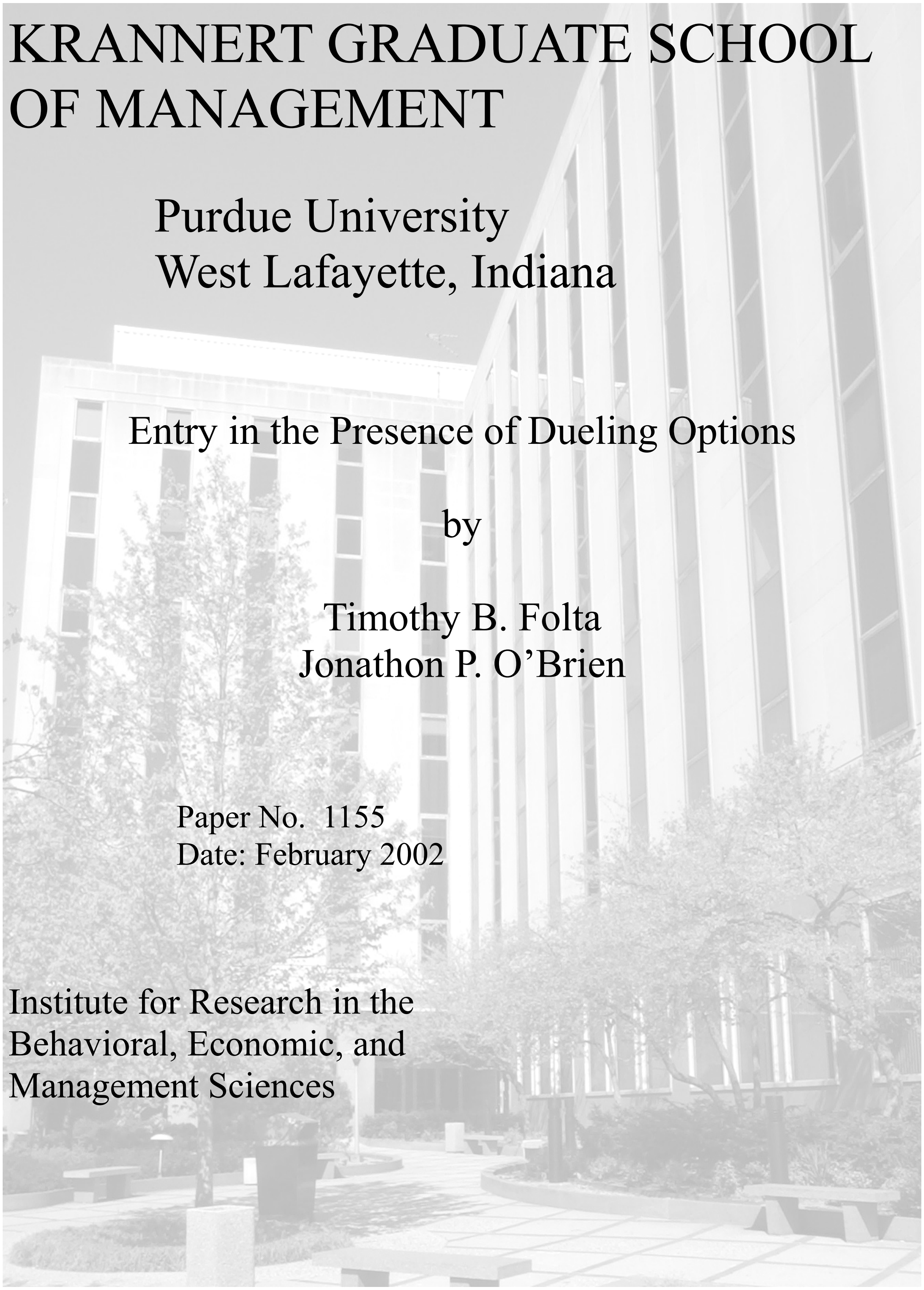

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Entry in the Presence of Dueling Options

by

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ENTRY IN THE PRESENCE OF DUELING OPTIONS

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ENTRY IN THE PRESENCE OF DUELING OPTIONS

ABSTRACT

This paper investigates the influence of industry uncertainty on the decision by established firms to *enter* a new industry. Specifically, we examine the tension between the *option to defer*, which discourages entry in the presence of uncertainty, and the *option to grow*, which may encourage entry in the presence of uncertainty when there are early mover advantages. Empirical analysis on data from a broad array of industries revealed that the effect of uncertainty is not monotonic, and that inflection points are influenced by factors that should theoretically influence the value of the option to grow and the option to defer. (100 words)

Keywords: *uncertainty, growth option, real option, entry, early mover advantages*

The purpose of this paper is to investigate the influence of industry uncertainty on the decision by established firms to *enter* a new industry. Traditional investment theory predicts that a firm will enter a new industry when the net present value (NPV) of the expected cash flows is greater than zero. However, it does not accurately describe the influence of uncertainty on entry because it fails to consider two crucial factors. First, most investments are at least partially irreversible since they cannot be fully recovered and costlessly redeployed in the event of a negative shock. Second, managers can adapt and revise their strategies in response to unexpected market developments that cause cash flows to deviate from their original expectations.[1] In contrast to traditional investment theory, the real options literature has evolved specifically to attend to situations where a prospective investment decision is characterized by significant uncertainty, some degree of irreversibility, and the potential for exercising future managerial discretion (Kogut and Kulatilaka, 2001). Accordingly, this perspective has lead to a significant understanding of optimal investment behavior in the midst of uncertainty.

Even within the real options literature, there remains a debate about the influence of uncertainty on the entry/investment decision. The source of this debate lies in the tension between the *option to defer* and the *option to grow*. Delaying entry allows a firm to "keep its options open", and avoid the opportunity costs associated with making an irreversible investment (McDonald and Siegel, 1986). A fairly rich stream of empirical work, mostly from finance and economics, has offered results consistent with the prediction that

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[1] This flexibility undermines the theoretical foundation of neoclassical investment models and invalidates the net present value rule as traditionally taught. Myers (1984) provides a complete discussion of the inadequacy of discounted cash flow methods in the presence of real options. See Dixit and Pindyck (1994) and Trigeorgis (2000) for a review of research on real options.

managers delay investment with higher uncertainty. The option to grow has received decidedly less attention in theoretical and empirical domains, yet may be of more innate interest to scholars of firm strategy. An initial investment may result in the acquisition of a "capability" that allows the firm to take better advantage of future growth opportunities in the industry. Curiously, a focus on the option to grow may lead to predictions opposite from those discussed above -- as the level of uncertainty about target industries increases, the incentives to enter quickly may also increase if entry opens up opportunities for future strategic investment (Kulatilaka and Perotti 1998). Although there is no theoretical consensus on whether, in the presence of uncertainty, the option to wait or the option to grow dominates, recent work by Kulitilaka and Perotti (1998) suggests that the relative influence of the options will vary at different levels of uncertainty. This is because the deferment option has diminishing returns while the upside of the growth option is not bounded. Therefore, the value of the growth option may surpass the value of the option to defer at extremely high levels of uncertainty. This leads to the possibility that uncertainty may have a non-monotonic effect on entry.

This paper is a first attempt to empirically examine how the options to wait and grow interact to influence the effect of uncertainty on the market entry decision by established firms. We examine how the value of these two options varies across industries, and investigate factors bearing upon their relative sensitivity to uncertainty. While our focus is entry, our results are applicable to all types of investment decisions and have broad implications for understanding how firms choose between expansion and delay in uncertain environments. We develop and test hypotheses using the Compustat II (Business Segment) database, from which we identified over 11,000 instances where firms entered a new industry during the period of 1981 to 1999. We approximate the level of time-varying uncertainty facing each industry in order to assess both the direct effect of uncertainty on entry and factors that may moderate this relationship through their influence on the options to wait and grow.

THEORETICAL BACKGROUND

A *real* option is the right, not the obligation, to take an action (e.g., defer, grow, contract, or abandon) at a predetermined cost, called the exercise price. Research in the real options literature centers around two broad applications of theory. The first seeks to improve existing capital budgeting techniques through the explicit application of options valuation. The second application of real option theory, which we adopt here, focuses on providing additional insight on the determinants of strategic investment behavior relative to theories that (either implicitly or explicitly) assume that investment is determined solely by traditional NPV. The purpose of this second approach is to demonstrate that even if managers do not employ sophisticated option valuation techniques to value opportunities, they may intuitively incorporate option value in decision-making. Specifically, managers may employ a "real options heuristic" (Kogut and Kulatilaka 2001) that gives weight to the managers concerns about industry uncertainty and the irreversibility of the investment. Thus, it is in this vein that we argue that real option analysis can illuminate the determinants of entry and predict the actual behavior of managers.

