KRANNERT GRADUATE SCHOOL OF MANAGEMENT

Purdue University
West Lafayette, Indiana

Uncertainty and the Likelihood of Entry: An Empirical Assessment of the Moderating Role of Irreversibility

by

Tim Folta
Douglas R. Johnson
Jonathon O'Brien

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Timothy B. Folta*

Douglas R. Johnson

Jonathan O'Brien

All from

Krannert Graduate School of Management
Purdue University
West Lafayette, IN 47907-1310
Phone: 765 494 9252
Fax : 765 494 9658
Foltat@mgmt.purdue.edu
Johnsond@mgmt.purdue.edu

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* Authors are listed alphabetically. Correspondence should go to this author.

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Abstract

Real options models have emerged as a compelling tool for understanding market entry decisions involving sunkness, or irreversibility. In contrast to neoclassical models of investment, real options models consider that uncertainty has a direct effect on the willingness to invest, and that the effect of uncertainty is intensified as the irreversibility of investment increases. Although the effect of uncertainty on investment has been documented, the theoretical interaction between uncertainty and irreversibility has not been empirically demonstrated because the existing literature has tended to assume that all investments are equally irreversible. Our paper addresses this issue and advances the literature on real options theory in the following three ways. First, we empirically validate the proposition that uncertainty is moderated by the irreversibility of the required investment. Second, we relate the irreversibility of the entry decision to a firm's corporate strategy, and demonstrate that the effect of uncertainty is moderated by how related that industry is to the firm's current portfolio of business segments. Finally, our results provide evidence regarding the tradeoff between the option to grow and the option to wait – the effect of uncertainty on entry varies in the presence of growth options. (193 words)

1.0 Introduction

In recent years, real options models have emerged as a compelling tool for evaluating market entry decisions (Dixit, 1989). Unlike traditional discounted cash flow approaches, real options models recognize that firms face certain opportunity costs when investments are irreversible. In particular, they bear the opportunity cost of foregoing the *option to wait* for additional information that may affect their decision. The magnitude of this opportunity cost is a function of both the level of uncertainty the firm faces as well as the degree of irreversibility associated with the investment.[1] As both uncertainty and irreversibility increase, the value of the option to wait and the incentives to delay entry increase. Thus, uncertainty is expected to have a direct effect on entry if it involves some irreversibility. If entry decisions can be costlessly reversed, uncertainty should have no direct effect on entry.

This interaction between uncertainty and irreversibility lies at the heart of this emerging literature on real options that applies not only to entry decisions, but to the broader study of investment (Dixit and Pindyck, 1994). Over the past decade, a significant body of empirical research has developed assessing the direct effect of uncertainty on investment and entry from a real options perspective (Carruth, et al., 2000). However, these studies have, for the most part, only looked at this phenomenon at the industry level of analysis. This is unfortunate for three reasons. First, by regressing uncertainty on industry (or even firm) investment levels, these studies make the assumption that all investments are equally irreversible. In the context of industry entry, this leaves virtually untested the central hypothesis that the probability of entry is determined by the interaction between uncertainty and irreversibility. Second, as Dixit and

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[1] In employing the term "uncertainty", we are referring to exogenours uncertainty, or the volatility of the stochastic process determining the returns from investment, consistent with Dixit and Pindyck (1994).

Pindyck (1994) argue, option models do not describe the level of investment *per se*, but identify the threshold at which firm-level investment should occur. As such, investigating simple relationships between rates of investment and uncertainty cannot directly test the models. Third, testing for the effect of uncertainty on total industry investment ignores the possibility that investment thresholds (entry trigger points) may differ across firms. Unless it is explicitly considered in empirical models, heterogeneity across firm-specific investment thresholds may bias or compromise efforts to test the predictions from real option theory.

This study seeks to partially address these issues by examining the combined effects of irreversibility and uncertainty on entry into new industries. We consider that investment thresholds may differ *across industries* because entry into some industries may require different levels of irreversible investment in physical assets, such as equipment or buildings, or intangible assets, such as reputation or technical ability. We also consider that investment thresholds may differ *across firms.* Borrowing from a rich literature examining entry from the perspective of the diversifying firm (Montgomery & Hariharan, 1991; Penrose, 1959), we argue that the level of irreversibility of entry into a particular industry will be contingent upon a firm's ability to re-deploy assets into its current portfolio of business activities. Firms diversifying into industries more related to their current portfolio of businesses will be making more reversible investments, and the effect of uncertainty on those firms' entry decisions will be less.

Using the Compustat II (Business Segment) database, we identified 12,127 instances where firms entered new business segments during the period from 1980 to 1999. These entries were then classified into 48 different industry groups using a classification proposed by Fama and French (1997). Using Fama and French's stock market returns for these 48 industry groups, we measured the level of time-varying uncertainty facing each industry. These measures of uncertainty were used in conjunction with other data to assess both the direct effect of uncertainty on entry as well, as the moderating effect of irreversibility on the relationship between uncertainty and entry.

The remainder of this paper is organized as follows: section 2 reviews the theoretical issues; section 3 discusses past empirical research; section 4 presents the model specification, the data sources, and the measures; section 5 presents the empirical findings; and section 6 discusses the implications of our study as well as directions for future research.

2.0 Theoretical Background

2.1 Neoclassical Investment Theory Versus Option Theory

Traditional investment theory predicts that a firm will expand into an industry when the net present value (NPV) of the expected cash flows from expansion is equal to or greater than zero. Underlying this prediction are two implicit assumptions that do not always match with reality (Pindyck, 1991). One underlying assumption is that investments are fully *reversible* - they can be recovered and costlessly redeployed if some negative event usurps the opportunity underlying the expansion alternative.[2] An important implication of this assumption is that the threshold investment level is not directly affected by the degree of uncertainty surrounding future cash flows. Second, the investment decision cannot be delayed.

[2] Kenneth Arrow (1968) pp. 8-9) was one of the first to recognize that most investments have some degree of irreversibility associated with them, remarking that "there will be many instances in which the sale of capital goods cannot be accomplished at the same prices as their purchase". The importance of investment irreversibility has infiltrated theories of the firm. It is now recognized that market frictions (irreversibilities) at least partially explain persistent differences in performance across industries and across organizations (Ghemawat, 1991).

