KRANNERT GRADUATE SCHOOL
OF MANAGEMENT

Purdue University
West Lafayette, Indiana

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by

Kent D. Miller
Timothy B. Folta

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Kent D. Miller

Krannert Graduate School of Management
Purdue University
1310 Krannert Building
West Lafayette, IN 47907-1310
Tel: (765) 494-5903
E-mail: kmiller@mgmt.purdue.edu

Timothy B. Folta

Krannert Graduate School of Management
Purdue University
1310 Krannert Building
West Lafayette, IN 47907-1310
Tel: (765) 494-9252
E-mail: foltat@mgmt.purdue.edu

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Emphasis on first-mover advantages has led strategic management researchers to advocate speed as a key to competitiveness. By contrast, real option theory emphasizes the value of waiting when considering sunk investments under uncertainty. We revisit the strategy question of market entry timing in light of theoretical advances in real option theory. The potential for real option purchases to enhance firm value arises from market imperfections. Unlike financial option pricing theory, we allow for time-varying option valuation parameters. These time-varying parameters have implications for initial option purchase decisions as well as subsequent exercise timing. Recognizing the option value associated with maintaining strategic flexibility sets a higher threshold for exercising options than conventional analyses of investment timing might suggest. Optimal timing for exercising real options depends on current dividends, the possibility of preemption, and whether the option is proprietary or shared, simple or compound. A final section elaborates the implications of real option theory for strategy practice and research.

In recent years, strategy theorist have shifted from static to dynamic explanations for competitive advantages (e.g., Porter, 1991; Teece, Pisano, & Shuen, 1997). Evolutionary and resource-based perspectives have combined to explained competitive advantages as the product of path dependence and on-going competitive interactions among firms. In contrast with previous theoretical arguments emphasizing industry structural barriers and static positioning vis-à-vis competitors, dynamic theories emphasize the roles of speed and organizational learning. Whether viewed in operational terms (such as cycle-time reduction) or strategic terms (e.g., rates of new product introduction), speed has been widely touted as a key to competitive advantage (e.g., D'Aveni, 1994; Eisenhardt, 1989; Stalk, 1988).

Although speed may, indeed, be a critical factor in gaining and sustaining competitive advantages, it is but one response to the broader strategy issue of timing. The American Heritage Dictionary defines timing as "the art or operation of regulating occurrence, pace, or coordination to achieve the most desirable effects...." Sometimes speed produces the most desirable effects. Sometimes, it does not.

The normative emphasis on speed is reasonable when first-mover advantages are expected. First-mover advantages occur when an initial entrant benefits from cost or revenue advantages unavailable to subsequent entrants (Lieberman & Montgomery, 1988).[1] By contrast, some industries may be characterized by cost structures that favor later entrants over first-movers (Grenadier & Weiss, 1997). In such industries, product-market development by the first-mover lowers costs for subsequent entrants. Such markets are readily contestable.

Largely overlooked in current treatments of entry timing in the strategy literature is the value of waiting under uncertainty. Even when first-mover advantages are achievable, the loss of flexibility associated with committing early constitutes an opportunity cost that should factor into entry timing decisions. This opportunity cost has received attention in recent theoretical advances applying option theory to evaluate the value of waiting. Research on real options examines a broad range of investment decisions characterized by sunk costs under uncertainty (Dixit & Pindyck, 1994). A fundamental conclusion from this research is that deferring sunk commitments may enhance the value of investments. If the value of waiting exceeds the benefits from moving quickly, delaying entry enhances firm value. Real option theory provides a framework for evaluating the value of waiting. Recent work in this stream of research has begun to incorporate game-theoretic assumptions about preemptive rivalry and derive implications for investment timing (e.g., McGahan, 1993; Smit & Ankum, 1993).

The core issue addressed in this article is the tension between moving quickly and waiting in the timing of strategic commitments under uncertainty. The next section addresses the rationale for purchasing real options as part of a sequential market entry strategy. We present option-theoretic arguments for the value of waiting and address the rationale for limited initial "foothold" investments (as opposed to immediate full commitment to new markets). The subsequent section deals with considerations surrounding the timing for exercising market entry options. The value of waiting to exercise real options depends on forgone dividends, whether options are shared or proprietary, and opportunities to preempt competitors (or the threat of being preempted by them). Options on other real options—compound options—raise another set of issues addressed in that section. The article's final section elaborates the implications of option theoretic considerations in the timing of strategic commitments for strategy practice and research.

Our perspective is that real option theory complements and broadens the decision criteria elaborated in existing strategy treatments of entry timing. Allowing for some modification of the assumptions underlying financial option theory, we argue that option theoretic reasoning has important implications for strategic thinking. In taking this position, we follow a handful of researchers in finance (Myers, 1984; Kester, 1984; 1993; Trigeorgis, 1996: ch. 8) and strategic management (Bowman & Hurry, 1993; McGrath, 1997; Sanchez, 1993) who have expressed optimism about option theory as a link between the two fields of research. Developing this link requires careful evaluation of the assumptions underlying option theory and integration with theoretical perspectives from strategy research. This study undertakes such an integration, focusing on the implications of real option theory for timing product and geographic market entries.

Throughout the article, we seek to make explicit previously unstated assumptions underlying the potential for real call options to contribute to firm value. These arguments focus on heterogeneities among firms and imperfections in real options markets. Such considerations—common to strategy research—have not received sufficient consideration in real options research emerging from the field of finance.

OPTION PURCHASES

Value of Waiting

A wide range of strategic investments and operating decisions can be characterized as real options.[2] Broadly categorized, options confer either the right to acquire assets (calls) or divest assets (puts) in the future. In this paper, we focus on entry decisions and therefore real call options.

Call option purchases reflect an initial commitment granting the right, but not the obligation, to enter a product or geographic market at some future time. To be valuable, a call option must offer the prospect of an exercise price that is lower than the prevailing price a firm would face without holding the option. By making an initial investment, the option buyer obtains a right to the resources necessary to compete in the market, but defers any further commitment until some future time. In this sense, call option purchases provide "foothold" or "platform" investments in emerging technologies and markets (Kogut & Kulatilaka, 1994). The subsequent decision to exercise an option involves striking the option by making the sunk investments necessary for full market entry.