There has been a concerted effort to study whether insight from real option theory illuminates actual firm behavior. Most of which has focused on the central role that exogenous uncertainty plays in deterring investment. This type of uncertainty is represented by the randomness, or volatility, in the external environment that cannot be altered by the actions of individual firms or managers. It has been represented a number of ways in empirical studies, including volatility in stock market index returns (Pindyck 1986; Episcopos 1995; Folta and Miller 2002), exchange rates (Campa 1993), GDP (Episcopos 1995; Price 1995), inflation (Huizinga 1993), output prices (Huizinga 1993), and demand (Kogut 1991; Guiso and Parigi 1999). The focus on total uncertainty is what distinguishes real options analysis from traditional investment theory, which argues that NPV is influenced only by the systematic component of uncertainty. However, since systematic risk may affect both the expected returns and the discount rate associated with a project, its net effect on investment is predicted to be ambiguous (Holland, Ott and Riddiough, 2000). Thus, evidence that uncertainty has a depressive effect on investment is interpreted as support for the explanatory power of real options theory.[2]

There is relatively strong support that macroeconomic uncertainty discourages economy-wide investment levels (e.g.,Pindyck 1986; Episcopos 1995). However, this relationship is less conclusive when examining firm-level investment behavior, since several studies report the expected negative relationship between uncertainty and firm investment levels (Huizinga 1993; Guiso and Parigi 1999), while others report weakly-negative or no relationship (Campa and Goldberg 1995; Driver, Yip et al. 1996; Leahy and Whited 1996). This ambiguity is curious since real options approaches to investment specifically attend to firm-level trigger points, and thus it is at the firm level of analysis that

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[2] See Carruth, Dickerson, and Henley (2000) for a review of these arguments and the empirical work testing them.

uncertainty should have its greatest impact (Carruth, Dickerson et al. 2000). Rather than focus on how uncertainty influences investment levels, a second group of studies have analyzed how uncertainty influences whether or not investment occurs. This second approach should be more amenable to real option analysis because the theory does not determine the level of investment per se, but rather it identifies factors that may affect the threshold at which investment should occur (Dixit and Pindyck 1994). Closely related to our study, Campa (1993) found that higher degrees of exchange rate uncertainty decreased the likelihood that foreign firms enter the United States wholesale markets. Kogut (1991) found that joint venture partners in manufacturing industries were less likely to buy out their partners when there was more uncertainty. Folta and Miller (2002) found a similar result for equity partnerships between pharmaceutical and biotechnology firms.

In total, these studies indicate that real option analysis, with its focus on uncertainty, is helpful in describing investment patterns. There remain, however, significant opportunities for further study. First, more work is needed to study the extent to which the relationship between uncertainty and the likelihood of discrete investment events holds across a variety of industry contexts. Existing work is confined to specific industry contexts and/or a specific form of entry. Second, there has been an exclusive empirical focus on how uncertainty deters investment. Such a focus inherently ignores that discrete investment events may provide options to grow – the option to make follow-on investments so as to exploit growth opportunities. Myers (1977) suggests that the value of many investments is based primarily on growth options. As will be discussed later, in the presence of growth options there is a possibility that uncertainty has a positive effect on investment. Existing empirical work has unsatisfactorily recognized this possibility, and the conditions that make it possible. Finally, growth options have proven interesting to scholars in strategic management in a number of contexts, such as the acquisition of new firm capabilities (Kogut and Kulatilaka 2001), and patterns of sequential investment in new ventures (Hurry, Miller et al. 1992), industry segments (Kim and Kogut 1996), international markets (Chang 1995); and technology (McGrath 1997). This work has served as an important bridge between finance and strategy, and has illuminated the benefits to sequential investment. It does not, however, empirically consider how uncertainty will influence investment, a central focus of our research.

In the remainder of this paper, we consider two types of real options and examine how entry decisions involve a comparison of both. The first option is waiting to invest, whereby it pays to wait before committing resources. In the second option of expanding operations, investment commitment is necessary in order to have the right to expand in the future. These two options, therefore, exemplify two polar types of real options (Kogut 1991). Whether entry should be undertaken immediately, or delayed until the environment becomes less uncertain, depends on the nature and the size of these two options, which depends critically on uncertainty. In the context of entry, a firm's exposure to uncertainty is determined by a number of factors, including the line of business entered, the cost structure, and the ability to obtain inputs and sell outputs. The options to defer and grow embedded in entry decisions are described in more detail below.

Deciding not to enter at any given time can be equated to a firm holding a call option to enter the market at a later time. By delaying the entry the firm receives an asymmetric payoff distribution: if conditions turn out favorable, entry occurs and the payoff is positive; if conditions turn out to be less favorable, entry does not occur and the payoff is zero. Like financial options, such asymmetric payoffs drive the value of real options. Once irreversible investment occurs, however, the option is "killed" (or exercised) and the possibility of waiting for new information to arrive that might affect the desirability or timing of the expenditure is sacrificed. Thus, investing immediately creates an opportunity cost that must be included as part of the cost of investment.

Most classic examples of the option to defer pertain to when a firm has a monopoly over the investment decision, such as delaying the decision to drill for oil when the future level of oil prices are uncertain (Paddock, Siegel et al. 1988). When the investor has a monopoly over the investment decision, the only cost to waiting is one period's worth of cash flow, because the firm continuously decides whether it should invest or wait until the next period and then decide whether to enter. The following simplified model helps to illuminate the intuition behind the option to defer (notation adapted from Miller and Folta, 2002). Assume a firm is deciding whether to enter a market at time t, or hold the call option on entry for an extra period, t+1. Let R represent the expected discounted resource value of the project at option expiration, and X the exercise price of the option (*i.e.*, the irreversible portion of the cost of entering the industry). Furthermore, let D equal the opportunity cost of investing the current period, which represents an "option premium". CF equal one period's worth of cash flow. The total payoff to entering in the current period, PE_t can be expressed as:

$$(1)\ PE_t = R - X + CF - D,$$

which should be compared to the payoff associated with waiting an extra period to make an entry decision,

$$(2)\ PE_{t+1} = R - X.$$

Providing that $PE_t \geq 0$, then the decision of whether or not to enter in the current period can be characterized by the following decision rule:

(3a) Enter if: $PE_t - PE_{t+1} \geq 0$, alternatively

(3b) Enter if: $CF - D \geq 0$.

Obviously, the larger the benefit from delaying the entry decision, D, the less likely entry will be. Furthermore, as discussed earlier, the size of D will depend critically on the uncertainty in the environment in the current period. The key insight from this model is that *entry is discouraged with greater uncertainty* because D escalates with uncertainty.

In addition to the option to defer, there is a second type of real option that is also embedded in the entry decision. When the firm chooses to enter an industry (*i.e.*, exercise the option to defer), it essentially purchases a *growth option* because entry gives the firm the right, but not the obligation, to expand operations in the future if industry conditions turn out to be favorable. If conditions turn out to be less favorable, these growth options will be allowed to expire unexercised. Like the option to defer, the value of growth options, G, escalates with uncertainty because of the asymmetry in their payoff distribution: their lowest value is zero, if not exercised, while their upper value has virtually no bounds. Thus, even if the forecast payoffs to entry are negligible (or even slightly negative), it may worthwhile to enter the industry if there is a significant potential for the industry conditions to far exceed the *expected* value imputed into the NPV analysis. This potential value of the growth options, G, must be accounted for in the entry calculus in both PE_t and PE_{t+1}.

While the model we have developed thus far is a reasonable representation of situations where the firm has a monopoly over the investment decision, it is an incomplete story of the potential costs to waiting an extra period to enter a competitive marketplace (Lippman and Rumelt, (1985); Dixit, (1989). In such situations, the costs of waiting may increase in the face of potential preemption by rivals (Trigeorgis, 1991). Thus, let us redefine CF to include not just one period's cash flow, but also all additional cash flow that is expected to be lost if entry is delayed.

In addition to the expected lost cash flow, it is also important to recognize that the growth options might be more valuable if entry occurs earlier. This has been the primary focus of the strategy research on entry timing. The value of G may be enhanced by some multiple, α, if there are competitive advantages from moving early (Lieberman and Montgomery, 1998). Entering now may lock in access to scarce information or resources relevant to the next investment stage. Examples of strategic investment leading to future advantages may be research into building a technological advantage, an advertising campaign leading to brand recognition, or essentially any investment that enables investors to gain a head start in developing a set of organizational capabilities that may lower costs or increase revenues relative to later movers (Lieberman and Montgomery 1988). In some instances, early entry may be a prerequisite for future expansion due to the path-dependency of resources. For example, Kim and Kogut (1996) addressed situations in which entry into one technological sub-field provides a platform into another sub-field. Thus, in competitive markets, the entry decision needs to be altered to reflect the potential to enhance growth option value with immediate entry.

$$(4)\ \ PE_t = R - X + CF + \alpha G - D$$

$$(5)\ \ PE_{t+1} = R - X + G$$

Providing that $PE_t \geq 0$, then following equation 3a, the decision rule becomes:

(6a) Enter if: $CF + \alpha G - G - D \geq 0$, or alternatively,

(6b) Enter if: $CF + (\alpha - 1)G - D \geq 0$

There are several key insights that can be gleaned from this model with respect to the firm's probability of entering a new market.

a) Entry is more likely when α is larger (i.e., there are competitive advantages to moving early). Note that α has a lower bound of 1. If α equals one there is no competitive advantage to early entry, so the entry decision boils down to equation (3b). If $\alpha > 1$, there is increased incentive to enter.

b) Entry is more likely when CF is large (i.e., there are opportunities to earn higher cash flows subsequent to enter).

c) Entry is more likely when as the option premium (i.e., $[\alpha - 1]G - D$) grows.