An emerging stream of research has shown that the ability to delay irreversible investments, such as those associated with entry, can profoundly affect the decision to invest (Dixit, 1989; Pindyck, 1991). It also undermines the theoretical foundation of neoclassical investment models and invalidates the NPV rule as traditionally taught.[3] When a firm makes an irreversible investment, it exercises its option to invest. It gives up the possibility of waiting for new information to arrive that might affect the desirability or timing of entry. This lost option value is an opportunity cost that must be included as part of the cost of investment. As a result, the NPV rule must be modified such that investment should occur only if NPV is at least equal to the value of keeping the option alive. Investment rules that ignore this opportunity cost (i.e., the value of keeping the option alive) can be grossly in error (McDonald & Siegel, 1986).

Lippman and Rumelt (1985) and Dixit (1989) were the first to place these concerns in the context of market entry. In their models, the firm continuously decides whether it should enter by sinking investment, or wait until the next period and then decide whether to enter. The problem becomes a dynamic tradeoff in which the firm delays entry as long as the opportunity cost of foregoing the option to wait an extra period is higher than the gain from entering in the current period. Based upon this decision rule, factors can then be identified that increase the value of waiting and raises the threshold, or trigger point, at which expansion should occur.

The standard result in option pricing theory is that the value of an option increases with an increase in the volatility in the underlying asset. In the case of market entry, the asset can be viewed as the product market investments used in serving the market. Expected returns from entry will may be uncertain due to forces exogenous to firm control, such as changing demand and supply characteristics, technological changes, or legislation. Greater exogenous uncertainty

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[3] Myers (1984) provides a complete discussion of the inadequacy of discounted cash flow methods in the presence of real options.

should raise the value of the option to wait and enter in the future increases with uncertainty, the more uncertain the environment, the more likely a firm is to wait before it decides to exercise its option to enter. Thus, as uncertainty increases, the likelihood of entry should decrease given that the costs of entry are irreversible. However, as the reversibility of investments increases, the opportunity costs of entering should also decrease. In this case, option models converge to neoclassical investment models, and uncertainty would have no direct effect on the entry decision (after controlling for systematic risk).[4] Thus, theory dictates that the effect of uncertainty should be *moderated* by the degree of irreversibility pertaining to the investment.

2.2 Industry and Firm Factors Affecting Entry Irreversibility

Factors influencing the degree of irreversibility or sunkness may reside at the industry or the firm level of analysis. Across industries, entry may require different *types* or *magnitudes* of investment, both of which affect irreversibility. For example, some industries may necessitate more investment in facilities or equipment. Investments in tangible resources, such as plant and equipment, and intangible resources, such as R&D, may vary in salvage value across time and across industries, particularly given unique exogenous shocks to industries in which firms enter. As a result, firms should be slower to enter industries requiring a higher absolute level of investment in either tangible or intangible resources because more dollars are at risk. Investments in intangible resources may be especially susceptible to exogenous shocks. Such resources are likely to suffer from market failure (Arrow, 1968) making trade on the open market difficult relative to physical assets (Long & Malitz, 1985).

Firm-specific factors may also affect the firm's ability to re-deploy, or avoid sunk cost investments. For example, previous diversification decisions made by firms will determine the

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[4] Our definition of uncertainty corresponds to total variance of an asset price, not purely the systematic component of variance.

types of resources and capabilities already possessed by the firm. If these resources lend themselves to entry into related industries, and the firm has excess capacity, then entry may be less costly and more attractive. More relevant to our theory, if investments in the new industry can be easily re-deployed back to other industries in which the firm already competes, then the entry decision will be viewed as more reversible. Firms targeting industries more unrelated to their portfolio of businesses should have more irreversibility. Thus, the effect of uncertainty should vary depending on how related the target industry is to the firm's existing portfolio.

2.3 The Confounding Effect of Growth Options on Uncertainty

While the real option literature has tended to emphasize the opportunity costs of foregoing the option to wait, it should be noted that the presence of growth options may confound the effect of uncertainty on the likelihood of entry. Entry provides growth options if it gives the firm opportunities to make follow-on investments. Increases in volatility will increase the value of such options and increase the incentives to invest now (Roberts and Weitzman, 1981; Kulatilaka and Perotti, 1998). Any particular investment may have some characteristics increasing the value of defering investment and others that increase the value of the option to grow (Abel, et. al, 1996). Since uncertainty has an inverse effect on the value of these two options, the net effect of uncertainty on investment depends on which of these two options dominate. To our knowledge, there has been no empirical assessment as to whether the existence of growth options moderates the effect of uncertainty. Nevertheless, controlling for the presence of growth options is important when assessing to what extent the value of the option to delay is influenced by the moderating effect of irreversibility on uncertainty.

In summary, of real options theory offers the following propositions on how uncertainty and investment irreversibility jointly influence firm entry decisions:

1. The degree of irreversibility of the expansion will moderate the relationship between uncertainty and the likelihood of entry. Specifically, uncertainty will have a stronger negative effect on entry as irreversibility increases.
2. Irreversibility may differ across *industry* contexts, especially when industries require greater amounts of investment in either tangible or intangible assets.
3. Irreversibility may differ across *firm* contexts, particularly when firms can re-deploy assets to other uses at low marginal costs.

3. Empirical Precedents

Although a significant body of theoretical work has been done in recent years extending option-based models of investment, there remain significant opportunities to empirically examine these models. For example, relatively little empirical research has examined the central proposition that the effect of uncertainty on entry decisions is moderated by the degree of irreversibility. One exception is Campa (1993), who examined the effect of exchange rate uncertainty on entry by foreign firms in the United States, and found that at higher degrees of irreversibility, uncertainty had a larger negative effect on entry. He measured irreversibility in two ways: (1) the ratio of fixed assets to net wealth of all U.S. firms in an industry, and (2) the ratio of media expenditures to company sales by all U.S. firms in each industry. Only the first interaction term significantly explained entry. Given Campa's focus on international expansion, his few (industry-level) measures of irreversibility, his concentration on only one specific type of uncertainty (exchange rate), and his lack of overwhelming support for significant moderating effects, further work is needed to determine whether entry is affected by the relationship between uncertainty and irreversibility in domestic expansion settings.

Both our study and Campa's view entry as a function of two factors: expected returns and entry thresholds. Options directly influence entry thresholds, but since entry thresholds are not observable, options are proposed to influence entry, holding expected returns constant. Our approach differs from that of most other studies, which have focused on the direct effect of uncertainty on *levels of investment*. Underlying this approach is the implicit assumption that all investments are *equally* irreversible. Such an approach compromises validation of the interaction effect between uncertainty and irreversibility.