The value of options derives from managerial discretion regarding whether and when to exercise them. When the value of market entry depends on uncertain contingencies, the prerogative to wait offers the opportunity to see whether key contingencies prove favorable. After purchasing an option, management's discretion to defer or completely forego further investment introduces an asymmetry in the probability distribution of future cash flows. If unfavorable states of the world arise, management will choose not to exercise their option. The discretion to avoid further investment if unfavorable states prevail, allows management to limit their downside risk. The potential for loss avoidance is the basis for positive valuations of options. Kensinger (1987) showed that waiting for the resolution of uncertainties can greatly enhance the value of investments relative to static go/no-go decisions that do not allow for timing considerations.

The real options perspective emphasizes managerial foresight and activism. Managers must consider the value of resources if currently deployed, and possible values assuming future deployment under alternative scenarios. Such decisions can be viewed as multiperiod contingent claims analyses with managerial discretion to adjust strategies over time (Kester, 1993). Managers add value to the organization by timing the deployment of resources, as well as through subsequent decisions to shut-down, restart, or expand projects. As such, managers contribute to organizational competitiveness not only through initial capital budgeting decisions but also through on-going operating and strategic decisions affecting the deployment of existing resources.

Because option valuation recognizes that the active role of management over time adds value to organizations, option valuation diverges from the most widely used approach to investment valuation—net present value. The traditional net present value criterion ignores managerial discretion by assuming investment decisions must be fixed in the current period and not allowing for future revisions of these commitments (Kulatilaka & Marcus, 1992). This assumption renders all decisions go/no-go in the current period rather than leaving open the possibility to wait. As such, NPV analysis restricts the value-added of management to one-time decisions rather than on-going interventions (Kensinger, 1987; Trigeorgis & Mason, 1987).

Market Imperfections

The possibility of avoiding losses is a common source of value for both financial and real options. However, to state that options are valuable, does not necessarily mean that option purchases confer any net value to a firm. The potential for adding value depends on the values of options relative to their purchase prices. If option markets are efficient, the potential for upside gains and avoiding losses on the underlying asset are factored into the prevailing option purchase prices. The equilibrium option price reflects risk-neutral valuation, rather than individual risk preferences (Cox, Ross, & Rubinstein, 1979; Trigeorgis & Mason, 1987). The implication of efficient option markets is that purchases of real options have no ex ante net effect on firm value. This line of argumentation leads to rejecting the use of options to manage corporate risk.

Two considerations challenge the argument that real option acquisitions cannot add value. First, firms are heterogeneous and the distinct resources they bring to option transactions may create unique firm-specific value. Second, unlike financial options, which trade in liquid and relatively efficient markets, real option markets are imperfect and incomplete. Each of these points deserves further elaboration.

A critical—but generally unacknowledged—assumption justifying option transactions is heterogeneity among market participants. Differential valuations of real options across firms reflects the potential for competitive advantages based on resource heterogeneity, information asymmetry, differences in absorptive capacity, and factor market imperfections. The existence of valuable real options presumes some adjustment costs, market power, or other imperfections in the marketplace (Myers, 1977). There are no value-enhancing option investment opportunities if product and factor markets are perfectly competitive and in continuous, long-run equilibrium.

Not only do resource heterogeneities across firms lead to different potential gains from option investments, they may also result in differential advantages from loss avoidance. Losses are costly to the extent that organizational stakeholders require compensation for bearing downside risk (Miller, 1998). When stakeholders are poorly diversified and highly exposed to downturns in a firm's performance, loss avoidance may be critical to reducing costs. Resource heterogeneity implies differential benefits across firms from loss avoidance.

Real options may be idiosyncratic, having little or no net value to another firm. This occurs if real options are embedded in organizations in such a way as to make them inseparable from other firm-specific resources. Learning-by-doing may generate such options. The accessibility of real options is a function of past experience with related resources and options. Hence, just as Arthur (1989) indicated for resources themselves, the firm-specific valuations of real options on resources are path dependent.

Even if real options are not firm-specific, they may be traded in thin and imperfect secondary markets. In this regard, Kester (1984) observed that most real options are nontradeable. Asymmetric information regarding available options creates a "lemons" problem (Akerlof, 1970) resulting in inefficient and incomplete markets. As such, real options' liquidation values are generally less than their values as part of going concerns.

The simplifying assumptions associated with financial option pricing theory (Black, 1989; Black & Scholes, 1973) make questions regarding the timing for purchasing and exercising financial options uninteresting. Assuming the markets for financial options are efficient, the timing of option purchases is irrelevant. No prospective buyer has access to unique information allowing advantageous timing of option trades. Similarly, under the standard assumptions of financial option theory, optimal timing for exercising options becomes straightforward. When the value of the underlying asset is the only time-varying parameter and the asset pays no dividends, Merton (1973) showed that it is optimal to wait until the option expiration date to exercise an American call option. The value of an option is always nonnegative and exceeds the value of exercising the option and holding the underlying asset itself. Hence, the assumptions underlying financial option theory render timing irrelevant when purchasing options and straightforward when exercising options.

If the timing of real option purchase and exercise decisions is to confer any competitive advantage, it must be that certain critical assumptions in financial option pricing theory do not apply. Assumptions about the stability across time of option pricing parameters must be relaxed. Asymmetric information about parameter values must be introduced. The values of certain option pricing parameters may be unknown and the uncertainty surrounding their values may only be resolved over time. For example, whereas financial options have prespecified exercise prices and time horizons, these option parameters are generally not known for real options. Some real option parameters may be exogenously determined, while others may be subject to managerial control. Markets for real options are inefficient and incomplete. The time-varying nature of real option parameters, coupled with the heterogeneities across firms, make real option purchase and exercise timing decisions relevant to competitive advantage.

