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Entrepreneurs' Decisions on Timing of Entry: Learning From Participation and From the Experiences of Others

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Depending on the type of industry, an entrepreneur's decision of when to enter an industry may be a crucial one. The longer entrepreneurs wait, the more they learn from others. However, by waiting, they reduce their ability to learn directly and the possibility of locking in competitive advantages. We suggest that the optimal time of entry depends on the hostility of the learning environment since the latter has an impact on dimensions of performance, such as profit potential and mortality risk. The environment for entrepreneurial learning is less hostile when the information to be learned is abundant and when learning from others is relatively more effective at increasing performance than learning from participation. Our results suggest that delaying entry is desirable when the environment is less hostile. Entrepreneurs, however, cannot wait forever. We show that, under some general conditions, an optimal time of entry can be determined, and discuss the specific situations in which, instead, multiple equilibria may arise.

Introduction

Existing literature suggests that firms gather information through direct participation in the industry and/or vicariously from the experiences of others (Huber, 1991; Levitt & March, 1988). Most existing works focus on how learning influences the decision to enter the industry (Klepper, 1996; Nelson & Winter, 1982). To complement these works, we study how the possibility of learning from participation or from others influences the *timing* of entry given that a positive decision to enter has been made.

The distinction between learning from participation and from the experiences of others is important. While some entry strategy studies have found learning to be positively related to entry performance (Burt, 1992; Feeser & Willard, 1990), there has not been

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sufficient recognition that the amount of information learned from participation and vicariously—and their trade-off—vary from industry to industry, and from entrepreneur to entrepreneur depending on their relative learning speed. For example, some industries may offer a steep experience curve where the amount of information learned from participation early on is high but rapidly diminishes with industry maturity, whereas others may have a flatter experience curve where later entry still provides ample opportunity to learn from participation. Such differences are likely to influence the timing of entry decision and, therefore, not only the performance of individual entrepreneurs but also the competitive structure of industries.

Although learning scholars (e.g., Cohen & Levinthal, 1989, 1990) have made a significant contribution by showing that some environments enhance a firm's ability to learn while others diminish it, most studies have focused on either learning from participation or learning from the experiences of others. We contribute to this literature by investigating the relative role of both sources of learning. Our work complements Gavetti and Levinthal (2000) who use simulations to examine the role and interrelationship between search processes that are based on individuals' cognitive maps of action and those that are experience based. Gavetti and Levinthal show that, although approximate, these representations of learning still act as a powerful guide to initial search efforts and usefully constrain the direction of subsequent search. Particularly in volatile, newer, or highly dynamic industries, entrepreneurs operate under uncertainty and rely significantly on environmental clues when making decisions (Aldrich, 1999). Thus, useful insights about performance can be gained by investigating the learning captured by an entrepreneur before entry and after entry relative to the learning of later entrants.

To characterize the relative contribution of both forms of learning, we define and identify the hostility of the learning environment and relate it to timing of entry decisions. The environment for entrepreneurial learning is less hostile when the information to be learned is abundant and when learning vicariously becomes relatively more effective at increasing performance than learning from participation. The distinction between learning from participation and learning from the experiences of others forms the basis of our decision-theoretic model of entry timing. We show that, under certain conditions, comparing the information acquired by an entrepreneur before entry relative to the information available to later entrants allows the identification of a unique optimal time of industry entry which maximizes the entrepreneur's expected performance as a function of profit potential and mortality risk. A unique optimal time of entry, however, cannot always be univocally determined, and two alternative scenarios are possible. In fact, although increases in learning correspond to higher profit potential, mortality risk can be lower or higher.

In scenario 1, delaying industry entry has an impact on learning and the higher the learning (from participation or vicariously) the greater the profit potential and the lower the mortality (bankruptcy) risk, both of which increase performance. Delaying industry entry increases the amount of information that can be learned vicariously which, in turn, increases profit potential and lowers mortality risk. The amount of information learned from participation, however, is reduced, which decreases profit potential and increases mortality risk. Thus, in scenario 1 there is a clear trade-off between what the entrepreneur gains from the two types of learning, even though the two measures of performance (profit potential and mortality risk) both improve as either type of learning increases. That is, an increase in the amount of learning of either type increases profit potential and reduces mortality risk. Under these circumstances, a unique optimal time of entry can be determined. The conditions under which that optimal time exists allow us to derive insights on when entry should be delayed and when it should be expedited.