These first two points do not surprise anyone. The last point (c) is relatively unexplored, yet is of considerable interest because it illuminates the relationship between uncertainty and entry (and investment more generally). It implies that when $\alpha < 1$ (i.e., there are early mover advantages), the likelihood of entry increases with G, but decreases with D. What is curious is that both G and D increase with uncertainty, making the total effect of uncertainty ambiguous. Absent competition (i.e., $\alpha = 1$) there is no doubt that uncertainty should negatively influence the entry decision. However, when there are competitive advantages to earlier entry, the effect of uncertainty becomes less clear. Since the values of both options are increasing functions of uncertainty, predicting exactly how uncertainty will impact the entry decision requires assumptions about the relative magnitudes of each option and how their valuations grow with respect to uncertainty.

Figure 1 illustrates how G and D may vary in uncertainty, and how this may bear upon the incentive to enter immediately. To simplify our illustration, we are setting $\alpha = 2$ and $CF = 1$, but changing these values does not alter the intuition. Figure 1a exhibits the basic result that uncertainty has a negative effect on entry whenever the slope of D exceeds the slope of G. Uncertainty has a positive effect on entry whenever the slope of G exceeds the slope of D. This figure is tailored to demonstrate a point: uncertainty may not have a monotonically decreasing effect on the option premium, and hence entry, when there are competitive advantages to moving early. This point has been emphasized by Amram and Kulatilaka (1999, pp. 196-197): "In many instances, the growth option is more sensitive to uncertainty than the option to defer, making preemption the best strategy in markets with high levels of uncertainty".[3] The reason for this are elaborated below.

[Insert Figure 1 about here]

A standard result from option pricing theory is that the maximum value of a call option is bounded by the current price of the underlying security, which is the maximum amount of money that an investor could lose by purchasing that security now (and hence, the most that buying a call option can potentially save the investor). In the real options analogy, the maximum amount of money that a firm can save by holding the option to defer, instead of committing now, is the irreversible investment needed to enter the industry. Thus, although the value of the option to defer will be monotonically increasing in uncertainty, it is also

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[3] Kulatilaka and Perotti (1998) obtain this result shown in a model in which investment creates a cost advantage vis-à-vis a single potential entrant.

asymptotic to the irreversible investment required to enter the industry, which occurs only at very high levels of uncertainty. This implies that there are diminishing returns to waiting (Trigeorgis 2000). In contrast, growth options have no such upper bound on their value. As the uncertainty about future industry conditions increases, so does the potential economic value of gaining a competitive advantage in that industry (Kulatilaka and Perotti 1998). Since the upside of the growth option is not bounded, or asymptotic, the effect of uncertainty on growth options may be substantially more than its effect on the option to defer at extreme levels of uncertainty.[4]

In the end, it is an empirical question whether growth options are more sensitive to uncertainty than deferment options. Moreover, the result may vary across industries. As far as we can tell, Campa (1993) is the only researcher to test the conjecture that uncertainty has a non-monotonic effect. In testing whether exchange rate uncertainty affects entry by foreign firms into U.S. wholesale trade markets, he included both uncertainty and uncertainty-squared in the model, but found that the latter had no significant effect. His finding implies that the effect of exchange rate uncertainty on entry is negative and monotonic. It should be noted, however, that his industry context may be void of growth opportunities, and exchange rate uncertainty represents only one form of potential uncertainty. Further work is needed to verify whether total industry-level uncertainty has a non-monotonic effect on entry. If growth options are present in a

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[4] Predictions from an options theory perspective suggest that extreme levels of uncertainty lead to a *positive* effect on entry. It is interesting to contrast this with predictions from the behavioral theory of the firm, a more psychology-based perspective, where uncertainty should have a negative effect on entry because managers wish to avoid extreme uncertainty. This behavioral prediction is reinforced by an incentive system/culture where individual reward for great success is small and individual punishments for failure are great.

reasonable number of industries, the overall net impact of uncertainty on the probability of entry will be non-monotonic (Kulatilaka and Perotti 1998).

Hypothesis 1: On average, the effect of uncertainty on the probability of entry will be U-shaped – it will be negative for low levels of uncertainty and will become positive at very high levels of uncertainty.

The remaining hypotheses attend to factors that may systematically alter the relative value of growth options and deferment options, and thereby shift the inflection point of uncertainty. Relative to the base case provided in figure 1a, figure 1b alters the slope of D to illustrate how more valuable deferment options bear upon how uncertainty influences the option premium. We see that the uncertainty has a negative effect on the option premium over a larger proportion of its range. One could imagine that if D were steep enough (i.e., valuable deferment options), that uncertainty would have a monotonically decreasing effect on the option premium.

The value of the option to defer is influenced by the degree of irreversibility of the investment required for entry. If the investments required for entry are completely reversible, then the deferment option has no value and there is no point in delaying entry, since those investments can be fully recouped in the event the firm is forced to subsequently exit the industry. However, as those investments become more irreversible, there is a higher opportunity cost of making an erroneous entry decision, and hence the value of the option to defer increases. Thus, higher irreversibility should be associated with more valuable deferment options, making entry less likely.

Hypothesis 2: Uncertainty will have a negative effect on entry over a wider range of uncertainty when firms target industries that have larger options to defer (i.e., greater irreversibility).

The curvilinear effect described in hypothesis 1 should also be affected by the size of growth options. Relative to the base case provided in figure 1a, figure 1c alters the slope of G to illustrate how the option premium varies in uncertainty with larger growth options. It shows that, relative to the base case, the option premium becomes positively related to uncertainty at lower levels of uncertainty. Holding the firm's NPV constant, this suggests that the effect of uncertainty on entry will switch (from negative to positive) at lower levels of uncertainty. Similarly, if G were flat enough (suggesting the growth option is small), uncertainty would have a monotonically decreasing effect on the option premium.

Hypothesis 3: Uncertainty will have a positive effect on entry over a wider range of uncertainty when firms target industries with larger growth options.

The same result illustrated in figure 1c can be obtained if we hold the value of G constant relative to the base case (assuming, $G > 0$), but increase the importance of α (i.e., early mover advantages) relative to the base case, where $\alpha = 2$. This implies, that when early entry conveys an increased ability to benefit from growth options (i.e., α is larger), there are added reasons to move early with greater uncertainty. In particular, capabilities in manufacturing or marketing, often referred to as learning or experience curve advantages, are often emphasized as being important (Lieberman and Montgomery 1988). In some industries, rents can be secured through competitive preemption in a market. If there is only space for n firms in an industry, then entry by firm n+1 will not seem economical because it will reduce profits below the threshold level (Schmalansee, 1978). This may lead to an incentive for early entry to secure growth options before the competitive space is filled. Thus, since early mover advantages escalate the importance of growth options, the effect of uncertainty will switch (from negative to positive) at lower levels of uncertainty.

Hypothesis 4: Uncertainty will have a positive effect on entry over a wider range of uncertainty when firms target industries where early entry conveys an increased ability to benefit from growth options.

METHODS

Data

The empirical test of the above hypotheses entailed estimating entry of existing firms into new industries during the nineteen-year period of 1981-1999. The primary sources of data used for this study were the Compustat Industrial and Business Segments databases, commonly referred to as Compustat I & II. These databases, which are maintained by Standard and Poor's, are derived from the audited financial statements that all public firms file with the Securities and Exchange Commission (SEC).[5] The Compustat Industrial database (Compustat I) contains detailed financial information at the level of the firm, while the Compustat Business Segments (Compustat II) database provides financial data for each of the firm's business segments. Most of our firm-level variables were drawn from Compustat I, while Compustat II was used to detect instances of entry and to develop most of the industry-level variables. Since Compustat II is not available for years prior to

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[5] In addition to public firms that must file, a number of private firms also choose to file financial statements with the SEC.

1980, our analysis encompassed the 17,897 unique firms and 144,947 firm/year observations that were listed in Compustat II between 1980 to the 1999. Thus, our data represents a large sample of firms operating in many different industries over a significant period of time. For the purposes of this study, these qualities are advantageous since they should yield significant variation in industry-level uncertainty and the factors that influence the values of growth and deferment options.

Despite the potential strengths of this data, potential issues with the use of Compustat must also be considered. Probably the greatest concern is that industry segment SIC codes may be inconsistently assigned, making it difficult to observe legitimate instances of new business activity. This shortcoming in the data is one of the principle reasons we decided to move to a higher level of aggregation than the 4-digit SIC.[6] An additional concern is that there is some discretion in how firms group business activity in a single segment, leading to the potential agglomeration of diverse business activities into the same segment. However, Davis and Duhaime (1992) argue that the problem should not be substantive because of FASB reporting requirements. Furthermore, by moving to a higher level of aggregation, we attenuate this concern.

We reclassified reported SICs into fifty-one possible industries, roughly corresponding to 2-digit SICs, for which we could obtain measures of Gross Domestic Product (GDP) by industry.[7] These measures were critical to approximate uncertainty in total demand in each

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[6] For example, while a segment may be coded as manufacturing disk drives (SIC 3684) one year and computer peripheral parts (SIC 3688) the next, it will probably always be classified inside of the more general 2 digit SIC of 36.