Purchase Timing

A firm considering entry into a new market faces three alternatives: (1) directly purchasing the resources necessary for entry, (2) not purchasing those resources, or (3) buying an option to acquire the resources necessary for entry at some future time. Conventional analysis considers just the first two of these alternatives. Let P_R represent the cost of acquiring the resources necessary for entry. The resource value, R, is the current value of immediate entry.[3] The conventional valuation criterion indicates a resource should be acquired if its net present value is positive. Framing the investment decision as a dichotomous choice between resource acquisition or no investment, the value-maximizing decision rule would be to undertake the investment if resource value exceeds the acquisition price (i.e., $R-P_R > 0$).

The third alternative—unconsidered in conventional analysis—is to purchase a call option on the resources needed for market entry. Designate the call option value C, and the option purchase price P_C. As specified, there are three possible decision outcomes at any point in time. A call option should be purchased if its net value exceeds that of the resource and is positive (i.e., $C-P_C > R-P_R$ and $C-P_C > 0$).[4] If, however, the net value of the resource is positive and exceeds that of the call option (i.e., $R-P_R > C-P_C$ and $R-P_R > 0$), then direct resource acquisition maximizes firm value. In this case, no intermediate step of purchasing an option is warranted. Failing both the conditions for option purchase and direct resource acquisition (i.e., $P_C > C$ and $P_R > R$), the firm will not engage in either investment toward product market entry. The firm may, however, continue to monitor these parameters to determine if investment is warranted at some future time.

Kulatilaka and Perotti (1998) considered the potential for competitive advantage through purchasing real options. In their model, a firm that buys a real call option experiences a lower average cost (relative to firms with no option investment) after it exercises its option. This cost differential discourages entry by those who did not previously purchase options. As a result, the firm faces a more attractive payoff function because of its early foothold investment than in the absence of such investment.[5]

Unlike financial options, real option purchases may involve a series of investments over time rather than a single purchase decision. Holding real options may require on-going maintenance costs (Garud & Nayyar, 1994). Organizations cannot costlessly place real investment opportunities "on-the-shelf," as they may decay or require upgrading as a result of rivals' innovations. Hence, the option purchase price may not be a simple one-time payment, P_C, but an initial investment followed by a series of on-going option maintenance expenses. It may be tempting to take the present value of these payments and use this augmented purchase price to determine whether and when to initially purchase the call option. Such an approach would be incorrect because it overlooks the discretionary nature of future option holding costs.[6] The appropriate approach is to factor option maintenance costs into valuing the call option itself. This can be viewed as a multiperiod contingent claims analysis where payoffs are reduced by the amount of the option maintenance cost in each period in which the option remains unexercised.[7] Exercising the call allows the firm to avoid future option maintenance costs.

Having clarified the rationale for acquiring real call options and the timing for doing so, we now turn to the subsequent stage in the sequential investment process—exercising options.

EXERCISE TIMING

A firm that has already purchased an option faces a dichotomous choice. Upon acquiring the option, its purchase price (P_C) became a sunk cost. At any point in time, the option can be exercised at a net value of R-X, where X is the option exercise price. At the time of expiration the value of the option is max(R-X,0). The option will remain unexercised if the value of the underlying resource does not exceed the exercise price.

In order to adequately adapt option theory to the realm of real investments, other critical issues should be considered in the option exercise decision. The first of these considerations—current dividends—has been considered in the financial options literature because holding some options involves forgoing dividends paid on the underlying assets (usually equities). Proprietariness and the potential to enhance asset value by preempting competitors are aspects of real options not shared by financial options. Finally, we consider the problem of exercise timing when options have other options as their underlying assets (i.e., compound options).

Current Dividends

Merton's (1973) proof that it is optimal not to exercise an American option prior to its expiration date is an important benchmark. Whereas strategy research emphasizing speed places the burden of proof on those who would advocate waiting prior to market entry, Merton's conclusion shifts the burden of proof to those advocating current sunk commitments. Waiting is the optimal course unless some compelling counterargument can be made. The value of holding an option should never fall below the value associated with exercising the option (i.e., $C \geq R\text{-}X$). Violations of this condition present an arbitrage opportunity.

Merton's proof considered the simple case of a call option on an asset paying no dividends. If we make the alternative assumption that holding the option requires forgoing current positive cash flows associated with the underlying asset, then the conclusion that waiting is always preferable to exercising the option no longer holds universally. In the case of entry decisions, holding an option to enter precludes enjoying the cash inflows from immediate entry. Trigeorgis (1991) pointed out that intermediate cash flows may prompt early exercise of real options.

Let D designate the discounted present value of the foregone sales (i.e., dividends) over the remaining duration of the option. R_T stands for the discounted resource value at the time of option expiration (T).[8] The optimal time to exercise the option is when the present value of $V = R_T - X + D - C$, reaches a maximum.[9] Subtracting the value of the call option, C, acknowledges the opportunity cost associated with striking the option.

The value function, V, could take a variety of paths over time. If we make the simplifying assumption that the value function, V, is strictly concave, there is a unique solution to the optimal exercise timing problem. This occurs when the rate of appreciation of the value function equals the risk-free interest rate ($dV/dt=r$).[10] Figure 1 illustrates this case. The optimal time to exercise the option is at t*, providing value V*.

Insert Figure 1 about here

If V is strictly concave and $dV/dt > r$ at all points prior to the expiration date (T), then optimal value is achieved by waiting until the expiration date to exercise the call option. It would also be optimal to wait until the expiration date if V is convex. The option would not be exercised prior to expiration if V remained nonpositive, because the value of a call option always has a lower bound of zero. If forgone current cash flows (D) are nonpositive, waiting is the optimal choice. When current period dividends become positive and $D > 0$, then it becomes relevant to consider exercising the option prior to its expiration date.