There are situations, however, when mortality risk may increase with previous learning as a greater stock of existing information may channel new thinking down known paths (e.g., Nystrom & Starbuck, 1984). Scenario 2 describes a situation in which a larger stock of existing information increase the opportunity costs of innovation, reduces flexibility and, as a result, increase profit potential but also mortality risk. Under these circumstances, a unique optimal time of entry cannot always be determined. Delaying industry entry increases the amount of information that can be learned vicariously, which increases *both* profit potential and mortality risk. The amount of information learned from participation, however, is reduced, which, in this case, decreases *both* profit potential and mortality risk.[1] As a result, multiple equilibria may arise and entrepreneurs may find themselves facing a significantly more complex entry decision.

Our study fills a gap in the literature by contributing to our understanding of how different learning environments may influence the entry behavior of entrepreneurs. Specifically, our findings change the way we think about industry entry timing and entrepreneurial learning by considering simultaneously the fact that learning varies from individual to individual and from industry to industry. In addition, our study provides new insights for policy makers with respect to the type of behavior they can expect from potential entrepreneurs in different industries.

Entrepreneurial Learning and Timing of Entry

Regardless of firm size, entry is an inherently entrepreneurial action. Lumpkin and Dess (1996) write: "The essential act of entrepreneurship is new entry. New entry can be accomplished by entering new or established markets with new or existing goods or services. New entry is the act of launching a new venture, either by a start-up firm, through an existing firm, or via internal corporate venturing" (p. 136). Kirzner (1979) defines entrepreneurial knowledge as "a rarefied, abstract type of knowledge—the knowledge of where to obtain information (or other resources) and of how to deploy it" (p. 8). Thus, entrepreneurs' information is molded by their subjective circumstances while their interests determine which elements of this information are relevant to their purposes. Clearly, entrepreneurs are not independent from one another, and what they know is the outcome of a process involving reciprocal observation, repetition, and experimentation that increase their confidence in certain actions and improve their ability to make decisions. Also, information is cumulative. What is learned in one period by someone builds upon what was learned in an earlier period by someone else (Minniti, 2005).

There is a relatively large amount of literature on entrepreneurial learning and on how entrepreneurs learn. Parker (2006) argues that there are several aspects to entrepreneurial learning, namely, what entrepreneurs learn, why entrepreneurs learn, and how entrepreneurs learn. Minniti and Bygrave (2001) argue that what entrepreneurs learn relates to conditions and opportunities in specific industries, and to how to be entrepreneurial in general. Arrighetti and Vivarelli (1999) contend that the reason why entrepreneurs learn is to increase the value of their ventures. Minniti and Bygrave also suggest that entrepreneurs learn through an ongoing adjustment process of their original plans and beliefs, possibly by trial and error. This adjustment process is also supported by McGrath and MacMillan (1995) who offer a practical tool converting (often wrong) assumptions made

1. This is consistent, e.g., with standard portfolio analysis in which systematic risk and expected profit are negatively correlated but nonsystematic risk cannot be eliminated.

by entrepreneurs about the unknown. Several other authors have argued that learning is central to the entrepreneurial process (Harrison & Leitch, 2005). Among others, Cope (2005) looked at the temporal phases of entrepreneurial learning, Lumpkin and Lichtenstein (2005) discussed the roles of behavioral, cognitive, and action learning in the opportunity recognition process. Politis (2005) considered the role played by the entrepreneur's experience. To our knowledge, no one has yet focused on our learning dichotomy and the entry timing decision. Thus, we complement these works by suggesting that the learning process is also important for the timing of entry.

With respect to entry timing, most research on market entry indicates that timing is a key factor for success. Numerous measures of performance have been used in entry timing research, thus providing some guidance on what may influence the entry decision. These measures include profitability (e.g., Abell & Hammond, 1979; Rothaermel, 2001), survival (e.g., Aaker & Day, 1986; Agarwal & Gort, 1996; Mitchell, 1989; Robinson & Min, 2002; Wernerfelt & Karnani, 1987), market share (e.g., Robinson, 1988; Robinson & Fornell, 1985; Szymanski, Troy, & Bharadwaj, 1995; Urban, Carter, Gaskin, & Mucha, 1986), and multiple measures (e.g., Lambkin, 1988; Mitchell, 1991). In this article, we conceptualize performance in terms of the combination of two dimensions: profitability and exposure to mortality risk.