[7] As mentioned earlier, there is a precedent for using GDP to calculate uncertainty GDP (Episcopos, 1995; Price, 1995). While those studies calculated macroeconomic uncertainty, we calculate separate measures of uncertainty for each industry.

industry. GDP by industry, which represents an industry's contribution to overall GDP, provides an excellent measure of total industry demand. It is often referred to as "value added", and is calculated by gross output less intermediate goods and services purchased. This data, obtained from the Bureau of Economic Analysis at the U.S. Department of Commerce, has the advantage of encompassing all business activity in the each industry. This level of aggregation provided benefits in addition to those noted above. Attempts to construct industry-level variables at the 3-digit level from Compustat I and II yielded many instances of missing data, and resulted in a large proportion of observations (approximately one third) being excluded from the analysis.[8] We found, however, that this problem is largely attenuated by moving to our higher level of aggregation. The specific industry coding scheme we employed is given in the Appendix.

Dependent Variable - Entry

Entry was defined as entry by an existing firm into an industry in which the firm had not reported involvement in the previous two years. Firms may report up to ten individual business segments, with six 4-digit SIC codes per segment: 2 primary segment SIC's (SSIC's), and 4 product SIC's (PSIC's).[9] Thus, for any given year, a particular firm may report up to sixty SIC codes. After reclassifying each of the reported SIC's to our fifty-one industry definitions, we examined whether any of the reported primary segment industries

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[8] The missing data is attributed to differences in the information provided through the Industrial file and the Segments file (a.k.a., Compustat I and II). Although most of our industry-level variables were constructed from Compustat II, three (M:B, InvLev, and Advertising) are only available from Compustat I. Since each firm can report multiple SIC codes in Compustat II, but only one is listed in Compustat I, there is inherently less variability in industries for variables constructed from the later. It is important to note, however, that analysis at the 3-digit level yielded results substantively similar to those presented here.

[9] Approximately 46% of firm/year observations only report a single segment, and less than 0.5% report ten segments.

(*i.e.*, the reclassified SSIC's) in the current year matched any of the possible sixty industries reported by the firm in the each of the two previous years. If no match was found (*i.e.*, firm activity in a new industry surfaced in which it was not listed by the firm anywhere for the previous two years), and the firm was in Compustat II in the prior year, that industry was coded as an entry. Using this approach, we identified 11,016 instances of entry between 1981 and 1999. In some instances, firms have multiple entries in a given year.

Independent Variables

All of the independent variables were computed for each year and lagged one year to avoid potential endogeneity with the instances of entry.[10] Descriptive statistics and correlations are illustrated in Table 1.

[Insert Table 1 About Here]

Uncertainty

Testing our hypotheses necessitates developing time-varying measures of industry-specific uncertainty. One common approach to quantifying the construct of uncertainty is to calculate the variance of some output or indicator (e.g., stock price, GDP, sales, etc) over time. However, for our purposes, this approach has two critical shortcomings. First, it fails to account for the trends in the data, which will increase the measured variance even though it may not constitute an element of uncertainty if they are predictable. Second, this approach does not allow for the possibility that the variance may be heteroskedastic (*i.e.*,

[10] For example, one might argue that any relationship between uncertainty and entry is due to the fact that when entry occurs, it induces uncertainty. By lagging uncertainty, we should attenuate this concern. Moreover, even if it was not attenuated, the above causality implies a positive relationship between uncertainty and entry. We expect a relationship that is mostly negative, although non-monotonic.

having-non constant variance over time), a characteristic that is typical of many economic time series (Campa 1993).

To address both of these concerns, we measure uncertainty with the conditional variance generated from generalized autoregressive conditional heteroskedasticity (GARCH) models (Bollerslev 1986). After obtaining annual measures of GDP for each of our 51 industries for the period of 1947 to 2000, we fit GARCH models to each of the individual time series. This enabled us to approximate unique time-varying estimates of uncertainty for each industry. The GARCH model produces an estimate of the conditional variance about any trend that might exist for each period the in the time series. Specifically, we employ the GARCH-in-mean, or GARCH-M model, with a functional form as follows:

$$(7)\ y_t = x_t^{'}\beta + \delta\sqrt{h_t} + \varepsilon_t$$

$$(8)\ \varepsilon_t = \sqrt{h_t}e_t$$

$$(9)\ h_t = w + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{j=1}^{p}\gamma_j h_{t-j}$$

$$(10)\ e_t \sim IN(0,1)$$

The GARCH process is parameterized by two values, p and q in equation (4). The first value, p, specifies the number of lags for the squared error terms. The second parameter, q, relates to the number of past variances to be included in the computation of the current variance. In general, a one period lag on both parameters (i.e., a GARCH-M[1,1] model) provides excellent fit for modeling a wide variety of asset prices (Solnik 1996). Diagnostic checks of our data indicate that the parsimonious GARCH-M(1,1) model provides excellent fit.[11] We used the square root of the annual conditional variances (h_t) generated from this model as our estimates of industry specific *Uncertainty*.[12]

Variables Representing the Irreversibility of the Entry Decision

While it is impossible to measure irreversibility directly, theory suggests several approximations. For example, Arrow (1968) suggests that intangible assets may have very little use outside their current application because they are likely to suffer from market failure, making trade on the open market difficult relative to physical assets (Long and Malitz 1985). Thus, the irreversibility of an investment decision is negatively related to the tangibility of the assets invested in (Titman and Wessels 1988). We measure *Intangible* by taking subtracting from one the ratio of total property, plant and equipment to total assets for each industry. While intangible assets are expected to be highly irreversible, the reversibility, or salvage value, of tangible assets may also vary across industries. Tangible or intangible assets that have high salvage value (*i.e.*, are less irreversible) can support a high level of debt, while assets that have low salvage value will have to rely on equity financing (Williamson 1988). Thus, the investments required to enter high leverage industries should be more reversible than the investments required to enter low leverage industries. To proxy for irreversibility, we subtract the total industry leverage from one to

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[11] We evaluated model fit based on verification that the residuals were distributed as white noise; the statistical significance of the hyperparameters (*i.e.*, the ω, α_1, and γ_1 in Eq. 4); and comparison of the model with alternative lag structures.

[12] Specifying *Uncertainty* as $\log(h_t)$ produced substantively similar results, however, model fit was inferior to the current specification. We also got qualitatively equivalent results when we substituted measures of uncertainty based on the volatility of stock market indices generated for 2 or 3 digit SIC codes. Results are available upon request.

create *InvLev*, where total industry leverage is defined as the total value of long-term debt in an industry divided by the total book value of industry assets.[13]

Variables Representing Growth Options or Early Mover Advantages

One broad proxy for the presence of growth options in an industry is its average market-to-book ratio. Myers (1977) argued that a high market-to-book ratio should be associated with a higher proportion of growth opportunities relative to assets in place. As a result, firms targeting industries with higher average market-to-book ratios will have more valuable growth options. The variable *M:B* is the total industry market-to-book ratio, and is intended to capture expected future industry growth opportunities. This variable was computed by summing, for all firms listed in Compustat I, the market values (*i.e.*, the market value of equity plus book value of debt) of all firms competing in each industry, then dividing by the total book value of industry assets.

Industry growth rates should also increase the importance of growth options relative to deferment options. When an industry grows quickly, a firm must invest in order to exercise the option to grow with the market. Having a strategic advantage is particularly valuable in states of high demand when profits per unit of output are higher (Kulatilaka and Perotti, 1998). Thus, firms targeting higher growth industries should have more valuable growth options. The variable *Grow* is intended to capture expectations about the future

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[13] We used the book value of assets in the denominator instead of the market value of the firm for two reasons. First, a substantial number of firms listed in Compustat I (about 20% of observations) had either no public equity or no data available on it. These firms would have to be excluded from the computation if market value was used, which could potentially bias the results. Second, holding all else constant, a firm that has more future growth opportunities will have a greater market value and an apparently lower leverage if the market value of the firm was used. We desired a measure of leverage that was not confounded by growth opportunities, and hence used the book value of firm assets in the denominator.

growth rate of the industry. The GARCH model that was used to produce our measure of uncertainty also produces, for each year and each industry, an estimate of the predicted value of industry GDP (*i.e.*, a $\tilde{y}_t$). To capture expected industry growth, we computed *Grow* as the predicted value for industry GDP for the year that entry occurred, less the actual value of industry GDP in the previous year, all divided by the actual value of industry GDP in the previous year.

Preemption is a way that firms secure competitive advantages when the industry can only support a limited number of players. If the minimum efficient scale in an industry is large relative to the total industry size, then firms that delay entry too long may find it infeasible to enter at later date. Thus, target industries defined by a larger ratio of minimum efficient scale to total industry size should be stronger candidates for early entry. An estimate of each industry's minimum efficient scale, MES, was constructed by ranking all firm business segments that compete in each industry, for each year, based on total assets. MES is represented by the median value.[14] Since it is the ratio of MES to total industry size that should be relevant, we develop a measure of relative scale, *MinScale*, by dividing the estimate of minimum efficient scale by total industry assets.