This decision rule incorporating consideration of current dividend payouts deviates from standard net present value analysis in several ways. First, as noted earlier, the conventional NPV decision rule would evaluate the option exercise decision at a point in time, rather than consider the dynamic problem of timing. A more sophisticated—but still inadequate—application of the NPV rule would consider the full option duration time horizon and invest in the period that maximizes NPV. Second, NPV analysis overlooks the option value associated with the resource itself. If we designate the conventional NPV of a resource at the end of the option time horizon as R_T', the conventional NPV approach considers $V' = D - X + R_T'$ at t. V′ sums the NPV of cash flows (D-X) during the option time horizon and the NPV associated with the deployed resources beyond the option time horizon (R_T'). The decision rule is to invest if this value is positive. Third, NPV overlooks the option value of waiting (C). The aggregate difference between the valuation incorporating option value and the NPV approach (V-V′) is the value of the option to wait plus the option premium associated with the resource itself (i.e., $C+R_T-R'$). Because option value is strictly non-negative, the expanded investment decision rule encompassing option value is always at least as stringent as the NPV decision rule (i.e., $V \geq V'$). Hence, even a multiperiod "dynamic" application of the standard NPV analysis may lead to premature investment relative to a decision rule explicitly incorporating option value.

Proprietariness

Kester (1984; 1993) highlighted the contrasting nature of financial options, which are proprietary, and real options, which are often shared. Proprietariness refers to the degree of exclusivity of a holder's claim to an option. "Shared real options can be seen as jointly held opportunities of a number of competing firms or of a whole industry, and can be exercised by any one of their collective owners" (Trigeorgis, 1996: 143). Strategic alliances may produce shared options on future business opportunities. When we speak of shared options, there is an implicit notion that some firms have inside positions relative to outsiders who hold no option claim. Hence, even shared options have some degree of exclusivity—but it is exclusivity in terms of a set of firms. Privileged access to information and defined property rights limit the set of firms sharing a real option.

Of interest to strategists is whether shared real options confer competitive advantages. A shared option is a local public good, equally available to all who share joint ownership. A shared option has the potential to add value to the set of owners vis-à-vis outsiders but cannot be readily appropriated by any single firm to gain a competitive advantage. Consider the growth option associated with technology shared among firms in an industry. Acting collectively, the joint owners of the option could follow the optimal timing guidelines derived earlier to maximize the value of the technology for the collective. They could exercise the option when the collective value function—equal to the sum of the individual firms' valuation functions—reaches its maximum. However, divergent interests among industry rivals would speed up exercising the option relative to the optimal timing under collusion. Competitive firms, seeking to optimize the values of their own holdings, incorporate expectations about preemptive moves by other firms into exercise timing decisions. If firms are homogeneous, competition results in exercising options as soon as the present value of expected cash flows exceeds the call option value, i.e., $R_{Ti}-X_i+D_I > C_i$ for all firms i. Here, each of the valuation parameters is a function of the interdependent strategic moves of industry rivals. Simultaneous moves to exercise the shared option eliminate rents to the industry.

Because preemptive exercising of shared options reduces potential rents, one of the holders of a shared option may seek to purchase the option rights of the others. Turning a shared option into a proprietary option requires a competitive bidding process similar to those of acquisitions in general. Following Barney (1988), if such bidding processes are efficient, competitive advantages from internalizing shared options should be limited. In fact, if bidders are homogeneous, economic rents to the acquirer are eliminated. The only difference between internalizing a shared option and acquisitions in general is that in the case of shared options there is a set of bidders with inside information about the acquisition candidate. This limits the set of potential bidders for shared options.

An alternative approach to assigning proprietary rights to shared options is buyout options among firms sharing options. Partner buyout clauses in alliance agreements clarify property rights for shared options, effectively embedding the shared option in a proprietary compound option (i.e., an option on the shared option). Some joint venture partners have taken this approach by defining the terms for partner buyouts in their venture contracts (Kogut, 1991). A necessary condition for partners to enter into such option agreements is that they expect partners' valuations of their stakes in the shared option may diverge at some point in the future (Chi & McGuire, 1996).

Because explicit buyout terms for shared options are rare in partnerships and nonexistent among industry rivals, it is worthwhile considering whether there may, nevertheless, exist implicit buyout options among partners. Hurry, Miller, and Bowman (1992) and Hurry (1993) contend such implicit buyout options exist and have strategic implications; that is, they can confer competitive advantages. However, in the absence of explicit buyout terms, the exercise price and duration are determined endogenously by the firms holding the shared option. As before, if those sharing the option are homogenous, no implicit buyout option can be said to exist. The exercise price at which any given firm is willing to give up its right to the shared option is the same across all firms. Thus, the claim that implicit buyout options exist among firms holding shared options can only be valid in the context of heterogeneous firms. Heterogeneities may arise from differences across firms in resources or absorptive capacities resulting in unequal potentials to leverage new resources.

Among heterogeneous firms sharing an option, the firm willing to outbid all other option holders possesses a buyout option. Such a firm must have inside information or complementary resources that cause it to assign a value to the shared option that exceeds the value to other bidders. Because the valuation of the shared option by other option holders varies over time, the high bidder faces a moving exercise price for making the option proprietary. Let C_C and X_C designate the buyout option value and the exercise price for the first stage of the compound option. C is the value of the call option when converted from shared to proprietary. The optimal timing for buying out the other option holders is when rate of appreciation of the function $C-X_C-C_C$ equals the risk-free interest rate (and $C-X_C-C_C > 0$).[11] Once a buyout has taken place, the optimal timing problem reverts to that of a proprietary simple option.

In this section, we considered three strategies firms may consider when seeking to capture economic value from shared options: (1) early exercise to preempt the exercise decisions of other option holders, (2) converting the option from shared to proprietary by buying out the other option holders, and (3) holding an implicit buyout option. Our evaluation indicates limited potential for adding value through such strategies due to competitive responses and bidding processes among the option claimants. The key insight from this analysis is that firm-specific complementary resources are the source of competitive advantages from shared options. Shared options can be exercised in combination with firm-specific resources to generate competitive advantages. Such is the case when a shared technology is deployed by the option holders in distinct, non-competing product markets. The resulting rents are attributable to firm-specific resources rather than the shared option. Hence, we come back to the resource-based proposition that rents accrue to rare, inimitable resources (Barney, 1991).