In addition, an impressive body of empirical regularities has emerged from the study of firm-size distribution and the relation between firm growth rates and firm size. Klepper and Graddy (1990), for example, present a model of how chance events and exogenous factors influence the number of potential entrants in an industry, the growth rate of incumbents, and the ease of imitation of industry leaders that influence the ultimate number and size distribution of firms in the industry. Klepper (1996), instead, presents a model emphasizing differences in firm innovative capabilities and the importance of firm size in appropriating the returns from innovation. The model also explains regularities regarding the relationship within industries between firm size and firm innovative effort, innovative productivity, cost, and profitability, and predicts that, over time, firms devote more effort to process innovation but the number of firms and the rate and diversity of product innovation eventually wither. Unlike our work, the overall focus of Klepper's work is on industry structure and firms' interdependence rather than on any individual firm.

Also with a focus on industry structure and firms' interdependence, Nelson and Winter (1982) propose an evolutionary economics approach (an alternative to a neoclassical economics approach) for the study of economic growth. Because of their focus on the evolutionary aspects of industry dynamics, Nelson and Winter stress the importance of the time dimension and use various Markov processes to describe sequences of actions and reactions. They generate results on the impact of entry timing on expected profitability as a function of learning-by-doing (research and development and scale) and vicarious learning (spillovers). However, their focus is not on the entrepreneurial decision and, as such, they do not explicitly measure the effects of different types of learning on (mortality) risk and the trade-off between risk and return. While Nelson and Winter study primarily industry dynamics, our study focuses on the irreversible entry decision of a single entrepreneur given the information available to her at a specific time and the hostility of the learning environment.

Nelson and Winter (1982) take a neo-Schumpeterian view and argue that evolutionary ideas provide a workable approach to the problem of elaborating industry dynamics as an engine of progressive change. Their work allows researchers to address questions, such as why is the state of knowledge what it is? How does it change over time? Is it the same for all firms at the same time? These are question that standard decision theory cannot answer.

Decision theory, however, is very well suited to study a firm's production set and decisions for any given amount of information available. The decision when to enter the industry falls within this group. Thus, we complement their work by studying with a different method (decision theory) the details of a specific decision of the entrepreneur (when to enter) at a given point in time.

The important point in our study of the effects of learning is that, unlike other entrepreneurial choices that can be updated and emended, the decision to enter is a one-shot action that cannot be repeated or improved upon. Thus, the effect of learning on timing of entry contributes to an irreversible decision that does not have the characteristic of an updating process. When making decisions about when to enter the industry, entrepreneurs take into account the advantage they may acquire upon their competitors through learning from participation. This type of information requires the explorations of a new course of action. In this first case, entrepreneurs learn by entering the industry and by creating new, and possibly private, information. However, they also consider the information they may acquire from observing others. In this second case, entrepreneurs learn vicariously thereby exploiting preexisting and common knowledge. The relative amounts and importance of personal and public information, however, as well as the rate at which they become available are likely to differ from industry to industry.

Importantly, our distinction between two venues of learning allows us to emphasize the important distinction between "knowledge" and "information." Knowledge is context specific and is constantly changing while information is fixed (Boettke, 2002). Knowledge emerges from the specific context in which individuals act and cannot be communicated or observed. Information is a stock while knowledge is a flow, and the two concepts are fundamentally different. This is an important point because entrepreneurs cannot possibly know the knowledge they will learn outside the very process of learning. At any point in time, however, the amount of information represents a state of the system. In our model, entrepreneurs who postpone entry can learn from observing other entrepreneurs who are already in the industry. In other words, they can learn from the stock of information created by others. In an alternative, they can contribute to that stock of information by entering the industry.

Finally, our distinction between learning from participation and learning vicariously may be related to the distinction between tacit and explicit knowledge. In fact, learning from participation is more likely to contribute to the accumulation of tacit knowledge, whereas learning vicariously is more likely to be a way of acquiring explicit knowledge. Tacit knowledge, as originally characterized by Polanyi (1966), is constructed from individuals' own experience in the world. Along similar lines, Nonaka and Kanno (1998) have argued that tacit knowledge represents knowledge that people possess, while explicit knowledge represents knowledge that can be codified in tangible forms. The vast body of work related to these concepts is a testament of just how important they have become. The unfortunate consequence of all this activity, however, is that the words have grown to mean different things to different people, thus giving rise to some confusion and to strong discrepancy between many of the ideas being proposed and Polanyi's original concept.