In addition, most empirical studies have examined the effect of various types of macroeconomic uncertainty on aggregate (total industry or macroeconomic) investment. For example, Pindyck (1986) demonstrates a negative correlation between the variance of lagged stock market returns and aggregate investment spending in the US. Episcopos (1995) found that the level of fixed investment in the U.S. is inversely related to five different types of macroeconomic uncertainty. Carruth, Dickerson, and Henley (2000) summarize various aggregate empirical studies that attempt to correlate investment with a proxy measure of uncertainty. The broad consensus is that there is a significant negative relationship between macroeconomic uncertainty and investment. The interaction between uncertainty and irreversibility has not been explicitly tested in these studies of aggregate investment.

While there are expected to be significant option-based effects on aggregate investment (Caballero & Pindyck, 1996), real options approaches to investment specifically attend to *firm-level* trigger points. Heterogeneity across industries and firms may mask the true effects of uncertainty in aggregate-level studies. For these reasons, Carruth, Dickerson, and Henley (2000) have argued that it is at the firm level of analysis that any measurable impact of irreversibilities on investment would most likely be detected.[5] However, they note that the results obtained by firm-level studies of investment are far less conclusive regarding the relationship between uncertainty and investment. While a number of studies report the expected negative relationship between uncertainty and investment (Campa, 1993; Guiso & Parigi, 1999; Huizinga, 1993), a number of firm-level studies also report weak or no relationships (Campa & Goldberg, 1995; Driver, Yip, & Dakhil, 1996; Leahy & Whited, 1996). One potential explanation for these contradictory findings at the level of the firm is inattention to firm-level differences in investment threshold levels. Unless firm-level studies control for differences in firm thresholds, the effects of uncertainty may be ambiguous or inconclusive. As argued earlier, firm thresholds may differ because their investments have different degrees of irreversibility.

In many ways, this body of research is related to studies examining the effect of firm diversification on entry (Montgomery et al., 1991; Silverman, 1999). A central prediction of the diversification school is that firms better able to leverage existing assets into expansion alternatives will be more likely to enter. Surprisingly, there has been little integration of real options theory into the diversification literature. Recently, however, a few studies have considered that real options theory has implications for a firm's mode of entry (Kogut, 1991; Folta, 1998). The underlying assumption of these studies is that entry modes differ in their degree of irreversibility. For example, Folta (1998) argued that equity partnerships involve less commitment than complete acquisitions, and found that uncertainty increases the likelihood that firms will expand via equity partnerships versus complete acquisition. Mode of entry is a specific case of our more general focus on entry. Thus, our work is complementary to the mode

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[5] See their paper for a more thorough discussion of why firm-level analysis offers a number of potential advantages for testing real option theory.

of entry literature, yet provides a more general examination of the entry decision and a more precise test of the interaction between uncertainty and irreversibility.

Collectively, these empirical precedents point toward our expectations, yet differ critically from the present study. Most studies focus on the relationship between uncertainty and investment levels and implicitly assume that all investments are equally irreversible across firms and/or industries. Only Campa (1993) has examined the moderating effect of irreversibility on uncertainty. However, his context was entry into international markets, and he did not consider that irreversibility may differ across firms. Further, most of the studies use industry level, not firm level data, and thus are limited in their ability to address issues relating to firm-specific resource bases, one important focus of this study.

4.0 Research Method

4.1 Data

The primary sources of data for this study come from the Compustat industrial and business segment databases, commonly referred to as the Compustat I & II databases. Compustat I contains detailed financial information at the level of the firm for all public companies in the United States. Accordingly, most of our firm level variables were drawn from this database. Compustat II provides financial data for each of a firm's business segments from 1980 to the 1999. In Compustat II, firms may report up to ten individual business segments, with six 4-digit SIC codes per segment (2 primary SSIC's, and 4 product PSIC's). Thus, for any given year, a particular firm may report up to sixty SIC codes per year. We use Compustat II to define entry, and to generate most of our industry-level variables. Our analysis included all firms listed in Compustat I and II from 1980 to 1999, which encompassed 17,861 unique firms and 143,770 firm/year observations. Thus, our data represent 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 both industry-level uncertainty and the extent of irreversibility associated with entry decisions.

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 4-digit SIC.[6] Additionally, 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.

Following Fama and French (1997) and Brav and Gompers (1998), we reclassified reported SICs into forty-eight possible industries, for which Fama and French (1997) measure industry level stock market returns. Broadly speaking, these 48 industries represent a recoding of the SIC system to somewhere between the 2-digit and 3-digit level. Using the forty-eight industry classification, we identified 12,127 instances of entry between 1981 and 1999 in the Compustat data. 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. After classifying each of the reported SICs to our industry definitions, we examined whether any reported SSIC's in the current year matched any of the possible sixty SIC's reported by the firm in the two previous

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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 not be classified outside of the more general category of the "computer industry" (Industry number 35 under our system).

years. If they did not match, and the firm was in Compustat II in the prior year, they were coded as an entry. It should be noted that one firm entering several new industries would provide multiple instances of entry.

4.2 Model Specification

Real options theory predicts that entry will occur when the discounted value of future cash flows, less the opportunity cost associated with foregoing the option to delay entry, exceeds zero. In traditional discounted cash flow models, there are a number of factors that might influence a firm's estimate of the present value of future cash flows. The current rate of industry profitability, expectations regarding future growth, the size of potential entry barriers into the industry will all influence a firm's expectations about the NPV of investment. Similarly, the value of the option to wait will also be affected by a number of different factors all related to the degree of uncertainty and irreversibility associated with the investment. To model the relationship between the likelihood of entry and these factors, we specify the following model. Specificially, we model the probability that firm *K* enters industry *J* at time *t* as: $P_t(K,J) = f[NPV_t(J,K), U_t(J), I_t(J,K), U_t(J)*I_t(J,K)]$, where expected $NPV_t(J,K)$ is a function of both industry *J* and firm *K* specific factors, $U_t(J)$ represents industry-level uncertainty, $I_t(J,K)$ represents variables affecting the degree of irreversibility for investments in industry *I* by firm *K*, and $U_t(J)*I_t(J,K)$ represents a vector of interactions between uncertainty and irreversibility.

4.3 Logit Procedure

Similar to Montgomery and Hariharan (1991), we test our model with a series of multivariate binomial logit models that compare 12,127 instances of entry with a random sample of 60,000 non-entries.[7] The sample of non-entries was created by randomly generating (with replacement) a sample of 60,000 firm-year observations, and randomly assigning industries to these observations in which firms had not competed for the previous two years. The sample of non-entries represents only a fraction of the set of all potential non-entries. Specifically, 127,073 firm-year observations combined with 48 potential industries implies 6,099,504 potential industry-firm-year combinations. Although state-based sampling does not give a pure random sample (the probability that an instance of entry is in the sample is 1, whereas the probability that an instance of non-entry is in the sample is 1.0% [60,000 / (127,073 * 48 – 143,770)], there are important advantages in state-based sampling. If a purely random sample were selected, it would consist overwhelmingly of instances of non-entry, since instances of entry form such a small proportion of the total population. In comparison to the derived state-based sample, the information yield from a purely random sample would be very small. Hence, estimates from state-based sampling have superior efficiency properties (see Manski and McFadden, 1981).

