an option. Indeed, Galunic & Eisenhardt (1996) found that indeed firms do shed old units when they fully commit to new core businesses. Since this type of radical strategic shift often requires new management (Tushman & Romanelli, 1994), exercising the option may not reflect the ease implied by most options proponents. As a result, firms may fail to fully exercise options that have been created and isolated.

However, the longer the firm holds the option, the less compatible the isolated routines may become. That is, rather than co-evolving and co-specializing; the isolated unit is likely to develop its own idiosyncratic routines. Indeed, this is the main advantage of skunkworks-style programs – they are not bound by existing routines. However, the firm may ultimately lack the “transformative capacity” to benefit from such options (Garud & Nayyar, 1994).

Put another way, the exercise price, which is typically not specified ex ante, will tend to creep up over time when options are kept isolated. These integration costs may be hard to monitor or measure since they reflect incompatibilities in intangible structures such as routines, values, and tacit knowledge. Furthermore, they manifest themselves in implementation costs that are hard to identify until the firm has begun exercising the option.

Proposition 5: The longer an isolated option on a core competency is allowed to develop before the exercise decision, the greater will be the (initially) unforeseen exercise price (i.e., cost of integration).
This mirrors our discussion of unanticipated disposal costs in that each decision appears rational when examined separately. Still, firms might be better off if not enticed into purchasing options that ultimately cannot be fully exercised. Furthermore, the addition of persistent uncertainty may exacerbate the problem by creating pressure to postpone the exercise decision (proposition 1) – thereby allowing the exercise price to creep up even more.

Of course, this is a problem of bounded rationality more than decision bias. However, the fact that a high exercise price cannot be anticipated ex ante raises questions. Indeed, if the exercise price were known, the option might not have been purchased initially. Again, this is a critical departure from the financial option analogy where the exercise price is clearly specified.

A bias to kill the option. Beyond this, however, biased exercise decisions may result when uncertainty about the value of a full commitment persists, augmenting the effect of social capital (proposition 2). However, unlike the situation for integrated subunits, the elements of social capital work to deter further investment because the experimental subunit is isolated.

This includes the direct influence of the managers in the affected unit, managers in other divisions, and the decision-makers themselves. First, it is likely that the managers in the experimental subunit (i.e., the option) are not well connected because isolation limits their contacts throughout the firm. In addition to the small number of ties, such managers may have weaker ties because they are not reinforced through day-to-day interaction or routines. As such, they will be in a weak position to influence the exercise decision towards continued investment even if the option shows great promise (Pfeffer & Salancik, 1974).

Furthermore, managers in other units are unlikely to rally for further investment that requires substantial change. Since the systems have not co-evolved, one might predict that managers will
lobby against further investment even in the face of great promise. Indeed, this describes the
dynamics at PARC Xerox when so many profound innovations were thwarted.

Finally, the decision-makers themselves may feel less connected to the experimental subunit –
creating less of an obligation to preserve implicit contracts. Such managers might not be prone
to escalate commitment since their own association with the project is limited. In essence, strong
forces are aligned to stop further investment even if the project shows signs of promise.

Proposition 6: For options on core competencies that have been isolated initially,
greater persistent uncertainty about the value of a full-scale investment increases
the likelihood of a bias against exercising the option.

The distinction between Propositions 5 and 6 is similar to the distinction noted above
between Propositions 3 and 4. Proposition 5 describes rational exercise decisions that may lead
to sub-optimal outcomes. Here, because of unanticipated costs of integrating an incompatible
asset, the firm’s losses (i.e., due to expenditures on the initially-isolated option) are greater than
they would have been if a real option heuristic had not been applied. Proposition 6 adds the
possibility that, due to political and social processes, the exercise decision itself may be biased
against continued investment in promising assets.

Which Biases are Firms Most Likely to Encounter?

We have identified different biases that may emerge when applying a real options approach
to core competencies – depending on the levels of integration and persistent uncertainty.
However, in building a resource-based advantage, which of these biases would a firm be most at
risk of experiencing? We draw on resource-based theory to explore links between strategic
investments, persistent uncertainty, and initial integration.