Overall, our main concern is to view learning as occupying a central place in the development of competitive advantages which, in turn, may influence performance. Thus the exact definition of what learning from participation includes versus what learning vicariously includes is beyond the scope of our paper. The focus of our paper is not to identify what is included in the information set available to the entrepreneur at any point in time, but on variations in the relative role played by different learning venues on the decision about when to enter the industry.

Analytical Framework

Learning From Participation and Vicariously

Let t represents the time when the entrepreneur is to enter, as measured by industry age. Let P_t (>0) be the amount of information that can be accumulated from participating in the industry from t (the time of entry) to some point F in the future at which the entrepreneur will wish to (or will have to) evaluate the performance of her business.[2] The amount of learning the entrepreneur can accumulate from participating in the industry decreases as entry is delayed because, by participating in the industry longer, early entrants have more time to learn about the industry than later entrants (Burt, 1992; Feeser & Willard, 1990). In addition, the rate at which learning from participation accumulates increases at a decreasing rate (i.e., a decreasing concave relationship exists between P_t and t) since, as it matures, the industry becomes more stable and predictable and there is less new information to be learned.

Analytically, we express the information learned from participation as $P_t = C - ct^n$, $n \geq 1$, $C > cF^n$. We select an exponent function because by varying the value of the exponent n it is possible to "swipe" an infinite set of possible curves, making it easier to transform our theoretical model into an empirically testable framework. c (>0) is the rate at which the amount of information learned from participation decreases as entry is delayed. C corresponds to the maximum amount of information that can be learned from participating in the industry up until some point F in the future, when performance will be evaluated. That is, C corresponds to the amount of information that can be obtained by the industry's pioneering entrepreneur who enters at $t = 0$. The lower bound condition on this parameter insures that learning from participation stays nonnegative.[3]

An entrepreneur delaying entry does not learn from participation, but she does learn vicariously from the experiences of others (Minniti, 2005). The information available in the industry is a form of collective learning both within and outside the industry (Miner & Haunschild, 1995). Let V_t (>0) be the total amount of information that can be learned vicariously if the entrepreneur chooses to enter the industry at t. The amount of information that can be learned vicariously increases the longer entry is delayed, and can be expressed as $V_t = B + bt^m$, $m \leq 1$, where we again select an exponent function because of its flexibility. b (>0) is the rate at which the accumulation of information takes place and B ($\geq$0) is the amount of information that can be learned vicariously by the industry's pioneering entrepreneur.[4] The rate at which information accumulates as entry is delayed increases at a decreasing rate (i.e., an increasing concave relationship between V_t and t) since, as argued earlier, industries tend to become more stable and predictable as they mature.[5]

2. F is likely to be larger for, e.g., a biotech innovation as compared to software development. Model parameters such as F can be scaled accordingly to better capture the window of opportunity.
3. The amount of information gained from participation can be measured by the number of lessons learned from the experience of being in the industry, and/or past production output (Epple, Argote, & Murphy, 1996).
4. Although learning vicariously may continue after entry, our focus is on how acquired information influences the irreversible commitments associated with entering the industry.
5. The amount of information learned from others' experiences is challenging to measure. Scholars have used the aggregate cumulative production output across all relevant organizational units (Argote, Beckman, & Epple, 1990; Darr, Argote, & Epple, 1995). Vicarious learning could also be operationalized by: (1) the degree to which entrepreneurs imitate products, services, and processes that have been successful in the past; (2) the level and use of intellectual property protection, e.g., in some industries sharing information is more important than keeping it proprietary; and/or (3) a survey of the industry's pioneers or experts capturing how much a new entrant can learn from their experiences.

Profit Potential and Timing of Entry

The profit potential of an entrepreneur is the discounted expected total return to her business at some point F in the future when the performance of the venture is evaluated. Early entrants can often achieve higher profit potential than later entrants because with less competition they find it easier to gain customers (Karakaya & Kobu, 1994; Robinson, 1988) and because their industry share gains are worth more given their association with increasing sales and lower competition (Carpenter & Nakamoto, 1989; Golder & Tellis, 1993). Entrepreneurs who can learn (from participation or vicariously) faster are also likely to achieve higher profits potential because of their ability to process available information better and to incorporate it into their actions (Burt, 1992; Feeser & Willard, 1990).