To be unbiased and consistent, however, the maximum likelihood function derived from state-based samples must be modified. This can be done through a straightforward correction where ln[(proportion of non-entries in the population that are included in the sample)/(proportion of entries in the population that are included in the sample)], or, in this case, ln(0.01/1.00), is added to the constant term. The values of all other parameters are unaffected by this procedure.

4.4 Independent Variables

4.4.1 Measurement of Uncertainty

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[7] 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.

In any empirical investigation of real options theory, uncertainty is one of the most difficult and important constructs to quantify. One approach that has been commonly employed in studies of economics and strategy is to simply calculate the variance of some output (e.g., stock price, GDP, price, exchange rate) over time. However, for our purposes, this approach has two critical shortcomings. First, it fails to account for the trends in the data. Although trends in the data will increase the measured variance, they may not constitute an element of uncertainty if they are predictable.[8] Thus, our measure of uncertainty should only consider variance about a predicted trend. Second, this approach does not allow for the possibility that the variance may be heteroskedastic (i.e., having-non constant variance over time), a characteristic that is typical of many economic time series (Bollerslev, 1986).

To address both of these concerns, we measure uncertainty with the conditional variance generated from generalized autoregressive conditional heteroskedasticity (GARCH) models, (Bollerslev, 1986). The conditional variance produced by GARCH models provides a time varying estimate of uncertainty about the trend. Fitting this model on monthly data for forty-eight different series of stock market indices from 1950 to 1998, enabled us to approximate unique time-varying estimates of uncertainty for forty-eight different industries.[9] Specifically, we employ the GARCH-in-mean, or GARCH-M model, with a functional form as follows:

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

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

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[8] For example, if a time series such as a market index were to increase 10% every year, a rational observer would believe there to be essentially no "uncertainty" in this series. However, a simple variance of these returns would exhibit a positive variance over every time interval.

[9] As an alternative measure of uncertainty, we estimated the conditional variance of industry profitability (Net Income / Assets) from quarterly Compustat I data. In using this measure of uncertainty to estimate entry, we produced qualitatively identical results to those reported in table 2.

$$(3)\ h_t = w + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \gamma_j h_{t-j}$$

$$(4)\ e_t \sim IN(0,1)$$

The GARCH process is parameterized by two values, p and q in Equation (3). 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[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(1,1) model provides excellent fit.[10]

We used the monthly conditional variances (h_t) generated from the GARCH-M(1,1) model to develop yearly measures of INDUSTRY UNCERTAINTY by taking the square root of the average conditional variance over the calendar year. We lagged these measures twelve months to account for the fact that average entry for the year occurred in the middle of the year (i.e., during June or July), and there may be a time lag of six months between the entry decision and the actual entry as recorded in Compustat.[11] For example, if entry was observed at the end of 1985, we considered uncertainty from January 1984 to December 1984.

4.4.2 Variables Pertaining to Irreversibility

A number of variables are developed to approximate industry and firm-specific irreversibility. To capture the degree irreversibility in destination industries, we use average industry R&D expenditures (INDUSTRY R&D) and average industry capital expenditures (INDUSTRY CAPEX). These measures were calculated from data in Compustat II by

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[10] 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.

[11] We also created a measure of uncertainty based on six month lags, but found that the coefficient for uncertainty did not change substantively.

aggregating across each of our forty-eight industries, and dividing by the number of firms competing in each industry. This aggregation method is identical to the one used by Montgomery and Hariharan (1991). We transform average industry R&D by a logarithm to correct for skewness.[12]

The relatedness of a destination industry to the prospective entrant should also have an effect on the degree of investment irreversibility. 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 use of French & Fama's 48 industry classification. To address these issues, we adopt a measure of industry relatedness similar to that proposed by Teece, Rumelt, Dosi, & Winter (1994), which measures the likelihood that a firm operating in industry *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 from the previous authors in that we calculate the index for the 48-industry classification used in this study and allow the measure to vary over time.

Our measure of unrelatedness (UNRELATED) between any single given industry and a firm's existing portfolio of industries was the minimum distance between that industry and all of the industries that are already in the firm's portfolio. We felt that the minimum distance between the target industry and the firm's existing portfolio was appropriate since relatedness was predicted to impact the redeployability of the assets committed to the new industry (and hence

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[12] Consistent with previous research (Minton & Schrand, 1999), INDUSTRY R&D was assumed to be zero if no R&D expenditure was listed in Compustat for a given firm/year observation. One was added to the measure prior to the logarithmic transformation.

their degree of "sunkness"). Redeployability should be most affected by the distance between the new industry and their next most appropriate use within the firm.

4.4.3 Measurement of Growth Options

Whether the option to delay or the option to grow dominates the entry decision may depend on the value of the industry's market-to-book ratio. As argued by Myers (1977), a high market-to-book ratio may be associated with a higher proportion of growth opportunities relative to assets-in-place.[13] For firms targeting entry into industries with low market-to-book ratios, the option to wait may dominate the timing decision. As the market-to-book increases, the option to grow should take on greater importance, influencing, and possibly changing, the effect uncertainty has on the likelihood of entry. Such an effect is similar to one discussed by Kulatilaka & Perotti (1998). To control for the presence of growth options we use the industry market-to-book ratio. INDUSTRY M/B was calculated from Compustat I by aggregating across firms for the industry designated at the firm's primary line of business.

4.4.4 Variables Pertaining to Other Industry and Firm Characteristics Influencing NPV

As argued previously, a firm will enter into an industry when the NPV of expected cashflows, less the opportunity costs of foregoing the option to wait, are greater than zero. Our measures of uncertainty and irreversibility allow us to account for the opportunity costs of the option to wait. However, a model that properly reflects the specification of the theoretical model should also include industry and firm variables correlated with the present value of investment. We first describe our industry-level variables approximating forecasted performance, systematic

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[13] Following Miller and Modigliani (1961), firm market value is represented by the present value of (earnings generated by) assets-in-place and growth opportunities, which can be approximated by tangible and intangible assets, respectively; whereas book value is the present value of assets-in-place.

risk, and industry structure, and then discuss our firm-level variables meant to approximate the firm's unique ability to enter new industries.