Causal ambiguity and persistent uncertainty. One of the key attributes proposed to hinder
imitation in the resource-based view is causal ambiguity. Causal ambiguity means that the link
between the underlying asset and superior performance is not understood (Lippman & Rumelt,
1982). It prevents imitation since rivals cannot determine what to copy. This can only lead to a sustained advantage if both the firm and its rivals continue to be perplexed by the relationship between the resource and performance (Barney, 1991: 110).

This creates a paradox: firms must invest in capabilities that cannot be linked to performance. Clearly, then, causal ambiguity is associated with persistent uncertainty. That is, if the firm’s own managers cannot discern causal linkages between the asset and performance, there must be considerable uncertainty about the efficacy of a full commitment. As discussed earlier, while persistent uncertainty may introduce bias into exercise decisions, the direction of this bias depends on the degree of integration – a topic to which we now turn.

**Integration, firm specificity, and social complexity.** Firm-specific or socially complex resources are also hard to imitate and thus may help sustain a competitive advantage (Barney, 1991). Firm-specific resources are hard to imitate because they reflect the idiosyncrasies of a single firm. Socially complex resources are embedded in social networks or teams that are too complex for rivals to duplicate in another setting.

In each case, we can trace inimitability to the fact that these resources are integrated and/or co-specialized within the firm. Firm-specific resources are integrated with other assets since they are designed to accommodate the firm’s idiosyncratic systems. Such contextual specialization is merely another way of saying that firm-specific resources are integrated and could not be extracted or duplicated and applied in another firm.

Socially complex resources also tend to be integrated. Such resources are embedded in teams or complex social networks that are hard to replicate in another setting. For example, Hargadon and Sutton (1997) describe how informal networks created from past work assignments facilitate technology brokering at IDEO Corporation. Even if rivals knew that the complex social system generated rent, they may not be able to replicate the unique social ties in a different context.
Since the strategic value of such assets lies in their co-specialization with other resources, integration will probably be required to gather enough information to decide whether to exercise the option. Much of the uncertainty about the value of a full commitment revolves around absorptive capacity. Keeping the option isolated may be insufficient to reduce the uncertainty and facilitate a sound exercise decision. Accordingly, it seems especially likely that real options involving firm-specific or socially complex resources will have to be integrated initially.

In sum, when using real options theory to build a resource-based competitive advantage, managers are most likely to establish integrated options and face persistent uncertainty when making exercise decisions. Taken together, this suggests firms may exhibit a bias in favor of exercising such options (i.e., relatively high risk of type I errors).

**Proposition 7:** Managerial attempts to build a resource-based competitive advantage using a real options approach are most likely to exhibit a bias toward continued investment in the exercise decision.

**DISCUSSION**

We have offered a critical analysis of decisions to exercise options on core competencies – a problem that has received scant attention in the literature. While we agree with proponents (e.g., Kogut & Kulatilaka, 2001; McGrath, 1997) that real option heuristics should promote initial investments in core competencies, this is just the beginning. Effective exercise decisions are critical to realize the value of a real options approach.

Exercise decisions on core competencies pose unanticipated dilemmas since such assets often violate basic assumptions in an options framework (Bowman & Moskowitz, 2001). We especially focus on two important assumptions that are violated: 1) persistent uncertainty at the time of the exercise decision and, 2) the ultimate need to integrate the assets. The resulting risk of over-investment or under-investment is summarized in Figure 1.
Even if the exercise decision itself is free from bias, the act of establishing an option on core competencies may set path-dependent processes in motion that create unanticipated costs. Firms may face substantial costs to integrate a project with other resources (making it attractive to kill the option) or substantial costs to terminate it (making it attractive to exercise the option). These are depicted in quadrants I and II of Figure 1, respectively. If the firm had foresight about these cost elements (as is the case for financial options), the option might never have been purchased.

In contrast, under persistent uncertainty the firm may make biased judgments due to pressures within the firm to either continue (exercise the option) or terminate investment (let the option expire). With an isolated option these forces may be aligned to terminate investment; with an integrated option, these forces may promote continued investment (quadrants III and IV of Figure 1, respectively). Initially integrated options under persistent uncertainty (quadrant IV) create structural and institutional factors that increase the risk of escalation.