Thus, we express the profit potential of the entrepreneur if industry entry occurs at t (the industry age) as $p_t = p_0 - \rho t + f\ (p_t, V_t)$. p_0 is the profit potential of the pioneering entrepreneur (not attributed to learning but to first mover advantage), ρ (>0) the direct marginal loss of profit potential due to delayed industry entry and competition, and f a nonnegative function measuring the influences of both types of learning on profit potential with $\frac{\partial f}{\partial P_t} > 0$, $\frac{\partial f}{\partial V_t} > 0$, $\frac{\partial^2 f}{\partial P_t^2} \leq 0$, and $\frac{\partial^2 f}{\partial V_t^2} \leq 0$. In other words, for any given level of accumulated learning (both vicariously and from participation), profit potential decreases over time due to the direct effect of industry aging. However, as time passes, the levels of accumulated learning also change. Specifically, as time passes, vicarious learning increases and influences profit potential positively, learning from participation, on the other hand, decreases and influences profit potential negatively. As a result, the two types of learning cause a trade-off on profit potential and we cannot conclude that overall p_t decreases (or increases) as the time of entry t is delayed. Finally, the nonincreasing rate at which p_t increases with the amount of information accumulated from both types of learning reflects diminishing marginal returns.

As argued earlier, exponent functions are promising because they make empirical validation more feasible. We thus express the contribution of both types of learning to profit potential as $f(P_t, V_t) = \mu\left[P_t^{n_1} + \nu V_t^{n_2}\right]$, where $\mu > 0$, $\nu > 0$, $0 < n_i \leq 1$, $i = 1$ or 2. μ is the marginal profit potential from total learning, whereas the parameter ν determines the contribution of learning from participation *relative* to learning from others' to profit potential. Specifically, an increase in ν implies that the information learned vicariously becomes more effective at increasing profit potential relative to the information learned from participation. In other words, when the importance of vicarious learning increases relative to that of learning from participation, profit potential increases and entrepreneurial performance may improve as entry is delayed.

Mortality Risk and Timing of Entry

Mortality risk refers to the probability that the new business will not be profitable and become insolvent and that, as a result, the entrepreneur will cease operations either by entering bankruptcy or by ceasing operations to preempt bankruptcy.[6] Similarly to profit

6. Mortality risk can be measured by an assessment of the likelihood of bankruptcy by an expert such as a venture capitalist (e.g., Shepherd, 1999) and/or the mortality rate of entrepreneurs within the industry or a similar industry (e.g., population ecology studies, such as Carroll & Delacroix, 1982).

potential, for any given level of accumulated learning (both vicariously and from participation), mortality risk decreases over time due to the direct effect of industry aging (Mitchell, 1991). Although changes in survival chances are unlikely to be smooth because of, for example, environmental jolts (Venkataraman & Van de Ven, 1998), their behavior may be reasonably approximated by an exponential function. Also, as time passes the levels of accumulated learning change and, when considering mortality risk, two alternative scenarios are possible.[7] In scenario 1, entrepreneurs who learn faster may be able to reduce their mortality risk more quickly by being able to assess more accurately the external environment and adapt accordingly their actions. In scenario 2, instead, past learning creates inertia that channels thinking down known paths. Entrepreneurs finding themselves in such a situation may be unable to adapt and reduce mortality risk and, instead, see it increase.

Given the description above, we express mortality risk when the entrepreneur enters the industry at t as $r_t = \gamma e^{-\eta t} + g(P_t,V_t)$. γ (>0) measures the effect of industry age on mortality risk, η (>0) is the exponential rate at which that mortality risk directly decreases as entry is delayed, and g is a nonnegative function with $\frac{\partial g}{\partial P_t} < 0$, $\frac{\partial g}{\partial V_t} < 0$ for scenario 1, $\frac{\partial g}{\partial P_t} > 0$, $\frac{\partial g}{\partial V_t} > 0$ for scenario 2, and $\frac{\partial^2 g}{\partial P_t^2} \geq 0$, $\frac{\partial^2 g}{\partial V_t^2} \geq 0$ for both scenarios. Thus, in scenario 1 the entrepreneur's mortality risk when she enters the industry at t decreases at a nonincreasing rate (in absolute value) with the amount of information accumulated from both types of learning, reflecting the fact that mortality risk decreases as either type of learning increases. In scenario 2, instead, mortality risk increases at a nondecreasing rate with the amount of previous learning (reflecting a sort of "competence trap"). Note also that delaying entry has a direct effect on mortality risk (reduced because of increased industry maturity), but also has indirect effects due to (1) an increase in the amount of information learned vicariously; and (2) lost opportunities to learn from participation. In other words, we cannot conclude in either scenario that overall r_t decreases (or increases) as entry is delayed.