Control Variables

In addition to the variables specified above, to properly reflect the specification of the theoretical model we should include variables correlated with the present value of the entry opportunity (*i.e.*, *R* - *X*). Several industry level variables should influence the

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[14] Results are substantively identical if the minimum value of assets, the 10th percentile, or the 25th percentile are used instead of the median.

attractiveness of entering a given industry. *I-Profit* is defined as total industry profitability, as measured by the operating profit to sales ratio. *Concentration* is the industry's Herfindahl concentration index. *I-Size* is the natural log of the total assets of all business segments competing in each industry. *Beta* controls for the systematic risk of each industry, and is calculated as the covariance between the returns on each industry's stock index and the market return over the previous 60 months. The intensity of investment in capital, R&D, and advertising is approximated by *I-CAPI*, *I-RD*, and *I-Adver*, respectively. We measure them by the ratio of total industry assets, total R&D, and total advertising, respectively, to total sales.[15]

Several firm-level factors could also impact the static NPV of the entry decision. The degree of relatedness between the industry entered and the portfolio of industries in which the firm already competes should greatly influence the expected value from entry. Traditional measures of industry relatedness focus squarely on the similarity of the industry SICs. However, this approach is problematic because it is unclear whether the same degree of similarity exists between all pairs of SICs at all levels of analysis. In addition, such an approach in this particular study is difficult due to our industry classification. To address these issues, we adopt a measure of industry relatedness similar to that proposed by Teece, Rumelt, Dosi, & Winter (Teece, Rumelt et al. 1994), which measures the likelihood that a firm operating in industy *j* will also operate in industry *m*, corrected for the expected degree of relatedness under the null hypothesis that diversification is random. Our measure differs

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[15] Since advertising expenditures are only available at the level of the firm, while capital and R&D expenditures are available at the level of the business segment, *I-Adver* was calculated on firm level data while I-CAPI and *I-RD* were based on segment level data.

from the previous authors in that we calculate the index for the 51-industry classification used in this study, and we allow the measure to vary over time. Our measure of relatedness, *ConProb*, was the minimum distance between the target industry and all of the industries that are already in the firm's portfolio.

Diversification controls for how diversified the firm was prior to the new entry by measuring the sum of squared shares of each of the firm's business segments. *F-Size* controls for the size of each firm by taking the natural log of total firm assets. The variables firm level capital intensity (*F-CAPI*), firm level advertising intensity (*F-Adver*), and firm level R&D intensity (*F-RD*) were computed in a similar fashion as their industry level counterparts, but for each individual firm.[16] Finally, the variables *CAPI-Diff*, *RD-Diff*, and *Adver-Diff* help control for differences between the expanding firm and its target industry. These variables are computed as the absolute difference between capital, R&D, and advertising intensities, respectively, of the firm and the target industry.

In total, we adopted nearly all of the industry and firm controls present in either of two important papers on entry (Montgomery and Hariharan, 1991; Silverman, 1999). In addition, we introduced control variables corresponding to relatedness to the target industry (*ConProb*), industry size (*I-Size*), and systematic risk (*Beta*). Thus, according to precedent, we thoroughly control for factors that should affect potential profitability.

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[16] We ran models including firm profitability and firm growth (in sales) and the models remained essentially unchanged. We opted to exclude these variables from the final analysis because of missing data.

Method

As previously discussed, the dichotomous decision of whether or not to enter a new industry provides the ideal context for a rigorous test of real options theory. Thus, we take an approach similar to Montgomery and Hariharan (1991) and test our models with a series of multivariate binomial logit models that compare instances of entry with a random sample of all the non-entries.[17] Instances of non-entry are actually quite observable from the Compustat data: for every firm/year observation, the firm essentially "did not enter" every industry that it does not compete in that year. Thus, the hurdle to overcome in this analysis is not finding instances of non-entry, but rather how to handle the tremendous volume of non-entries, which numbered over 6 million. We elected to use state-based sampling techniques to construct our sample of entries and non-entries (Manski and McFadden, 1981). The sample of non-entries was created by randomly generating (with replacement) a sample of 60,000 firm-year observations, and then randomly assigning industries to these observations in which firms had not competed for at least the previous two years. Manski and McFadden (1981) have demonstrated that state-based sampling provides more efficient generation of information than does a purely random sample (of both entries and non-entries) when a population is overwhelmingly characterized by one state (e.g. non-entries), and that logit estimation derived from state-based sampling will yield unbiased and

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[17] The data do not distinguish between direct entry and entry by acquisition. Nevertheless, the motives for delaying expansion outlined above should apply to both modes of entry. While it is possible that the scale of entry differs across these modes, we do not expect the degree of irreversibility per dollar invested to differ across these modes.

consistent coefficients for all variables except for the constant term.[18] After eliminating observations with missing data, the derived sample includes 11,015 instances of entry and 59,868 instances of non-entry.

Since our hypotheses predict that uncertainty may have a non-monotonic effect on the probability of entry, we include both *Uncertainty* and *Uncertainty*^{2} as predictor variables in our model. Our expectation is that the sign of the coefficient on *Uncertainty* will be negative and the coefficient on *Uncertainty*^{2} will be positive, which would be consistent with a relationship that is generally negative but turns positive at high levels of uncertainty. Although ideally we would like to be able to independently assess the value of the growth option and the option to defer, in reality we can only observe their joint effects. Hence, our hypotheses relate to their relative sensitivity to uncertainty. As growth options become more valuable, the coefficient on *Uncertainty*^{2} should become larger. As the option to defer becomes more valuable, the coefficient on *Uncertainty*^{2} should become smaller. We test our hypotheses that relate to the strength of growth options relative to the option to defer by interacting the relevant variables with *Uncertainty*^{2}. This flexible formulation should provide adequate fit to the data as long as the relationship between uncertainty and the probability of entry, as it is moderated by the interacted variables, has no more than one turning point. Factors that either weaken the value of the option to defer or strengthen the value of the growth option should produce a positive interaction with *Uncertainty*^{2}. Put differently, higher levels of these variables (such as reversibility) result in a stronger

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[18] The constant term can be corrected by subtracting from it the log(proportion of all entries in sample/proportion of all non-entries in the sample), where the numerator is 1, and the denominator is [59,868 / (144,947 * 51 – 144,947)].

"upturn" in the relationship between uncertainty and the probability of entry. Alternatively, factors that are associated with a more valuable option to defer (or weaker growth options) should produce a negative interaction with *Uncertainty*^{2}, indicating that higher levels of those variables are associated with a weakened upturn in the relationship between uncertainty and the probability of entry at high levels of uncertainty.

RESULTS

The logit models presented in table 2 test whether the independent variables significantly improve the ability to explain the choice between entry and non-entry. Models 1 and 2 report the coefficients for uncertainty, while models 3-7 add coefficients for moderating effects to uncertainty. Firm and industry-level variables are included to control for the static NPV of the entry opportunity. Also included in each these models, although not reported, are year fixed effects. The significance of individual coefficients is interpreted using two-tailed Wald Chi-Square tests.

The Effect of Uncertainty

Consistent with much of the prior research on the relationship between uncertainty and investment, model 1 indicates that *Uncertainty* has a significant negative effect on the probability of entry ($p<0.001$), after controlling for variables that should affect the static NPV of the entry opportunity. Our point of departure from these studies, however, is that we hypothesize a curvilinear effect for uncertainty. Model 2 incrementally introduces *Uncertainty*^{2}. A likelihood ratio test comparing model 2 to model 1 revealed a chi-square statistic of 269.7, suggesting that the addition of *Uncertainty*^{2} significantly improves model fit ($p < 0.001$; 1 d.f.). Moreover, the individual coefficient for this variable has a significant positive effect ($p < 0.001$) on entry. While this is consistent with expectations stated in Hypothesis 1, it is important to determine whether the effect of uncertainty is non-monotonic within the sample's range of uncertainty. We do so by taking the first derivative with respect to *Uncertainty* and comparing it to the distribution of *Uncertainty*. This process reveals that the inflection point (i.e., the point where the relationship switches from negative to positive) occurs at about the 94th quantile of *Uncertainty*.[19] Hence, the effect of *Uncertainty* is non-monotonic, as predicted in hypothesis 1.

Hypotheses 2-4 suggest that if target industries differ in the magnitude of deferment and growth options present, the effect of uncertainty will shift to reflect these differences. Columns 3-7 introduce interaction effects to test our hypotheses regarding the moderating role of growth options and deferment options.

The Moderating Effect of Irreversibility on Uncertainty

Models 3-4 incrementally introduce interaction terms involving separate measures of irreversibility. These models are meant to test hypothesis 2, which argues the irreversibility of the entry decision increases the relative importance of uncertainty on the option to defer compared to the option to grow. The addition of each of the interactions significantly improves model fit relative to model 2 ($p < 0.001$; 1 d.f.), as revealed in separate likelihood ratio tests. The presence of significant interaction terms requires a closer examination of the underlying relationships. In model 3, the negative interaction ($p < 0.001$) between *Intangible* and *Uncertainty*^{2} is consistent with hypothesis 3 and suggests

[19] The existence of the inflection point is robust to alternative specifications of *Uncertainty* (see footnote 12).

that high levels of *Intangible*, which approximates greater irreversibility associated with entry, weaken the turning point effect of uncertainty. Taking the first derivative with respect to *Uncertainty* reveals that the relationship of *Uncertainty* to entry is only non-monotonic when *Intangible* is less than the 40th quantile of its range in the sample, otherwise *Uncertainty* has a monotonic negative effect on entry. Model 4 introduces the interaction term involving *InvLev* and *Uncertainty*^{2}, and its negative coefficient also supports hypothesis 2. The higher the value of *InvLev* (i.e., the more irreversible is entry), the higher the inflection point.[20] In sum, these results are consistent with the expectation that for firms targeting industries that are characterized by irreversible investments, managers place high importance on the option to defer because its value is high relative to the value of growth options.