Forecasted industry performance is approximated by predicted industry returns, average firm sales, and industry growth. Predicted returns for the destination industry (INDUSTRY PRETURNS), are taken from the GARCH process identified in equation 1, $\tilde{y}_t$. We measure the industry sales (INDUSTRY SALES) from Compustat II by aggregating sales for each year across industries and dividing by the number of firms in each industry. Industry growth in sales (INDUSTRY GRSAL) measures the total growth in industry sales versus two years prior. This measure should control for the possibility that option valuations vary across industry or product life cycles (Bollen, 1999). Destination industries with higher predicted returns, higher average firm sales, and higher growth should be more attractive entry candidates.

The variable BETA provides, for each industry, an index of that industry's systematic risk relative to the whole market and is calculated in five-year increments to account for the possibility that systematic risk changes over time. On the one hand, an increase in systematic risk will tend to increase the discount rate, lowering NPV. At the same time, systematic risk may be associated with higher expected returns, raising NPV. Determining which of these effects will dominate is difficult to ascertain. It is measured by the covariance of monthly returns on each industry portfolio to the entire market portfolio.

We employ a Herfindahl ratio (CONC) to capture industry structure. We expect that more concentrated industries (i.e., higher Herfindahls) will have more significant entry barriers. This index is calculated for each industry by summing the squared market shares of all competitors in that industry. One disadvantage of this measure is that only accounts for publicly traded firms. However, for the vast majority of industries, total industry sales are dominated by publicly traded firms, minimizing measurement error. Furthermore, we do not understand how this potential problem would bias our results in any way that would favor our hypotheses.

A number of firm-specific variables help us establish which of these large, established firms are the most likely to pursue diversified expansion. FIRM DIVERS is the annual degree of firm diversification, as measured by the sum of squared shares of each of the firm's business segments, where business segments are defined as one of the 48 industries identified earlier. This measure has been commonly applied elsewhere and represents a variety of resources that may exist within a firm. We expect that a broader range of resources will lead to more entry. FIRM CAPI and FIRM R&D represent capital intensity and R&D intensity, respectively, and calculated by dividing firm capital expenditures and R&D expenditures by total firm sales. If firms have a particular competence for managing in capital intensive industries, this know-how may provide a basis for diversified expansion. Further, diversified expansion may be motivated by unused physical productive capacity. Resources represented by R&D intensity are likely to fuel diversified expansion because capacity constraints for these resources tend to be soft and they are likely to suffer from market failure, making trade on the open market difficult. Finally, FIRM SALES is measured by the logarithm of total firm sales.

All variables are calculated annually. Except for INDUSTRY UNCERTAINTY and INDUSTRY PRETURNS, all variables are lagged one year to prevent endogeneity with our dependent variable. Descriptive statistics and correlations are detailed in table 1.

[Insert tables 1 and 2 about here]

5. Results

We tested the significance of the theoretical model by examining whether the addition of independent variables significantly improved the ability to explain the choice between entry and non-entry. Table 2 reports the results from a model reflecting traditional investment theory (1), and models reflecting the real options approach (2-8). While each of these models include year fixed effects, they are not reported. An overview of the results shows that the general premise of the research, that entry is influenced by uncertainty, irreversibility (firm-specific and industry-specific), and the interaction between uncertainty and irreversibility, receives strong support.

5.1 Main Effect of Uncertainty

One key premise of real option theory is that, in the presence of irreversibility, uncertainty should have a direct negative effect on the timing of a firm's entry. Model 2 adds INDUSTRY UNCERTAINTY. A likelihood ratio test comparing model 2 with model 1 revealed a chi-square statistic of 240.0, far exceeding the critical value for one degree of freedom. This suggests that that the addition of industry uncertainty significantly improves model fit ($p < 0.0001$) relative to the traditional investment model. The negative coefficient ($p < 0.0001$) for INDUSTRY UNCERTAINTY is consistent with expectations, and suggests that greater industry uncertainty decreases the likelihood of entry.

5.2 Moderating Effects to Uncertainty

Model 3 adds the interaction term involving INDUSTRY UNCERTAINTY and INDUSTRY M/B to account for the varying impact of uncertainty in the presence of growth options. A likelihood ratio test comparing model 3 to model 2 revealed a chi-square statistic of 417.3, suggesting the interaction term significantly ($p < 0.0001$) improved explanatory power. As suggested in previously cited theoretical work, controlling for growth options appears to be important when studying the effects of uncertainty. After controlling for the presence of growth options on the effect of uncertainty, we incrementally add interaction terms (4-7) relating to irreversibility and predicted returns. Separate likelihood ratio tests comparing models 4-7 to model 3 suggest that all interaction terms significantly ($p < 0.0001$) improve explanatory power. This finding confirms our main expectation – that uncertainty is moderated by irreversibility.

Model 8 contains the full set of interaction terms. Since the coefficients and standard errors for these interaction terms do not vary considerably across models, we use model 8 to interpret individual coefficients. While the main effect of INDUSTRY UNCERTAINTY is positive in model 8, one cannot interpret total effects in the presence of significant interactions. The positive coefficient for the interaction between INDUSTRY UNCERTAINTY and INDUSTRY M/B is consistent with the view that the effect of negative effect of uncertainty becomes less pronounced in the presence of growth options. In the next section, we discuss this relationship in greater detail.

After controlling for the presence of growth options, we expect that the effect of uncertainty on entry will be moderated by the degree of irreversibility associated with entry. The negative coefficients for the interaction between INDUSTRY UNCERTAINTY and INDUSTRY CAPEX and between INDUSTRY UNCERTAINTY and INDUSTRY R&D are consistent with expectations, and suggest that the negative effect of INDUSTRY UNCERTAINTY is more pronounced when considering entry into industries with higher levels of average capital expenditures ($p < 0.0001$) and higher levels of average R&D expenditures ($p < 0.0001$).

The negative coefficient ($p < 0.0001$) for the interaction between INDUSTRY UNCERTAINTY and UNRELATEDNESS of target industries is consistent with expectations -- the negative effect of uncertainty is more pronounced when entering industries that are less related to the firm's existing operations. This finding supports our view that irreversibility differs across firms and that when combined with uncertainty, these firm-level differences bear upon entry timing decisions.

While the interaction between INDUSTRY UNCERTAINTY and INDUSTRY PRETURNS does not directly pertain to theory discussed earlier, standard expectations from real options theory are that we should see more entry when uncertainty is low and predicted returns are high. This is because the option to defer has less value at lower levels of uncertainty. As uncertainty increases so does the value of holding an option, so we should see less entry, even in industries with high predicted returns. The negative coefficient ($p < 0.0001$) for this interaction term confirms this expectation, adding validity to our option model.