As in the case of profit potential, we utilize exponent functions and express the contribution of both types of learning to mortality risk as $g(P_t, V_t) = G - \tau_{S1}\left[P_t^{n_3} + \theta_{S1} V_t^{n_4}\right]$ for scenario 1 and $g(P_t, V_t) = \tau_{S2}\left[P_t^{n_3} + \theta_{S2} V_t^{n_4}\right]$ for scenario 2, where $\tau_{S1} > 0$, $\tau_{S2} > 0$, $\theta_{S1} > 0$, $\theta_{S2} > 0$, $G > \tau_{S1}\left[P_0^{n_3} + \theta_{S2} V_F^{n_4}\right]$, $0 < n_i \leq 1$, $i = 3$ or 4. τ_{S1} is the marginal reduction in mortality risk from total learning in scenario 1, whereas τ_{S2} is the marginal risk from total learning in scenario 2. A decrease in θ_{S1} in scenario 1 or an increase in θ_{S2} in scenario 2 implies that the information learned from participation is more effective at reducing mortality risk than the information learned from others'. This also means that a decrease in θ_{S1} or an increase in θ_{S2} in their respective scenarios causes a reduction in the beneficial effect of both type of learning on performance. In other words, when the importance of vicarious learning increases relative to that of learning from participation, mortality risk decreases and entrepreneurial performance improves as entry is delayed.

7. Using a model of the entry decision based on the uncertain evolution over time of environmental volatility and competition, Lévesque and Shepherd (2002) have characterized the performance-maximizing time to enter an industry and have shown how this entry time is affected by changes in the business scenario.

The reverse is true, however, when the opportunity costs of adapting reduces the entrepreneur's flexibility.

Entrepreneurial Performance

Our framework allows us to investigate the potential trade-off between two measures of performance, namely profit potential and exposure to mortality risk, as the entrepreneur considers when to enter an industry. Investigating the decision between paying dividends and retaining earnings, Radner and Shepp (1996) suggest that firms should aim at maximizing a linear combination of profit and the probability of bankruptcy. Similarly, Schoemaker and Amit (1994) indicate that firms' strategic actions constitute a trade-off between profitability and risk. Such a trade-off can be captured when maximizing entrepreneurial performance is equivalent to maximizing the potential return from the new venture discounted to take into consideration the risk associated with the venture. Within this context, and consistent with the standard economic idea of a negative relationship between risk and returns, the entrepreneur's objective is to enter the industry and to maximize her expected total performance, which is a linear combination of profit potential and exposure to mortality risk.

The entrepreneur's objective function is thus given by

$$\text{(1)} \qquad \underset{t\geq 0}{\text{Max}}\{p_t - \varepsilon r_t\} = \underset{t\geq 0}{\text{Max}}\{[p_0 - \rho t + f(P_t, V_t)] - \varepsilon[\gamma e^{-\eta t} + g(P_t, V_t)]\},$$

where ε is a conversion factor that transfers each risk unit into a dollar value (this parameter can also be scaled to ensure that mortality risk stays between 0 and 1). Notice that both types of learning contribute to performance (to profit potential via the function f and to mortality risk via g) in an independent manner, that is, with no interaction effects. This separability assumption has some empirical supports from studies in which the relationship between vicarious learning and performance has been shown to be affected by the presence or absence of learning from participation, but not by its level (Argote et al., 1990; Baum & Ingram, 1998; Ingram & Baum, 1997). In addition, the mathematical properties and tractability of this framework make it particularly useful and attractive. Table 1 provides a summary of our notation.

Among others, Forlani and Mullins (2000) have shown that individuals exhibit different propensities toward risk. Along similar lines, Simon, Houghton, and Aquino (2000) have suggested that perceived risk influences individuals' willingness to start a business. Accordingly, equation 1 can also be interpreted as an individual's utility function in which, consistent with existing literature (Iyigun & Owen, 1998; Kihlstrom & Laffont, 1979), we assume individuals to be risk averse. In fact, the weight associated with (mortality) risk, ε, shows a disutility and is a proxy for an individual's propensity toward risk. Without loss of generality, the weight associated with the return (potential profit) is 1. We will show that our results are robust even when the linearity assumption on the utility function is relaxed.