**Compound Options: A Series of Relatively Small Investments**

Up to now our analysis has focused on timing options – small initial investments followed by decisions about a full-scale commitment. This captures the financial options analogy presented in most treatments of real options and reflects the way options are most often conceptualized.

However, would our assertions hold for options that manifest as a sequence of small investments? In the case of a compound option, each exercise decision involves purchasing a subsequent option. At any decision point, the firm may kill the option or keep it open with an incremental outlay. For example, many R&D programs follow a pattern of small infusions of capital rather than one large lump-sum investment. Despite this difference in relative magnitude of investment, our analysis applies directly to compound options as well as timing options.
Indeed, the dilemmas may also be compounded. When compound options are initially integrated, the bias to continue investment (proposed above) may be exacerbated. Each small-scale exercise decision should face less scrutiny than would a larger expenditure under a timing option. Meanwhile, the costs of disposal and the structural and institutional forces favoring continued investment continue to rise. In this way, integrated compound options may be especially prone to problems of escalation – at some point they become exercised de facto.

The effect for compound options that are initially isolated may be less obvious. As above, we expect individual, small-scale exercise decisions to face less scrutiny. Nevertheless, attempts to integrate the option with other resources will create the challenges we have described. Thus, we expect that initially isolated compound options will be kept alive, although in isolation, over a longer period of time than in the case of the timing options analyzed above. Again, the longer the option remains isolated, the higher the cost of exercising the option (proposition 5), and the less likely that the capability will be leveraged as a core competence. In effect, maintaining such an option longer will not increase the likelihood that the firm will develop it into a core competence. Hence, the firm may continue incremental investments without fully exercising the option.

Exercise decisions remain critical to capturing value – even if individual decisions involve small outlays, their sum can be sizeable. In fact, halting investment may seem more costly and time consuming than making an incremental investment. In the end, the firm may spend more in small increments than if they had faced a large commitment and killed the project sooner.

Are Real Options Best for Analyzing Investments in Core Competencies?

We have identified a number of dilemmas that suggest limitations to applying a real options heuristic to core competencies. Indeed, firms may escalate commitment to poor projects or kill promising projects. However, this does not necessarily suggest that real options theory lacks promise. It only implies that the financial options analogy does not translate perfectly, and we
must be aware that real options logic does not fully mitigate investment biases. Moreover, both type I and type II errors are well documented when options frameworks are not applied. Are the dilemmas associated with a real options heuristic more or less serious than those of alternatives?

Real options heuristics are an improvement if they increase the likelihood that the firm will invest in competencies by overcoming problems associated with uncertainty and long time horizons (Kogut & Kulatilaka, 1994, 2001; Laverty, 1996). If firms are prone to under-invest in knowledge, increasing such investments may be desirable. In other words, projects that have been “incorrectly” rejected though NPV analysis may succeed if an options framework promotes both the initial investment and the “correct” exercise decision.

However, real options could lead to lower performance under two scenarios. First, the heuristic may encourage firms to initiate many options assuming that they can easily be killed. Even a small tendency toward continued investment might be amplified by a large number of projects undertaken. Thus, while a firm using an NPV model might undertake and maintain a small number of low risk projects, a firm applying an options heuristic might initiate many options and end up with a large portfolio of failing projects – much like 3M (Tatge, 2000).

A second source of poor performance for firms applying options involves promising projects that are killed. An options heuristic should encourage firms to invest in and maintain projects that they would otherwise not consider. If they later drop even the promising projects, the firm would be losing the initial investment and maintenance costs that would not otherwise be incurred (e.g., the many promising investments left to wither at PARC Xerox).

In the absence of empirical research, we cannot specify whether and when real options will be more efficient. It is clear that it has great potential but it also may incur substantial costs if the organizational implications are not well understood.
IMPLICATIONS AND FUTURE DIRECTIONS

Options logic is poised to take its place in the mainstream of strategy literature as a heuristic to guide investment in core competencies. A complete theory of competitive advantage requires an understanding of how firms invest in core competencies. The problems of applying NPV models to these investments are well known, and an options heuristic may be a distinct conceptual improvement. Although the case for options is compelling, there is much to be done to open the “black box” and explore when options models are most useful and how firms should manage decision processes.