Preemption

Kester (1984) recognized that an interesting strategy issue is the optimal timing for exercising real option investments under the threat of competition. Preemption refers to strategic investments by rivals that reduce the value of real options and potential dividend payouts. Alternatively, if your firm moves preemptively into a new market, other firms may be placed at a relative competitive disadvantage. Rivals may act preemptively in ways that increase the cost of subsequent entry (i.e., increase the exercise price) or preclude further investment, causing other firms' call options to expire. If managers are able to predict such investments by rivals, they can choose whether to exercise an option in anticipation of rivals' actions. The decision rule for optimal timing of exercising options remains the same as that derived earlier for dividend paying assets, namely, maximize the present value of $V = R_T - X + D - C$. Any or all of the components of the value function may changes due to rivals' investments.

Smit and Ankum (1993) considered the valuation of real options under alternative assumptions regarding market structure. A call option on a monopoly position is analogous to a call on a stock with a constant dividend payout ratio. Under competition, the dividend payout erodes as rivals enter the market. Optimal timing calls for waiting until just prior to a rival's investment to exercise the option. This timing keeps the option "alive" for the longest possible time, yet avoids losing the dividend and call option reductions associated with rivalrous entry. Because the entries of various rivals will have differential effects on project value, it makes sense to key timing decisions to the entries of those firms that will have the greatest impact on total project value.

Trigeorgis highlighted key assumptions to derive optimal timing rules under the threat of preemptive entry by rivals: "...option-based analysis suggests that management may be justified in investing relatively early when (a) the anticipated competitive loss is large and can be preempted; (b) anticipated competitive entry is more frequent; (c) project uncertainty is lower; or (d) the anticipated competitive loss preempted exceeds the option value of waiting sacrificed by early investment" (1991: 153). These guidelines are wholly consistent with our investment timing decision rule, maximize the present value of the value function (V).

The key to optimizing firm value when faced with rivalry is to make inimitable option investments. McGahan (1993) pointed out that small initial investments in emerging technologies may allow privileged access to data regarding the feasibility of commercialization. The information advantage accruing to the foothold investor may deter others from preemptively committing to the market. The follower is relegated to waiting for a signal from the information-advantaged firm before making an investment decision. In the meantime, the insider can act as an industry leader and optimize its choice of timing and initial capacity. In the absence of a unique proprietary position conferring industry leadership, this discussion points to the importance of monitoring competitors' product development in timing product releases.

Up to this point, our analysis has been based on the assumption that individual firms time entry investments in ways that maximize firm value. It may also be insightful to consider two alternative decision rules: (1) entry timed to maximize own-firm value relative to that of a rival firm and (2) collusion to maximize total industry value. To illustrate the implications of maximizing relative value, consider a firm i that seeks to maximize total project value relative to rival firm j. Firm i's valuation function is as before, $V_i = R_{Ti}+D_i-X_i-C_i$, and that of firm j is similar. Firm i seeks to maximize $V_i - V_j$. If we assume that the two firms face equivalent resource values at the option expiration date and also face the same exercise prices (i.e., $R_{Ti}=R_{Tj}$ and $X_i=X_j$ in each period t), then the objective function simplifies to $\max[(D_i-D_j) - (C_i-C_j)]$. That firms would seek to time entry based on their current dividends relative to those of rivals is not novel. What is unique to this formulation is the incorporation of own-firm and rival's option values. Under this decision rule, early exercising of an option may occur in order to reduce rivals' option values. This is an intriguing motivation for preemptive investment that has not been explored previously.

Firms that do not hold options and have no intention of entering a market may, nevertheless, signal their intent to enter as a way to force premature exercising of options by rivals. Although such signaling does not directly enhance own-firm value, competitors lose option value. Hence, signaling the intent to preemptively enter enhances relative competitive position by reducing the value of competitors' options to wait.

If firm i sought to maximize its relative value at some time period t, firm j may be willing to buy out firm i's option if its optimal timing at some future period t^+ would result in greater value than firm i's investment in t. That is, if $\{[D_i(t)-D_j(t)] - [C_i(t)-C_j(t)]\}$ is less than the present value at t of $\{[D_j(t^+)-D_i(t^+)] - [C_j(t^+)-C_i(t^+)]\}$, then firm j would be willing to pay firm i up to the difference between these values to induce it not to preemptively exercise its option at t. If this increase in value is greater than the loss of relative value to j between t and t^+, there would be a mutually-beneficial trading opportunity to delay exercising options until t^+.

Alternatively, if firms sought to maximize the collective value of their holdings, the optimal timing maximizes the present value of $\Sigma_i V_i$ over all firms $i = 1,\ldots,n$. This objective assumes firms coordinate the timing of entry to maximize the collective value of the new opportunity for all industry players. If we make the simplifying assumption that resource values at the end of the option term, R_{Ti}, are fixed and exercise prices, X_i, appreciate at a rate equal to the risk-free rate, the critical issue becomes the tradeoff between aggregate current dividends and option value. Compared with a competitive environment in which the first firm to reach their maximum individual value (D_i-C_i) would determine the entry time for all investors, a collusive arrangement delays entry.

Hence, option theory motivates analysis of delayed entry as collusion to optimize aggregate value, including option value. From a social welfare perspective, rates of innovation may be suboptimal in the absence of preemptive threats. Although there may be positive welfare effects associated with alliances for developing industry standards, such alliances may also result in delayed adoptions of new technologies when collective option value motivates investment timing.

Compound Options

In contrast with the simple options considered up to this point, most options of interest to strategists involve complex series of interdependent investment decisions. These investments can be viewed as compound options. Often investments in new products and markets are of this sort. Initial foothold investments confer privileged access to information and opportunities for future investments. These investments may take the form of further product development stages or investments for product commercialization. The term "compound option" distinguishes such multistage investments from "simple options" on rent-generating resources. Portraying multistage investments as options within options is a way to conceptualize the interdependencies associated with strategic decisions regarding path-dependent resources.