The Moderating Effects of Growth Options and Early Mover Advantages on Uncertainty

The interaction between *M:B* and *Uncertainty*^{2} is entered in Model 5. A comparison of model 5 with model 2 produced a chi-square statistic of 133.3, suggesting that the interaction term significantly improved model fit ($p < 0.001$). Since a high average industry market-to-book ratio is indicative of strong growth opportunities in the target industry, the positive coefficient ($p < 0.001$) for the interaction term is consistent with hypothesis 3. Figure 2a demonstrates the effect of *Uncertainty* over the variable's range at three different levels of *MB*: the median of the range, the 5th quantile (i.e., target industries

[20] When InvLev is at the 95th quantile (i.e.,entry is largely irreversible), *Uncertainty* has an inflection point in its 94th quantile. However, when target industries have levels of *InvLev* in the 5th quantile, *Uncertainty* has an inflection point in its 87th quantile.

with low-valued growth options), and the 95th quantile (i.e., target industries with high-valued growth options). The figure illustrates that at the 95th quantile of *MB*, the effect of *Uncertainty* on entry turns positive in the 90th quantile of *Uncertainty*. This contrasts with target industries where MB is very low, the effect of *Uncertainty* on entry is monotonically negative.

Model 6 introduces an interaction between *Grow* and *Uncertainty*^{2}. A likelihood ratio test comparing this model to the base model (model 2) produced a chi-square statistic of 123.1, which exceeds the critical value for one degree of freedom. This suggests that the addition of this interaction term significantly ($p < 0.001$) improves model fit, and warrants an interpretation of the coefficient. The positive coefficient ($p < 0.001$) for the interaction is consistent with hypothesis 3. Figure 2b demonstrates the effect of *Uncertainty* over the variable's range at three different levels of *Grow*: the median of the range, the 5th quantile (i.e., low growth industries), and the 95th quantile (high growth industries). The vertical axis represents multiplier for entry resulting from the combined effects of *Uncertainty* and *Grow*. The figure demonstrates that at high levels of *Grow* (the 95th quantile), the effect of *Uncertainty* on entry becomes positive at lower levels of *Uncertainty* than when target industries have low *Grow* (5th quantile).

In Model 7 we introduce the interaction involving *MinScale* and *Uncertainty*^{2}to test hypothesis 4, that growth options will be more pertinent in industries with early mover advantages. Likelihood ratio tests indicate that a significant improvement in model fit relative to model 2. Consistent with expectations, the interaction term is positive ($p < 0.001$), indicating that for target industries with higher *MinScale*, *Uncertainty* has positive effect over a larger portion of the sample.

Control Effects

Since our whole sample constitutes a wide range of industries, results for control variables are not directly comparable to studies that focused only on manufacturing industries, such as Montgomery and Hariharan (1991) and Silverman (1999).[21] Nevertheless, the control variables largely have the expected effect. Among the variables unique to this study, *ConProb* had a positive effect ($p < 0.001$), which suggests that firms targeting more related industries are more likely to enter. This finding is consistent with predictions from the resource-based view.

DISCUSSION

Assumptions about a negative relationship between uncertainty and investment have dominated empirical attempts to validate the explanatory power of real option theory in the last ten years. Such a focus assumes that firm decision-making is dominated by the option to defer investment in the face of uncertainty. It ignores the possibility that growth opportunities are enhanced with greater uncertainty, leading to a potential for a positive relationship between uncertainty and investment. We make a critical contribution to the this literature by being the first to empirically investigate the circumstances that determine whether, in the face of uncertainty, firms tend to commit or to defer commitment. Our results suggest that the relationship of uncertainty to entry is not monotonic, as previous

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[21] An unreported model concentrating only on the manufacturing industry produced results for our control variables that correspond closely to these previous findings. We found that our advertising variables (*F-Advertising*, *I-Advertising*, and *Adv-Diff*) had no significant effect on entry, which contrasts with findings in both studies noted above, where both firm and industry advertising had a positive effect, while the absolute difference was negative.

theoretical researchers had postulated. We find that over 93 percent of the range of uncertainty, uncertainty has a negative effect on entry, implying that the option to defer normally dominates growth options. However, at high levels of uncertainty (beyond the 93rd quantile), uncertainty has a positive effect on entry, implying growth options dominate deferment options. This finding is the first that verifies the non-monotonic effect of uncertainty that has only recently emerged in theoretical treatments of real option theory, and amplifies the importance of considering both the option to defer and the option to grow when contemplating entry.

We also demonstrate that the relative importance of deferment options to growth options bears critically on the turning point of uncertainty. For example, in very fast growing target industries or in target industries where growth options are more important, the inflection point for uncertainty becomes very pronounced. In contrast, when targeting industries that require large irreversible investments, uncertainty is more likely to have the traditional negative effect on entry. Such findings add further evidence that two different classes of real options are underlying the complex relationship between uncertainty and the probability of investment.

These findings should be particularly interesting to scholars of strategic management, that have been intrigued by growth options, yet have provided little empirical evidence of their existence. Moreover, the role of uncertainty in this process is unexplored, which is curious given the central role that uncertainty plays in real option analysis. We have shown that uncertainty can have a positive effect across the full range of economic sectors.

Of course, future work should attempt to validate our findings. With our use of Compustat data, we have sought to provide a broad and generalizable picture of the importance of growth options for entry decisions by diversified firms. The need for such an approach should not be underemphasized. While we have made rigorous attempts to control for industry and firm-level factors, future research would benefit from more fine-grained data. By aggregating data into fifty-one industries, a shortcoming of our approach is that we cannot observe the precise sub-market that firms are entering. Although this may not be so much of a concern for the value of the option to defer, an underlying assumption of the value of growth options is that the sub-market that the firm is entering is not already crowded. Thus, despite our findings that growth options are important, we may not be capturing the full extent of their importance. More fine-grained data may allow for a more precise evaluation of the various factors that influence the value of growth options, including timing of entry. Another factor that may inhibit our ability to observe growth option effects is that we are focusing on existing industries that already have a lot of left-censored first-movers. It is possible that the effect of uncertainty turns positive at lower levels of uncertainty in new industries, where first-mover advantages are more likely to be more pertinent. Future research should examine our hypotheses in the context of new industries. Finally, future work may explore in which industries growth options play a pertinent role in decision-making. While not reported here, we found evidence that the presence of growth options, as evidenced by a non-monotonic effect of uncertainty, varies widely across industries. Growth options seem to be pertinent in about one-third to one-half of our fifty-one industries.

Our analyses have relied primarily on industry-level factors that may influence the value of real options. An interesting area for future research would be to investigate the potential firm-level factors that influence the value of options to defer or option to grow.

Such firm-level factors may help to explain why, in the face of similar industry characteristics, some firms enter and others do not, an issue that has not been satisfactorily resolved in either the real options literature (Carruth, Dickerson et al. 2000) or in work on early mover advantages (Lieberman and Montgomery 1998).

There are opportunities to extend this work in a number of other ways. We have not distinguished between large aggressive entries and smaller foothold entries. One of the managerial implications from infusing real options thinking into the organization is that firms are encouraged to increase flexibility by breaking investment into relatively small stages. Future research could examine whether the determinants of entry vary across different levels of investment. Divestment is another possible extension of this work. The study of divestment is the flip side of entry, and real options theory, when combined with the resource-based view of the firm, could illuminate the topic of inertia within firms (Dixit 1992). Mahoney and Pandian (1992) have argued that "while the resource-based view has developed a viable approach for explaining and predicting growth and diversification, a 'resource-based theory of divestment' is clearly lacking" (p. 367).

Despite the noted shortcomings and the broad research agenda ahead, we feel that this research provides an important first step in empirically examining the dueling options present in entry decisions. In general, these results suggest that, consciously or not, managers consider the value of real options and generally recognize the factors that influence their value. We have demonstrated that the effect of uncertainty is not monotonic, on average, and that inflection points are influenced by factors that should theoretically influence options to grow and options to defer. Since growth options are at the heart of strategic management, this first step is significant.