5.3 The Probability of Entry and Its Elasticity with Respect to Uncertainty

The empirical results reported above, in general, suggest that our results are statistically signifcant and support our proposed hypotheses. However, since we are using a logit estimation method, it is difficult to interpret the economic significance of these variables without converting the estimated log odds to actual probabilities. The results of this conversion are reported in Table 3, which illustrates the how uncertainty influences the probability of entry at different levels of the interacted variables: INDUSTRY M/B, INDUSTRY CAPEX, INDUSTRY R&D, UNRELATED and INDUSTRY PRETURNS. While these probabilities may appear to be quite small, a relevant comparison is the ratio of observed entries over the total probability space, i.e., the number of observed entries / the number of possible entries = 12,127 / 6,099,504 = .19%.

[Insert Table 3 about here]

Table 3 reveals significant variation in the effect of uncertainty on the probabilitity of entry over the various combinations of interacted variables. The probability of entry varies most with the relatedness of the target industry (UNRELATED) and industry market-to-book (INDUSTRY M/B). Across all levels of uncertainty, higher predicted returns (INDUSTRY PRETURNS) increase the probability of entry. Table 3 also demonstrates that, in general, as uncertainty increases, the probability of entry decreases, for some variables quite precipitously.

In addition, Table 3 reports the elasticitiy of entry with repect to uncertainty for the various combinations of variables, i.e. the percentage change in the probability of entry given a percentage change in uncertainty. In general, uncertainty has a negative effect on entry, however the strength of the uncertainty effect varies considerably across the variables. For example, when INDUSTRY UNCERTAINTY is at the 50 percent quantile and INDUSTRY CAPEX is at the 10 percent quantile, the elasticity of entry with respect to uncertainty is -1.08 percent, while it is -3.02 percent at high levels (90^{th} quantile) of INDUSTRY CAPEX. When INDUSTRY UNCERTAINTY is at the 50 percent quantile and target industries are unrelated (90^{th} quantile), elasticity equals -1.57 percent, while when they are related to existing businesses, uncertainty has a smaller negative effect. In contrast to these findings, the elasticity of uncertainty with respect to INDUSTRY R&D seems to be low (i.e., changes in INDUSTRY R&D have little impact on the effect of uncertainty.)

Finally, Table 3 illuminates our findings regarding the interaction between INDUSTRY UNCERTAINTY and INDUSTRY M/B. At low levels of market-to-book, the elasticity of entry with respect to uncertainty is negative, which is consistent with an option to wait perspective. However, as market-to-book increases, the elasticity of entry gradually becomes less negative until the effect switches sign, suggesting that as uncertainty increases, the likelihood of entry also increases. This non-monotonic effect stand in contrast to the monotonic effects associated with all the other interaction variables. These findings support the view that there is less incentive to delay entry when growth options are larger (Kulatilaka and Perotti, 1998; Abel, et.al., 1997).

They also suggest growth options can dominate the option to wait, leading to a positive effect of uncertainty on entry.

5.4 Main Effects of Other Variables

The results for the other independent variables reported in table 2 are largely consistent with expectations and findings from previous research. Firms are more likely to enter industries with higher predicted returns ($p < 0.0001$), higher growth in sales ($p < 0.0001$), and higher industry sales ($p < 0.0001$).[14] Firms are less likely to enter industries with higher average capital expenditures ($p < 0.0001$) and higher average R&D expenditures ($p < 0.0001$), consistent with the view that such industries require greater degrees of irreversibility for effective entry, or have higher entry barriers. The effect of INDUSTRY M/B is significant ($p < 0.0001$), yet non-monotonic. At levels of INDUSTRY UNCERTAINTY greater than 5.80 (approximately the mean), INDUSTRY M/B has a positive effect on entry, consistent with a growth option argument. When uncertainty is lower, INDUSTRY M/B has a negative effect on entry. This may suggest that when growth options are inconsequential (because of low uncertainty), entry decisions are dominated by concerns about irreversible investment in intangible assets. In contrast to expectations, industry concentration (CONC) has a positive effect on entry. Firms are more likely to enter industries with higher systematic risk, measured by BETA ($p < 0.0001$), a finding consistent with Holland, Ott, and Riddiough (2000).

Variables pertaining to relationship-specific and firm-specific effects behave largely as expected. We find that entry is much less likely into unrelated industries ($p < 0.0001$), a finding consistent with our view that unrelated entry is less reversible and past research examining the importance of existing resource profiles. Firm size, measured by FIRM SALES, has a negative effect (0.0001) on entry.[15] The breadth of a firm's resource base (DIVERS) is a very strong predictor of entry. More diversified firms are more likely to enter new industries ($p < 0.0001$).

6.0 Summary and Discussion

In this paper we set out to test existing theory that suggests uncertainty in the face of irreversible investment will affect firm entry decisions. Firm-level empirical studies on the effects of uncertainty are few and offer little consistent support of the implications from real options theory. Furthermore, empirical research at both the aggregate and the firm levels have tended to assume that all investments are equally irreversible. We explicitly test for the effects of uncertainty at different degrees of firm- and industry-level irreversibility.

Our findings suggest that uncertainty has the expected negative relationship with entry decisions. While this expectation has been validated at the aggregate level of analysis, very few studies examine the effect of uncertainty on individual firm commitment decisions. Thus, our study, across a broad range of industries and controlling for a variety of industry and firm characteristics, including year fixed effects, provides compelling evidence that uncertainty affects firm behavior. We should note that our test is a conservative one by the inclusion of other industry specific variables that may affect uncertainty.[16] Indeed, the main and moderating effects of uncertainty are much stronger in models excluding industry level variables. Thus, by including those industry variables we believe our findings to be fairly robust. Moreover, as noted in footnote 10, our results for uncertainty were robust to different measures of uncertainty.

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[14] The positive effect of INDUSTRY PRETURNS on entry holds for levels of INDUSTRY UNCERTAINTY less than 8.97 (97th percentile).

[15] We also introduced control variables pertaining to firm market-to-book ratio, growth in firm sales, and firm profitability. However, their introduction did not substantively effect other relationships, so we exclude them because we lack complete information on these variables.

[16] A simple regression, estimating uncertainty with the other industry variables, produced an R-squared of close to fifty percent.

Our study is unique in that it provides strong support for the view that increasing degrees of irreversibility lead to a more pronounced negative effect of uncertainty on entry. Uncertainty has a stronger negative effect on entry into industries requiring more investment in capital expenditures or R&D.