Developing a Research Agenda

In light of the potential dilemmas examined here, future research should explore how real option heuristics can be applied to invest in core competencies while avoiding their potential pitfalls. Such an agenda should explore decision processes and ways that options can be structured to mitigate the dilemmas we have described.

**Understanding managers’ strategic decision processes.** Bowman and Hurry (1993) and Slater, Reddy, and Zwirlein (1998) suggested that managers might consider option value intuitively. Given the complexity of formal calculations of option value, there are opportunities for laboratory research exploring “options logic” as a heuristic. How does an options framework influence individual preferences? Busby and Pitts (1997) and Howell and Jägle (1997) reported studies along these lines although they did not focus on core competencies.

We also hope to stimulate field studies examining how framing strategic investments as options affects decision-making. This would link the strategy process literature to the resource-based view by exploring how firms build resource-based advantages. John Stonier of Airbus Industrie has noted that real options changes the entire approach of top management teams toward investment under risk (Stonier, 2001). Bower’s (1970) study of capital budgeting and
some of the research on innovation are good models (Burgelman, 1983; Garud & Van de Ven, 1992). Kulatilaka’s (1993) detailed case study of a real options application is also valuable. Similar studies focusing on core competencies would contribute greatly.

Finally, we need research exploring the impact of limited foresight on the part of managers when initiating options and when making exercise decisions. Here, we described the problem of limited foresight about key parameters such as the value of the underlying asset, the exercise price and the disposal costs. Miller (2001) also offers a very useful mathematical model examining what types of biases managerial myopia might create in managing real options.

**Portfolio structure as credible commitment to kill options.** We have discussed interdependencies that develop between options and the firm’s other resources as they are integrated. In addition, if the firm invests in multiple real options, these may be interdependent as well. The same general logic applies to all such interdependencies, whether among options or between options and other assets. Where multiple options are complementary and initially integrated, the pressure to exercise will be more effective as the project champions lobby in concert – regardless of whether exercising the options is in the interests of the firm as a whole. This would tend to exacerbate the risk of escalation.

In contrast, when options compete (e.g., if the firm is hedging on a technological standard), champions for opposing options can be expected to lobby against exercising. This may be one avenue to mitigate the risk of escalation by signaling credible commitment to kill all but one of the options. This suggests that the problems identified here might have implications for decisions about portfolios of options, as opposed to treating each option as a separate decision.

**Process innovations: from junior faculty to scientific advisory boards.** Perhaps the most important question is how firms overcome the barriers we describe. For example, a logical response to the risk of over-investment is to specify initially a limited explicit and psychological
contract, which may reduce the risk of escalation later when making the exercise decision. Here, the academic model may be instructive since universities formally and informally specify that they are “buying an option” on junior faculty. It is clear at the outset that there is limited commitment. Rigorous external review provides important information for the “exercise” decision and limits the extent to which the candidate can influence decision-makers directly.

Aside from academia, cutting-edge technology firms often have scientific advisory boards to review their project portfolios. While these often serve to grant status and legitimacy to the firms (by involving eminent scholars), the review process may also provide useful information much like the external review in a university setting.

While we are cautious in suggesting that businesses emulate universities in the matter of tenure, the consequences of the process deserve attention. First, a natural consequence is that junior faculty may limit institution-specific investments, such as those required to build new programs, which will turn out to be worthless if the option is not exercised. Outside of the university setting, failure to invest in firm-specific knowledge may reduce the potential for competitive advantage and thus the value of the option. Second, while junior faculty develop social capital that may allow them to influence exercise decisions, the external review and review at the university level (where junior faculty are less likely to have direct social ties) limits the risk of escalation. Third, the tenure system seems to treat type I error (over-investment) as a more critical concern than type II error (“killing” a promising “project”). In universities, this may be the case, given that tenure creates colleagues for life. However, this may or may not be true in business settings where the cost of killing a promising project may be substantial.

Based on the potential dilemmas identified here, we encourage further research into such process innovations. It may be possible to design structures or processes to minimize the biases.
Managerial Implications: Making Sound Exercise Decisions

We have identified serious hurdles facing managers applying real options theory. Managers want to know how the logic of real options can improve investment decisions. This requires understanding: 1) why exercise decisions pose unanticipated dilemmas when applied to core competencies, and 2) when real options approaches add value.