For example, Kim and Kogut (1996) addressed situations in which entry into one technological subfield (semiconductors) provides a platform into another subfield. In their model, firms must follow a specific sequence of investments in order to gain access to future growth opportunities. Firms lacking these platforms fail in their attempts to enter new subfields.

Because the underlying asset associated with a compound option is itself an option, valuing compound options is a challenging problem. The value of a compound option is, in part, a function of the value of the embedded option. Holding other relevant variables constant, we can represent the value of a two-stage compound call option as $C = f(G)$, where the value of the first-stage option (C) is an increasing function of the value (G) of an embedded option. We use the notation G to indicate a common type of embedded option, namely, a growth option; however, G could be interpreted as any type of real option.[12]

If the exercise price is fixed, an option on an option is always at least as valuable as exercising the option and holding the underlying simple option.[13] If the exercise price is not fixed, an option on an option is still more valuable than exercising the option and holding the simple option if movements in the exercise price do not fully reflect movements in the value of the embedded option, i.e., when $X_C = \alpha G$ where $\alpha < 1$. If $\alpha = 1$, management would be indifferent between holding the compound option and the simple option. If $\alpha > 1$, management would prefer to exercise the first-stage option and hold underlying option. At each successive stage of a compound option, exercising the option escalates the firm's sunk investment. Hence, as a general rule, firms will seek to maintain the greater flexibility associated with holding compound options rather than exercising their options and holding the embedded options.

If maintaining maximum flexibility is optimal, why do we observe firms willingly making successive investments in uncertain technologies and markets? We argued earlier that for a simple option, exercise timing is accelerated by potential current cash flows (similar to options on dividend-paying stocks) and value-added from preemption. Forgone cash flows are not a relevant consideration if exercising an option simply leads to holding a non-dividend-paying embedded option. On the other hand, preempting rivals may enhance option value and, as such, be a very relevant motivation for exercising compound options, even under uncertainty (Kulatilaka & Perotti, 1998). Preemptively exercising an option may lock in access to scarce information or resources. Consider, for example, the willingness of firms to invest in uncertain developing country markets when early commitment confers privileged investment terms relative to later entrants.

The notion of locking in privileged access to information indicates another sense in which real options differ from financial options. The uncertainty surrounding financial options is exogenously determined rather than subject to control by the option holder. By contrast, managers often perceive themselves as controlling key variables determining the riskiness of their investments (MacCrimmon & Wehrung, 1986; March & Shapira, 1987). To the extent that uncertainty is controllable, managers will accelerate their multistage investments relative to when uncertainty is beyond managerial control (Cukierman, 1980). Roberts and Weitzman (1981) used the terms "endogenous" and "exogenous" to distinguish these two types of uncertainty. Uncertainty is endogenous to the extent it can be reduced through managerial control. Although not derived from an explicitly option-theoretic perspective, Wernerfelt and Karnani (1987) also argued that the ability to influence the resolution of uncertainty accelerates investment under uncertainty.

The implications of exogenous and endogenous uncertainty on commitment decisions are quite different. If the resolution of uncertainty is independent of what the firm does, option value is enhanced, creating an incentive to defer exercising an option. However, if uncertainty can be resolved by investing, firms will accelerate sequential investments. Each investment stage reveals additional information about potential growth opportunities.

Eliminating uncertainty eliminates option value. As such, the elimination of uncertainty holds no inherent value for the firm. The advantage associated with uncertainty reduction lies in the ability to accelerate subsequent stage investments such that the values of embedded options or cash flows increase. Hence, the justification for emphasizing organizational learning is the potential for generating new options and increasing their value through preemption. The "time compression diseconomies" identified by Dierickx and Cool (1989) may be less like learning curve effects and more like compound options, in which successive investments are path-dependent and uncertainty is at least partially subject to managerial control.

DISCUSSION

Real options research asserts the value of waiting when investments involve sunk costs under uncertainty. A key insight from this research is that decisions to move ahead with sunk investments carry the opportunity cost of lost option value. Acknowledging the value of waiting contrasts with the normative emphasis on first- and early-mover advantages in strategy research.

Strategy research generally considers entry decisions as dichotomous choices between direct resource acquisition and not entering. The NPV decision criterion incorporates assumptions consistent with this view. Conventional analysis only considers go/no-go decisions at a single point in time. Real options thinking motivates a third alternative, namely, purchasing an option to enter. Such an entry strategy explicitly recognizes the value of waiting before increasing sunk commitments in an uncertain market.

This study derived decision rules for call option purchase and exercise timing incorporating the tension between speed and waiting. In doing so, we made explicit some critical assumptions regarding the determinants of the time-path of the value of strategic investments. Dividend payouts, proprietariness, preemption, and the presence of embedded options are key determinants of optimal exercise timing. We showed how all of these disparate considerations could be brought together in an optimal decision framework incorporating option value, exercise price, dividends, and resource value at option expiration. Our simple decision rule—maximize the present value of $V = R_T - X + D - C$—encompasses the complexities associated with many investment timing considerations.

Nothing in our treatment of entry timing is inconsistent with managerial decision making based on maximizing shareholder value. Management incentives tied to shareholder wealth creation do not need to be altered. However, project selection and timing based on our valuation function may differ in important ways from decisions based on the static net present value criterion.

Adapting option theory to strategy research required relaxing some core assumptions in finance research. The opening portion of this study argued that market imperfections are essential for enhancing firm value through real option purchases. Although finance research on real options invokes arbitrage arguments to determine real option prices, we drew upon market imperfection arguments from strategy research to motivate deviations in option prices from their values to specific firms. Resource heterogeneities and information asymmetries across firms are critical to creating competitive advantage through real option transactions.

Unlike financial option pricing models, our derivations allow for time-varying option parameters. This relaxation of standard option pricing assumptions, along with allowing for inefficient and incomplete real option markets, motivates timing concerns for strategic investments with call option characteristics. Other distinctions of real options are their nonproprietary nature and susceptibility to preemption. These concerns do not arise for financial options with contractually-specified exercise prices, durations, and exclusive rights.