Noticeably, our framework holds even if the entrepreneur's objective is to maximize profit potential *or* to minimize mortality risk, but not a combination of both. This is the case because for each of these two measures of performance there is a trade-off between the amounts of information that can be accumulated from the two types of learning as time passes. Delaying entry means that more can be learned vicariously but less from participation. As these two types of learning affect each measure of performance in an opposite way (in both scenarios), there is always a trade-off present (this also holds true when the

Table 1

Notation Summary

Notation	Description
t	Time when the entrepreneur is to enter, as measured by industry age
F	Some point in the future at which the entrepreneur will wish to (or will have to) evaluate the performance of her business
c	Rate at which the amount of information learned from participation decreases as entry is delayed
C	Amount of information that can be obtained by the industry's pioneering entrepreneur who enters at $t = 0$
$P_t = C - ct^n$	Amount of information that can be accumulated from participating in the industry from t to F
b	Rate at which the accumulation of information takes place
B	Amount of information that can be learned vicariously by the industry's pioneering entrepreneur
$V_t = B + bt^m$	Total amount of information that can be learned vicariously if the entrepreneur chooses to enter the industry at t
P_0	Profit potential of the pioneering entrepreneur (not attributed to learning)
ρ	Marginal loss of profit potential due to delayed industry entry and competition
μ	Marginal profit potential from total learning
ν	The contribution of learning from participation relative to learning from others' to profit potential
$f(P_t, V_t) = \mu[P_t^{n_1} + \nu V_t^{n_2}]$	Nonnegative function measuring the influences of both types of learning on profit potential
$P_t = P_0 - \rho t + f(P_t, V_t)$	Profit potential of the entrepreneur if industry entry occurs at t
γ	Effect of industry age on mortality risk
η	Exponential rate at which mortality risk directly decreases as entry is delayed
τ_{S1} or τ_{S2}	Marginal reduction in mortality risk from total learning
θ_{S1} or θ_{S2}	Relative importance of vicarious learning
$g(P_t, V_t) = G - \tau_{S1}[P_t^{n_3} + \theta_{S1} V_t^{n_4}]$ or $g(P_t, V_t) = \tau_{S2}[P_t^{n_3} + \theta_{S2} V_t^{n_4}]$	Relationship between both types of learning and mortality risk
$r_t = \gamma e^{-\eta t} + g(P_t, V_t)$	Mortality risk when the entrepreneur enters the industry at t
ε	Conversion factor that transfers each risk unit into a dollar value

linearity assumption on the utility function is relaxed) but some of the conditions we offer in the next section are simplified. We believe, however, that our investigation is more complete by integrating into the entrepreneur's utility function a measure of return *and* a measure of risk.[8]

Sensitivity of the Optimal Timing of Entry

Up to this point, our framework suggests that, when deciding when to enter the industry, the entrepreneur wishes to select a time of entry that maximizes her expected performance. The longer she waits the more she learns from others (which improves her returns but may also increase her mortality risk) but the less she learns from direct participation (which reduces her returns but may also reduce her mortality risk). Our framework also suggests that how long she should wait to enter depends on the "hostility" of the learning environment. That is, on how much the entrepreneur can learn to begin

8. Most literature on learning and entry (among others, Klepper, 1996; Klepper & Graddy, 1990; Nelson & Winter, 1982) analyzes the impact of entry timing on expected profitability as a function of learning-by-doing (R&D and scale) and vicarious learning (spillovers). However, this literature does not explicitly measure the effects of both types of learning on (mortality) risk and the trade-off between risk and returns.

with (as captured by the parameters C and B), on the speed at which she can learn new information directly and from others (as captured by the rates c and b), and on whether the value to her performance of information provided by others increases *relatively* to that provided by information she can gain by participating (as captured by θ_{S1} or θ_{S2} and ν).[9] Changes in any or all of these parameters influence her decision. Our framework allows us to prove that, under pretty general circumstances, a unique optimal time of entry exists. In other words, that an entry-timing decision that maximizes performance and is superior to all others is possible.