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Appendix: Industry Coding Scheme by Bureau of Economic Analysis at the U.S. Department of Commerce

Industry	Name	SIC's
1	Agriculture, Forestry & Fishing	1-10
2	Metal and Coal Mining	10-12
3	Oil & Gas Extraction	13
4	Other Mining	14
5	Construction	15-17
6	Lumber & Wood	24
7	Furniture & Fixtures	25
8	Stone, Clay & Glass Prod.	32
9	Primary metal Indus	33
10	Fabricated Metal Prod.	34
11	Machinery	35
12	Electric, Electronic & Instruments	36, 38
13	Autos & Equipment	371
14	Other Transp. Equip.	372-379
15	Misc Manufacturing Indus	39
16	Food Products	20
17	Tobacco	21
18	Textile	22
19	Apparel	23
20	Paper	26
21	Printing	27
22	Chemicals	28
23	Petroleum & Coal Products	29
24	Rubber & Plastic Products	30
25	Leather Products	31
26	Railroad Transportation	40
27	Local Passenger Transit	41
28	Trucking/Wharehousing	42
29	Water Transport	44
30	Air Transport	45
31	Pipelines	46
32	Transportation Services	47
33	Communications	48
34	Electric, Gas, & Sanitary Serv.	49
35	Wholesale	50-51
36	Retail	52-59
37	Banking & Credit Agencies	60, 61
38	Security & Commodity Brokers	62
39	Insurance Carriers	63
40	Insurance Agents & Brokers	64
41	Real Estate & Holding	65-67
42	Hotels/Lodging	70
43	Personal Services	72
44	Business & Misc Professional Serv.	73, 84, 87
45	Auto Repair, Services & parking	75
46	Misc Repair Services	76
47	Motion Pictures	78
48	Amusement/Recreation	79
49	Health Services	80
50	Educational Services	82
51	Social Services	83

Table 1: Descriptive Statistics and Pearson Correlations

Variable	Mean	Std Dev	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 ConProb	0.03	0.06	-0.16	0.69																					
2 Diversification	0.13	0.23	0.00	0.90	0.21																				
3 F-Size	4.20	2.44	-0.69	12.88	0.09	0.38																			
4 F-CAPI	8.83	357.02	0.00	85352.00	0.00	-0.01	-0.01																		
5 F-RD	0.05	0.31	0.00	40.00	-0.02	-0.06	-0.13	0.00																	
6 F-Advertising	0.01	0.07	0.00	12.08	-0.01	-0.02	-0.04	0.00	0.00																
7 Beta	1.10	0.27	0.26	2.43	0.03	0.02	-0.01	0.00	-0.02	0.00															
8 Concentration	0.08	0.09	0.01	0.85	-0.15	0.00	0.01	0.00	-0.01	0.00	0.02														
9 I-Size	10.78	1.86	4.77	15.23	0.16	-0.03	0.03	0.00	0.02	-0.01	-0.13	-0.49													
10 I-Profitability	0.12	0.09	-0.03	0.64	-0.04	-0.01	0.01	0.00	0.01	0.00	0.00	-0.03	0.15												
11 I-CAPI	1.50	1.63	0.10	11.08	-0.04	-0.01	0.03	0.00	0.01	0.00	0.12	-0.08	0.36	0.68											
12 I-RD	0.01	0.01	0.00	0.10	0.16	-0.01	0.00	0.00	0.02	0.00	0.05	-0.19	0.29	-0.13	-0.15										
13 I-Advertising	0.01	0.01	0.00	0.08	-0.06	0.00	-0.02	0.00	0.00	0.02	0.06	-0.02	-0.24	-0.06	-0.19	0.02									
14 CAPI-Diff	8.64	356.99	0.00	85350.00	-0.01	-0.01	-0.01	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00								
15 RD-Diff	0.05	0.31	0.00	40.00	-0.03	-0.06	-0.12	0.00	1.00	0.00	-0.01	-0.01	0.02	0.00	0.01	0.03	0.00	0.00							
16 Adv-Diff	0.02	0.07	0.00	12.06	-0.02	-0.02	-0.04	0.00	0.00	0.97	0.01	0.00	-0.04	0.00	-0.03	0.00	0.15	0.00	0.00						
17 Intangible	0.61	0.21	0.08	0.99	0.08	0.00	0.02	0.00	0.00	0.00	0.18	-0.09	0.08	0.00	0.24	0.19	0.22	0.00	0.01	0.03					
18 InvLev	0.76	0.11	0.38	1.00	0.09	0.02	0.00	-0.01	0.00	0.00	0.04	-0.15	0.21	-0.10	0.08	0.28	-0.04	-0.01	0.00	0.00	0.53				
19 MB	0.99	0.43	0.10	3.51	-0.05	-0.05	0.03	0.00	0.02	-0.01	-0.06	0.03	-0.19	-0.04	-0.35	0.28	0.28	0.00	0.03	0.03	-0.12	-0.16			
20 Grow	0.02	0.14	-0.45	0.78	-0.01	0.04	-0.03	0.00	-0.01	0.00	-0.09	0.01	-0.11	-0.18	-0.08	-0.03	0.03	0.00	-0.01	0.00	0.07	0.12	-0.18		
21 MinScale	0.01	0.01	0.00	0.13	-0.15	-0.01	0.00	0.00	-0.01	0.00	-0.02	0.51	-0.55	0.16	-0.05	-0.17	-0.03	0.00	-0.01	-0.01	-0.17	-0.21	0.16	0.00	
22 Uncertainty	106.89	90.66	11.28	546.93	-0.05	0.00	0.00	0.00	0.01	-0.01	0.03	0.00	0.01	0.27	0.14	-0.06	-0.21	0.00	0.01	-0.03	-0.22	0.01	-0.04	-0.14	0.14

With n=70,883, correlations with an absolute value of 0.01 or more are significant at $p < 0.05$.

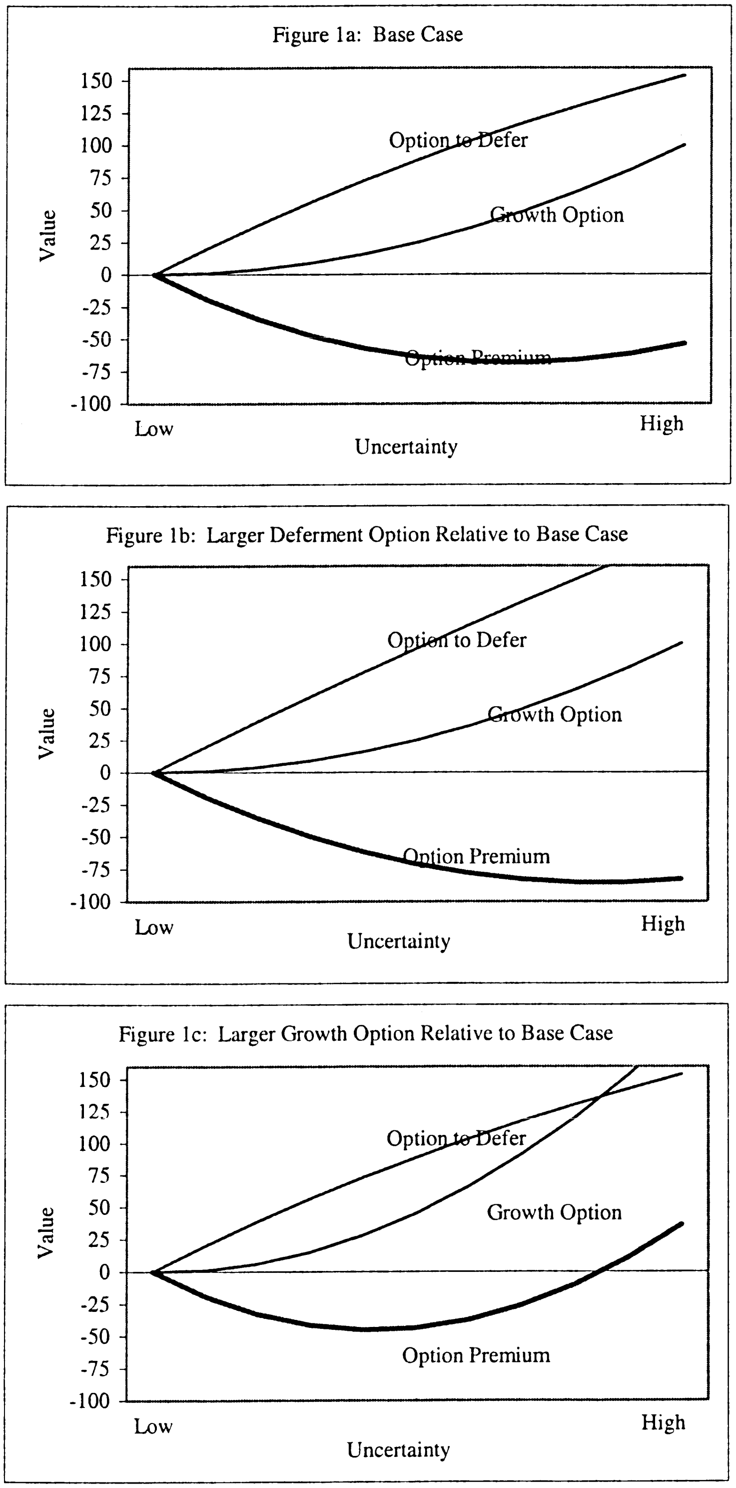
Table 2: Maximum Likelihood Estimates for the Determinants of Entry[a]