For simple options, our discussion highlighted the tradeoff between foregone dividends and call option value in determining exercise timing. Incorporating option value sets a higher hurdle value for exercising options relative to the standard NPV decision criterion, which neglects option value considerations. The possibility of capturing current dividends accelerates exercising options. In the absence of current dividends, the potential for partners or rivals to preemptively move into an emerging product market provides the fundamental motivation for exercising options.

For some time real options researchers have acknowledged that many such options are shared rather than proprietary (Kester, 1984). The competitiveness implications of shared options had not been carefully scrutinized prior to this study. Our analysis indicated that as with other public goods, individual firms with ownership interests in a shared option are incented to exercise their holdings prior to what would be optimal for the collective. The race to exercise positions in the shared option eliminates the potential rents that could accrue to the option holders. Buying out the other option holders will only be advantageous if the purchaser has specialized knowledge or complementary resources that add value above and beyond the option value to other holders. Hence, when evaluating the potential for competitive advantages from shared options, we returned to the basic strategy maxim that unique proprietary holdings, not shared holdings, confer advantages.

We were careful to distinguish shared options from buyout options. Although buyout options are sometimes assumed to exist among partners with shared options, we argued that an implicit buyout option can only exist among heterogeneous firms. Furthermore, an implicit buyout option can only have positive value for the firm with the highest value-adding complementary resources. Other partners limit buyout option value through their influence on the option exercise price. To the extent that partners' valuations of shared assets are positively correlated, buyout option valuations decline relative to buyout options with prespecified exercise prices. Thus, application of option theory to partner buyouts requires careful specification of which partner holds the call option. Partner buyout options are more relevant in contexts where explicit contractual agreements limit the exercise prices (Kogut, 1991), partners are heterogeneous (Chi & McGuire, 1996), and there are few partners.

It follows that real options explanations for alliance formation and dissolution (e.g., Hurry, Miller, & Bowman, 1992; Kogut, 1991) may be less compelling than applications of real options in contexts that are proprietary, such as internal R&D. For an internally-developed venture, the firm faces an exercise price that is determined by the technical characteristics of the project itself. By contrast, in the context of alliances, implicit buyout options are exercised at prices that result from bargaining processes involving two or more partners.

Real options research has given increased attention to preemption as a determinant of option purchase and exercise decisions. Previous research has developed fairly sophisticated models integrating game theoretic considerations into option valuation (Kulatilaka & Perotti, 1998; McGahan, 1993; Smit & Ankum, 1993; Trigeorgis, 1991). We showed that a simple decision rule, maximizing the present value of $V=R_T+D-X-C$, holds when considering the implications of preemption over time. Whereas previous models stressed deferring investment until just prior to a competitor's entry (e.g., Smit & Ankum, 1993), opportunities for first-mover advantages may incent earlier preemptive moves. Nevertheless, option theory provides an explanation for why we may observe nearly simultaneous entry moves even when the resources necessary to enter have been available for some time.

We showed that firms seeking to maximize their own value relative to competitors may do so by forcing competitors to exercise options prematurely. Entry or simply the credible threat to enter may be sufficient to cause rivals' to exercise their options, thereby forfeiting option value. This is a novel explanation for signaled intended entries that are never completed. Of particular interest in this regard would be instances when intentions to enter through greenfield investment are signaled to competitors and then not implemented, or when unsuccessful bids are made for acquisition candidates resulting in takeovers of the candidates by other acquirers.

Another intriguing idea is the possibility that delayed entry may evidence collusion to optimize collective option value. The social welfare and antitrust implications of such "collusion to delay" merit further study.

A corollary following from Merton's (1973) analysis of simple options is that a compound option is always worth at least as much as exercising the first-stage option and holding the embedded option. This observation raises the question: why do we observe races to make multistage investments? Is this blatant disregard for option value? We argued that it is not. Rather, value enhancement through learning and preemption in multistage investments overshadow the loss of option value with each successive investment.

For first- or early-movers enhanced option value arises from preemptive advances through path-dependent sequential investments. Early movers may control both the uncertainty they face (through their capabilities to learn), and the payoffs associated with alternative outcomes (through their abilities to determine industry standards and technological trajectories).

This study specified the decision problem and decision guidelines for managers seeking to incorporate the value of waiting into investment timing decisions. In this regard, the specification of the value function (V) is an important step. However, the simplicity of this function may mask the complexities of the valuation and forecasting problem managers face. Strategy and finance researchers must do more to elaborate guidelines for valuing real options. Although there has been growing interest in this issue[14], most valuation approaches found in the literature invoke unrealistic assumptions from financial options pricing models. In particular, they invoke arbitrage assumptions to value investments that are only truly valuable if they are unique and/or have unique value in combination with firm-specific complementary resources and capabilities. As such, these approaches provide limited guidance to managers seeking to incorporate option value into strategic decisions.

Valuation approaches grounded in contingent claims analysis seem to offer the greatest promise for managerial application. Applying contingent claims analysis to the prospective payoffs from strategic decisions has become more relevant as strategy research has shifted to dynamic analyses incorporating uncertainty. Game theoretic analyses and scenario planning approaches incorporate contingency perspectives to evaluate alternative strategies. Future research could more fully develop the link between option theory and contingent claims analysis for ex ante evaluations of strategy decisions.

In order to narrow the scope of this study, we focused on call options. Subsequent research may examine the timing of put (abandonment or shutdown) options. Robichek and Horne (1967) and Bonini (1977) provided early research on put options to abandon existing projects, and this line of research has more recently been picked up by other real options researchers. Strategy researchers have yet to undertake any systematic theoretical treatment of real put options or empirical research on this topic.

ENDNOTES

[1] Lieberman and Montgomery (1998) recently provided a comprehensive review of research on first-mover advantages.

[2] Hurry (1994), Kulatilaka and Marcus (1988), Sanchez (1993), and Trigeorgis (1996: ch. 1) present overviews of many types of managerial investment decisions involving option value considerations.