In addition, the expected interaction effect is also very important when considering our firm-level measure of irreversibility. Uncertainty has a more pronounced negative effect on entry into more unrelated industries, where assets are less re-deployable across business units. This study is the first attempt that we know of to model the joint effect of uncertainty and firm-specific irreversibility. This is an exciting finding, and speaks directly to the intersection between industry conditions and firm strategy as they relate to entry. In particular, it suggests that firm entry thresholds may be as enduring as firm strategy, and not purely a temporary phenomenon that fluctuates with industry conditions. It also, however, suggests that firm strategy may have long-term implications for industry structure. In more uncertain industry conditions, related diversifiers may be more likely than unrelated diversifiers to inundate the industry; whereas in less uncertain domains, entry may be more likely to come from both types of firms.

We believe that our study illuminates the tradeoff between the option to wait and the option to grow, both of which the entry decisions may involve. Since the value of both options rises with uncertainty, and the two options have opposing effects on the incentive to invest, the theoretical literature suggests that the effect of uncertainty is ambiguous (Abel et al., 1996). We find that the effect of uncertainty is not ambiguous, and depends on the target industry's proportion of growth options relative to assets-in-place. We use industry market-to-book ratios as a measure of growth options relative to assets in place (Myers, 1977). While this interpretation is one of several for this measure, it is difficult to construct a cogent alternative explanation for the strong and consistent effect for the interaction between industry market-to-book and uncertainty on the likelihood of entry observed in Figure 1. We find that uncertainty has a negative relationship with entry across a large portion of the sample, but the negative effect decreases in importance as firms target industries with larger growth options. Ultimately, when growth options become large enough, uncertainty has a positive effect on entry, an expectation aroused by Kulatilaka and Perotti (1998). Given that theoretical work reconciling the tradeoff between options to wait and growth options is very recent, this study may provide important empirical evidence that such a tradeoff exists. Additional work should examine this tradeoff. Strategic considerations such as competitive preemption (Trigeorgis, 1991; Kulatilaka and Perotti, 1998) or learning (Roberts and Weitzman, 1981) may exacerbate the incentive to exercise growth options.

Finally, there are opportunities to explore whether our findings translate to contexts involving other strategic decisions by firms at all levels, including exit from industries, divestment, and new product introductions. Understanding how uncertainty and irreversibility combine to create unique firm investment thresholds is a promising area of research.

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Table 1: Descriptive Statistics and Pearson Correlation Coefficients

	Mean	S.D.	Min.	Max.	Pearson Correlations 1	2	3	4	5	6	7	8	9	10	11	12	13
1 INDUSTRY PRETURNS	1.223	0.399	-0.261	3.225													
2 INDUSTRY SALES	11.146	1.308	6.742	13.882	0.136												
3 INDUSTRY GRSAL	0.200	2.692	-0.498	77.491	0.000	0.094											
4 INDUSTRY CAPEX	41.757	54.005	0.493	412.465	-0.070	0.470	0.054										
5 INDUSTRY R&D	0.283	0.725	0.000	4.666	0.150	0.122	-0.019	0.039									
6 INDUSTRY M/B	0.867	0.475	0.077	4.746	0.146	-0.112	-0.015	-0.100	0.067								
7 CONC	0.058	0.048	0.008	0.362	0.052	-0.213	-0.022	0.080	0.136	-0.089							
8 BETA	1.048	0.249	0.048	1.540	0.201	-0.058	-0.028	-0.290	0.049	0.008	-0.100						
9 UNRELATED	0.927	0.058	0.611	1.000	-0.015	-0.065	-0.045	0.051	-0.024	0.060	0.075	-0.111					
10 FIRM SALES	4.017	2.518	0.000	12.061	-0.018	0.024	-0.012	0.028	0.005	0.024	-0.005	-0.018	-0.104				
11 FIRM DIVERS	0.153	0.241	0.000	0.896	0.024	0.003	0.011	-0.026	-0.013	-0.014	-0.020	0.025	-0.266	0.381			
12 FIRM CAPI	9.643	471.728	0.000	85352.000	-0.004	-0.004	-0.001	-0.002	-0.003	-0.002	-0.002	0.001	0.004	-0.027	-0.009		
13 FIRM R&D	0.640	29.329	0.000	4672.000	0.002	0.008	-0.001	-0.001	-0.003	0.006	-0.007	0.004	0.000	-0.033	-0.013	0.137	
14 INDUSTRY UNCERTAINTY	5.889	1.309	2.978	15.047	0.211	-0.433	0.017	-0.285	0.007	0.115	0.087	0.387	0.000	-0.018	0.024	0.000	0.001