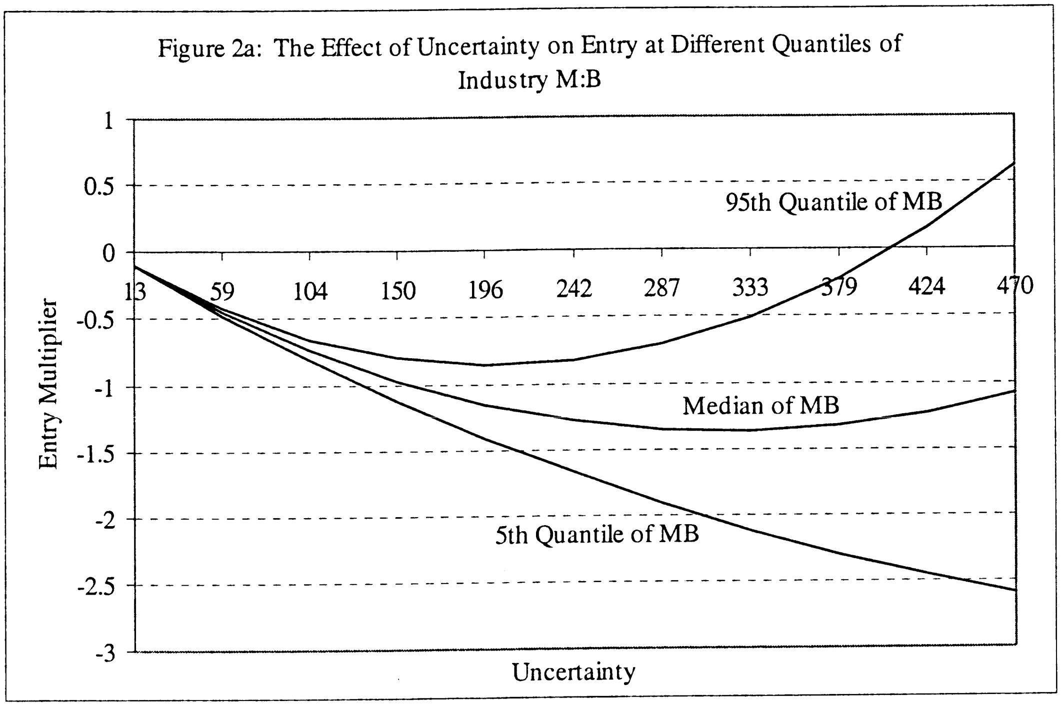
Variables	1	2	3	4	5	6	7
Intercept	-5.334 ***	-4.587 ***	-4.846 ***	-4.697 ***	-4.582 ***	-4.586 ***	-4.502 ***
ConProb	12.045 ***	11.826 ***	11.722 ***	11.803 ***	11.779 ***	11.750 ***	11.833 ***
Diversification	1.068 ***	1.078 ***	1.092 ***	1.082 ***	1.082 ***	1.088 ***	1.080 ***
F-Size	-0.039 ***	-0.038 ***	-0.039 ***	-0.038 ***	-0.038 ***	-0.038 ***	-0.039 ***
F-CAPI	0.067 ***	0.068 ***	0.071 ***	0.069 ***	0.070 ***	0.069 ***	0.068 ***
F-RD	4.182 ***	4.498 ***	4.567 ***	4.519 ***	4.565 ***	4.560 ***	4.499 ***
F-Advertising	-0.463	-0.342	-0.363	-0.356	-0.442	-0.401	-0.348
Beta	0.260 ***	0.246 ***	0.226 ***	0.228 ***	0.308 ***	0.321 ***	0.223 ***
Concentration	-0.623 *	-0.778 **	-0.793 **	-0.790 **	-0.866 ***	-0.702 **	-0.775 **
I-Size	0.249 ***	0.202 ***	0.202 ***	0.198 ***	0.207 ***	0.199 ***	0.196 ***
I-Profitability	0.068	-0.968 ***	-1.644 ***	-1.305 ***	-1.283 ***	-0.773 **	-1.201 ***
I-CAPI	0.015	0.082 ***	0.117 ***	0.101 ***	0.097 ***	0.069 ***	0.093 ***
I-RD	9.089 ***	12.662 ***	12.330 ***	12.456 ***	12.684 ***	13.184 ***	12.512 ***
I-Advertising	-26.627 ***	-26.524 ***	-25.666 ***	-26.579 ***	-25.380 ***	-26.452 ***	-26.521 ***
CAPI-Diff	-0.067 ***	-0.068 ***	-0.071 ***	-0.069 ***	-0.070 ***	-0.069 ***	-0.068 ***
RD-Diff	-4.232 ***	-4.547 ***	-4.620 ***	-4.568 ***	-4.615 ***	-4.610 ***	-4.549 ***
Adv-Diff	-0.092	-0.232	-0.195	-0.210	-0.119	-0.166	-0.228
Intangible	3.361 ***	3.386 ***	3.621 ***	3.375 ***	3.364 ***	3.468 ***	3.371 ***
InvLev	-3.248 ***	-3.121 ***	-3.018 ***	-2.871 ***	-3.057 ***	-3.094 ***	-3.095 ***
MB	1.053 ***	1.038 ***	1.046 ***	1.051 ***	0.897 ***	1.004 ***	1.055 ***
Grow	-0.713 ***	-0.448 ***	-0.448 ***	-0.458 ***	-0.525 ***	-1.046 ***	-0.455 ***
MinScale	-25.120 ***	-26.349 ***	-27.809 ***	-28.309 ***	-24.970 ***	-26.427 ***	-30.815 ***
Uncertainty	-2.82E-03 ***	-8.35E-03 ***	-6.08E-03 ***	-8.15E-03 ***	-8.45E-03 ***	-1.04E-02 ***	-8.30E-03 ***
Uncertainty^2		1.40E-05 ***	2.10E-05 ***	3.20E-05 ***	3.68E-06 *	2.10E-05 ***	1.40E-05 ***
Uncertainty2 * Intangible			-3.00E-05 ***				
Uncertainty2 * InvLev				-2.00E-05 ***			
Uncertainty2 * MB					1.00E-05 ***		
Uncertainty2 * Grow						1.70E-05 ***	
Uncertainty2 * MinScale							1.20E-04 ***
Likelihood Ratio	14900.070	15034.914	15107.232	15049.919	15101.561	15096.449	15049.247
Likelihood Ratio Test (vs. Model 2)			144.635 ***	30.010 ***	133.295 ***	123.071 ***	28.667 ***

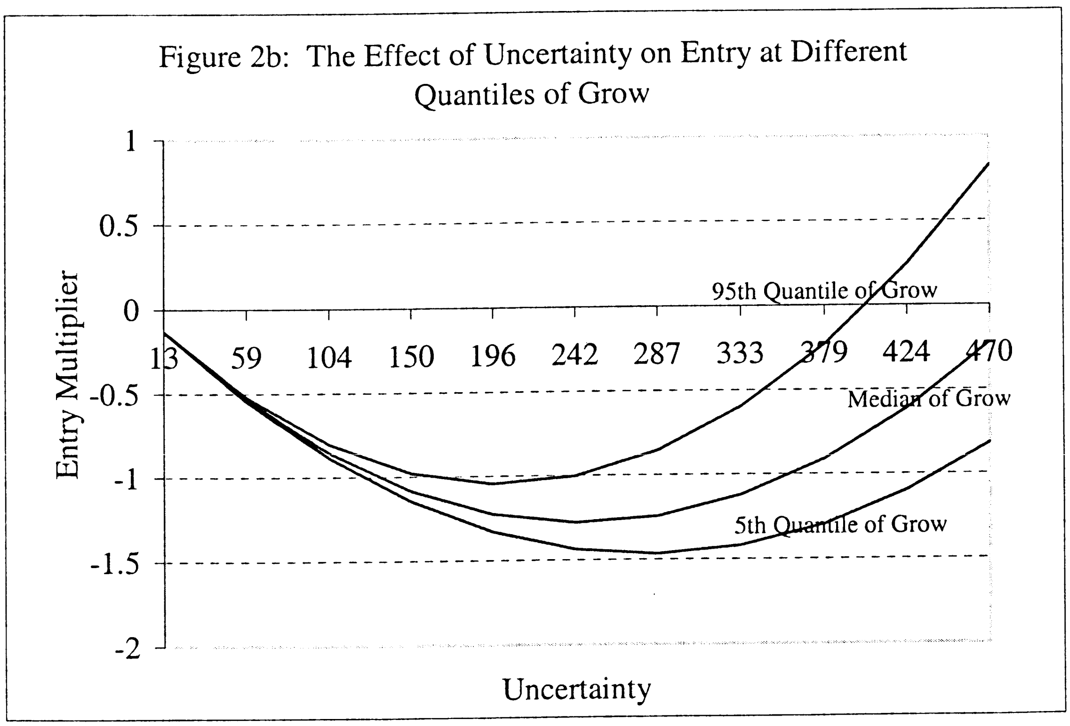
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

[a] Year fixed effects included in models, but not reported.

Figure 1: The Value of the Options to Defer and Grow with Respect to Uncertainty







The vertical axes in the figures represent the multiplier of entry resulting from the combined effects of Uncertainty and the variable of interest (MB in figure 2a and Grow in figure 2b), while other variables are held constant. The horizontal axes range from the 1st quantile of *Uncertainty* to the 99th quantile.

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