[3] Because both resource value and resource purchase price are considered in the current period, we could adopt the notation R(t) and $P_R(t)$ to make the time period explicit. In order to simplify the notation throughout this paper, we do not explicitly write variables as functions of time.

[4] Given the market imperfections associated with real options, it may also be relevant to consider the timing of option purchases. The net value of an option ($C-P_C$) may itself vary over time. If the necessary conditions for purchasing an option hold (i.e., $C-P_C > R-P_R$ and $C-P_C > 0$) and if $C-P_C$ is strictly concave then the optimal time to purchase an option is when $dC/dt-DP_C/dt = r$, where r is the risk-free interest rate.

[5] The real source of advantage in Kulatilaka and Perotti's (1998) model is access to real options. They do not address why some firms would buy the option and others would not.

[6] Majd and Pindyck (1987) recognized that discretionary expenditures can be viewed as options. They explored the timing of sequential irreversible construction outlays.

[7] For more on this issue see Amram and Kulatilaka's (1999: ch. 9) discussion of "leakage" in the valuation of real options.

[8] The appropriate discount rate for determining the present value of D and R_T is the risk-adjusted rate.

[9] The relevant discount rate for computing present values of V is the risk-free rate.

[10] The terms in the first-order condition $dV/dt = dR_T/dt - dX/dt + dD/dt - dC/dt = r$, can be rearranged as $(dR_T/dt - dX/dt + dD/dt) - r = dC/dt$. The left-hand expression indicates the marginal increase in the value of the resources if deployed, less the risk-free rate. The option will be exercised if this is at least equal to the marginal change in call option value.

[11] As before, we assume this is a strictly concave function so that there is either a unique time at which $d(C-X_C-C_C)/dt = r$ or a "corner solution" at the time of expiration of the first stage of the compound option.

[12] Geske (1979) provided solution techniques for deriving the values of two-stage compound options.

[13] This is a logical extension of Merton's (1973) earlier cited conclusion regarding simple options.

[14] Amram and Kulatilaka (1999) provide a helpful overview of existing approaches to real option valuation.

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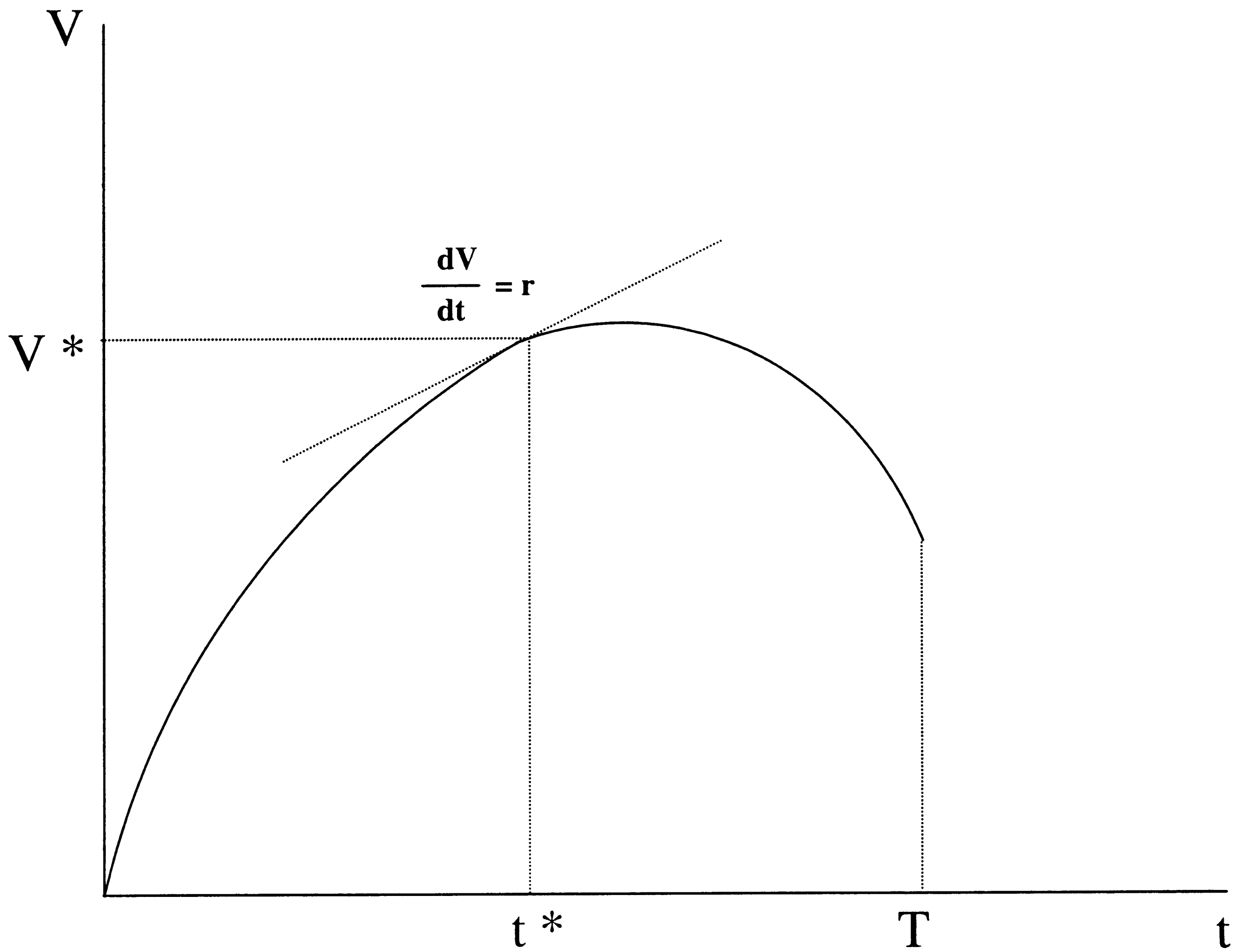
FIGURE 1
Optimal Timing for a Concave Value Function



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