n = 62,127

Table 2: Maximum Likelihood Estimates for Entry

Variable Name	1	2	3	4	5	6	7	8
INDUSTRY PRETURNS	0.2719 ** (0.0285)	0.4090 ** (0.0305)	0.4332 ** (0.0299)	0.4278 ** (0.0302)	0.4343 ** (0.0302)	0.4302 ** (0.0301)	1.0752 ** (0.1435)	1.2973 ** (0.1455)
INDUSTRY SALES	0.4383 ** (0.0098)	0.3734 ** (0.0107)	0.3627 ** (0.0108)	0.3693 ** (0.0108)	0.3625 ** (0.0107)	0.3630 ** (0.0107)	0.3670 ** (0.0108)	0.3764 ** (0.0109)
INDUSTRY GRSAL	0.0005 (0.0029)	0.0050 (0.0029)	0.0055 (0.0029)	0.0106 * (0.0029)	0.0055 (0.0029)	0.0051 (0.0029)	0.0050 (0.0029)	0.0100 * (0.0030)
INDUSTRY CAPEX	-0.0123 ** (0.0004)	-0.0115 ** (0.0004)	-0.0113 ** (0.0004)	0.0045 * (0.0013)	-0.0113 ** (0.0004)	-0.0112 ** (0.0004)	-0.0114 ** (0.0004)	0.0068 ** (0.0014)
INDUSTRY R&D	-0.3173 ** (0.0181)	-0.3054 ** (0.0181)	-0.2836 ** (0.0025)	-0.2663 ** (0.0181)	-0.2372 (0.1325)	-0.2842 ** (0.0180)	-0.2840 ** (0.0180)	-0.1833 (0.1347)
INDUSTRY M/B	0.0235 (0.0224)	-0.0195 (0.0222)	-1.7969 ** (0.0842)	-1.6924 ** (0.0841)	-1.7993 ** (0.0847)	-1.8497 ** (0.0869)	-1.7770 ** (0.0833)	-1.7342 ** (0.0850)
CONC	1.3049 ** (0.2076)	1.7386 ** (0.2066)	1.7994 ** (0.2093)	1.9903 ** (0.2090)	1.7922 ** (0.2076)	1.8241 ** (0.2065)	1.7322 ** (0.2069)	1.9143 ** (0.2099)
BETA	0.9040 ** (0.0474)	1.4246 ** (0.0599)	1.4127 ** (0.0574)	1.5100 ** (0.0566)	1.4142 ** (0.0565)	1.4111 ** (0.0562)	1.3999 ** (0.0559)	1.4981 ** (0.0556)
UNRELATED	-11.3611 ** (0.1527)	-11.3715 ** (0.1531)	-11.4871 ** (0.1526)	-11.4381 ** (0.1522)	-11.4873 ** (0.1526)	-8.9995 ** (0.7430)	-11.4880 ** (0.1526)	-8.3773 ** (0.7310)
FIRM SALES	-0.1380 ** (0.0044)	-0.1378 ** (0.0044)	-0.1406 ** (0.0024)	-0.1415 ** (0.0044)	-0.1406 ** (0.0044)	-0.1408 ** (0.0044)	-0.1405 ** (0.0044)	-0.1417 ** (0.0044)
FIRM DIVERS	2.4556 ** (0.0395)	2.4585 ** (0.0396)	2.4753 ** (0.0377)	2.4854 ** (0.0397)	2.4753 ** (0.0397)	2.4772 ** (0.0397)	2.4744 ** (0.0397)	2.4876 ** (0.0397)
FIRM CAPI	0.0001 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
FIRM R&D	-0.0004 (0.0004)	-0.0003 (0.0004)	-0.0006 (0.0005)	-0.0006 (0.0005)	-0.0006 (0.0005)	-0.0006 (0.0005)	-0.0006 (0.0005)	-0.0006 (0.0005)
INDUSTRY UNCERTAINTY		-0.1979 ** (0.0139)	-0.5110 ** (0.0212)	-0.4217 ** (0.0226)	-0.5103 ** (0.0212)	-0.1406 ** (0.1107)	-0.3532 ** (0.0401)	0.2654 † (0.1173)
INDUSTRY M/B x INDUSTRY UNCERTAINTY			0.3165 ** (0.0142)	0.2942 ** (0.0142)	0.3167 ** (0.0142)	0.3268 ** (0.0148)	0.3110 ** (0.0140)	0.2989 ** (0.0143)
INDUSTRY CAPEX x INDUSTRY UNCERTAINTY				-0.0030 ** (0.0003)				-0.0035 ** (0.0003)
INDUSTRY R&D x INDUSTRY UNCERTAINTY					-0.0077 * (0.0217)			-0.0136 ** (0.0222)
UNRELATED x INDUSTRY UNCERTAINTY						-0.4210 * (0.1235)		-0.5218 ** (0.1226)
INDUSTRY PRETURNS x INDUSTRY UNCERTAINTY							-0.1068 ** (0.0235)	-0.1461 ** (0.0240)
INTERCEPT (adjusted)	7.5604 ** (0.1969)	8.8844 ** (0.2191)	10.6744 ** (0.2387)	6.0692 ** (0.2452)	10.6718 ** (0.0239)	8.4737 ** (0.6873)	9.7365 ** (0.3163)	5.9772 † (0.7212)
Likelihood Ratio	-22762.63	-22655.29	-22459.86	-22409.04	-22459.80	-22453.94	-22447.75	-22378.84

† $p < 0.05$; * $p < 0.01$; ** $p < 0.0001$

Table 3: The Probality of Entry and Its Elasticity with Respect to INDUSTRY UNCERTAINTY at Different Quantiles of INDUSTRY M/B, INDUSTRY CAPEX, INDUSTRY RD, UNRELATED, and INDUSTRY PRETURNS

Quantile	INDUSTRY M/B		INDUSTRY CAPEX		INDUSTRY R&D		UNRELATED		INDUSTRY PRETURNS	
	Prob. Of Entry	Elasticity	Prob. Of Entry	Elasticity	Prob. Of Entry	Elasticity	Prob. Of Entry	Elasticity	Prob. Of Entry	Elasticity
Uncertainty at 10% Quantile										
1%	0.284%	-1.50%	0.188%	-0.58%	0.170%	-0.84%	1.371%	-0.47%	0.068%	-0.31%
10%	0.231%	-1.23%	0.186%	-0.62%	0.170%	-0.84%	0.461%	-0.66%	0.109%	-0.59%
50%	0.170%	-0.84%	0.170%	-0.84%	0.170%	-0.84%	0.169%	-0.84%	0.167%	-0.84%
90%	0.106%	-0.23%	0.118%	-1.73%	0.140%	-0.87%	0.117%	-0.90%	0.241%	-1.05%
99%	0.042%	0.97%	0.054%	-3.65%	0.073%	-1.00%	0.105%	-0.92%	0.321%	-1.22%
Uncertainty at 50% Quantile										
1%	0.093%	-2.62%	0.122%	-1.02%	0.091%	-1.46%	0.962%	-0.83%	0.054%	-0.54%
10%	0.092%	-2.16%	0.117%	-1.08%	0.091%	-1.46%	0.281%	-1.16%	0.070%	-1.03%
50%	0.091%	-1.46%	0.091%	-1.46%	0.091%	-1.46%	0.090%	-1.46%	0.089%	-1.46%
90%	0.089%	-0.40%	0.033%	-3.02%	0.073%	-1.53%	0.060%	-1.57%	0.110%	-1.84%
99%	0.086%	1.70%	0.004%	-6.38%	0.035%	-1.75%	0.053%	-1.60%	0.129%	-2.14%
Uncertainty at 90% Quantile										
1%	0.041%	-3.44%	0.088%	-1.34%	0.058%	-1.92%	0.742%	-1.09%	0.045%	-0.70%
10%	0.047%	-2.83%	0.083%	-1.42%	0.058%	-1.92%	0.195%	-1.53%	0.051%	-1.35%
50%	0.058%	-1.92%	0.058%	-1.92%	0.058%	-1.92%	0.057%	-1.92%	0.057%	-1.92%
90%	0.079%	-0.53%	0.013%	-3.96%	0.046%	-2.00%	0.037%	-2.06%	0.062%	-2.42%
99%	0.146%	2.22%	0.000%	-8.37%	0.020%	-2.29%	0.032%	-2.10%	0.066%	-2.80%

* Quantiles represent the location within the range of the variable.

** Base rate of entry at median levels of all variables = 0.090%.

*** All calculations are at the medians of other variables in the model.

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