In particular, managers must balance the risks of over-investing and missing key opportunities. Figure 2 depicts graphically the tightrope they must walk as they navigate the risk of bias (where the two surfaces intersect). The dark surface depicts a high risk of over-investment for integrated assets under persistent uncertainty. Conversely, initial isolation of the asset increases the risk of killing promising projects (light surface). As we have discussed, both risks increase as the value of a full-scale commitment becomes less certain.

It might appear, from Figure 2, that the optimal integration is where the two surfaces intersect (e.g., the tightrope). However, that presumes the cost of type I and type II errors are identical, which may not be the case. For example, sometimes the cost of killing a promising project may not be as high as the cost of a high profile failure (i.e., betting the company).

Finally, given the levels of persistent uncertainty associated with knowledge, managers face a daunting political task. On the most basic level, financial options cannot vote on whether they should be exercised, whereas purchasing an option on a core competence creates a constituency that will advocate further investment as well as the possibility of institutionalized opposition. In this context, managers may find it exceedingly difficult to make rational exercise decisions.
REFERENCES


<table>
<thead>
<tr>
<th>Parameter/aspect</th>
<th>Financial Call Option</th>
<th>Real Option on Core Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time frame for making exercise decision</td>
<td>Date is specified ex ante for European options. Binding expiration date, with flexibility in exercising prior to this, for American options.</td>
<td>Unspecified expiration date allows managers to postpone the exercise decision.</td>
</tr>
<tr>
<td>Exercise price</td>
<td>Binding price is specified ex ante and does not change over time.</td>
<td>Price may even be unknown at exercise; may increase over time for isolated options.</td>
</tr>
<tr>
<td>Disposal cost for killing option</td>
<td>Virtually no cost for allowing the option to expire</td>
<td>Disposal cost is unspecified and hard to quantify; increases over time for integrated options.</td>
</tr>
<tr>
<td>Persistent uncertainty about value of full-scale commitment</td>
<td>Uncertainty dissipates fully with the passage of time (downside risk can be minimized)</td>
<td>Some uncertainty persists over time (downside risk remains at exercise decision)</td>
</tr>
<tr>
<td>Asset’s integration/isolation at exercise decision</td>
<td>Independent or part of a portfolio of options with limited interrelationships.</td>
<td>Complementarities determine value – integration is essential to understanding asset value.</td>
</tr>
</tbody>
</table>
FIGURE 1
Dilemmas When Exercising Options on Core Competencies

<table>
<thead>
<tr>
<th>Persistent Uncertainty at Exercise</th>
<th>Integration/Isolation Prior to the Exercise Decision</th>
<th>Isolated</th>
<th>Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>I. Unexpectedly high exercise price</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The investment’s efficacy is clear, but the exercise price creeps up as routines diverge due to isolation making the assets incompatible. The exercise price cannot be predicted ex ante.</td>
<td></td>
<td>(P5)</td>
</tr>
<tr>
<td>High</td>
<td>II. Unexpectedly high disposal cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The disposal cost (extraction, etc.) creeps up over time with integration; rational exercise decision but it might be best not to have invested at all. Disposal costs cannot be predicted ex ante.</td>
<td></td>
<td>(P3)</td>
</tr>
<tr>
<td></td>
<td>III. Risk of “killing the golden goose”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A bias against continued investment due to persistent uncertainty and isolation. It is easy to kill a sound project that lacks widespread support (unit managers have low social capital).</td>
<td></td>
<td>(P6)</td>
</tr>
<tr>
<td></td>
<td>IV. Risk of over-investment/escalation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A bias toward continued investment due to: 1) strong pressure to invest further as managers apply social capital; and 2) no consistent evidence to stop investing. This is a likely hazard for strategic assets.</td>
<td></td>
<td>(P4, P7)</td>
</tr>
</tbody>
</table>

(P) indicates references.
FIGURE 2
Competing Risks of Type I and Type II Errors

Risk of Error

Risk of Type I Errors (Over-investment)

Isolation of investment

Certainty about value of a full commitment

Risk of Type II Errors ("Kill the golden goose")