Local, as opposed to global, optima would suffice for the results presented herein to hold true (at least generically). Consequently, the optimality conditions we articulate are tighter than needed. Moreover, specifying conditions for local optima would not add qualitative insights. We therefore choose to keep the analysis simpler by focusing on global optima. To establish how changes in key model parameters affect the timing of entry, we conduct a comparative static analysis on such parameters and derive entry timing propositions. All necessary and sufficient conditions for optimality are provided by the first and second order derivatives of the performance function in equation 1 with respect to t and are presented in the Appendix. Sufficient conditions for uniqueness are also derived.

Conditions for Optimality and Uniqueness

In scenario 1, the performance function is shaped as an inverted U (i.e., concave) and a unique optimal entry time exists. The necessary condition for this optimal entry time occurs when the marginal gain from delaying entry equals its marginal cost. The marginal gain from delaying entry is generated by a decrease in mortality risk directly due to industry maturity (age) and an increase in the information learned vicariously, whereas the marginal cost arises from a decrease in profit potential caused by delaying entry and from the forgone opportunity to learn from participation. We characterize sufficient conditions for a unique optimal timing of entry also for scenario 2, but these conditions are tighter than those for scenario 1. Specifically, (1) the same power functions for the contribution of learning from participation and vicariously to profit and mortality risk must be utilized for mathematical tractability (captured in C1 below); and (2) in relative terms, the benefit from increased profit potential has a higher impact on performance than the loss associated with mortality risk (captured in C2 and C3 below).[10] These conditions are derived in the Appendix and expressed as

$$n_1 = n_3 \text{ and } n_2 = n_4 \text{ (C1)}, \quad \varepsilon < \frac{\mu}{\tau_{S2}} \text{ (C2)}, \quad \varepsilon < \frac{\mu\nu}{\tau_{S2}\theta_{S2}} \text{ (C3)}.$$

Given our model, we are now able to derive entry propositions that hold for scenario 1, and for scenario 2 under conditions C1–C3. The results for scenario 1 and for scenario 2 (under conditions C1–C3) are identical. As mentioned earlier, when C1–C3 do not hold, we can no longer guarantee that the optimal time of entry is unique.

9. The latter condition compares the effectiveness at increasing profit potential and decreasing mortality risk from learning vicariously *relative* to learning from participation.
10. In other words, the conversion factor that transfers each risk unit into a dollar value must be relatively low implying that entrepreneurs need to attach a relatively low opportunity cost to mortality risk. As a result, the fact that learning increases mortality risk in scenario 2 does not change the results.

Industry Participation and Timing of Entry

Proposition 1[11]: Ceteris paribus, the entrepreneur should expedite entry when the rate of decline in the amount of information learned from participation increases (i.e., c is increased) while entry is delayed.

If the marginal amount of information learned from participation decreases at an increasing rate while the entrepreneur delays entry, it means that the benefits to be gained from participation accrue more quickly than those from vicarious learning; in other words, that it is possible to create and retain competitive advantages from early entry. In those cases, participation is beneficial if the entrepreneur enters in the early stages of the industry. While some entry strategy studies have found learning from participation to be positively related to performance (Burt, 1992; Feeser & Willard, 1990), there has not been sufficient recognition that the amount of information learned from participation varies across industries. These variations have a very important effect on the timing of entry decision. For example, early entry in some industries may produce a lock-in effect or network externalities that later entrants may find hard or impossible to penetrate (Arthur, 1989). In other cases, instead, most of the risks are faced in the early stages of the industry while later stages still provide ample opportunity to learn from participation. Also, capturing the relationship between a maturing industry and learning from participation has the potential to add further insight into contingency theories of entry strategy and the environment.

Proposition 2: Ceteris paribus, the entrepreneur should expedite entry when the amount of information from participation at $t = 0$ is lower (i.e., C is low).

This proposition refers to situations in which the entrepreneur needs to participate longer in order to accumulate learning from participation. In other words, if the amount of learning from participation to be realized by an entrepreneur at the beginning of the industry's life cycle is low, then that entrepreneur should enter early in order to build up her information set compared with other entrepreneurs with higher initial learning abilities. It is important to recall that C (as many of the parameters in our model) is individual specific and contributes to describing the entrepreneur's learning abilities. As mentioned in the introduction, the amount of information learned from participation and vicariously varies not only across industries, but also among entrepreneurs depending on their relative learning speed. Although some entry strategy studies have looked at the relationship between learning from participation and performance (i.e., Burt, 1992; Feeser & Willard, 1990), to our knowledge there has been no sufficient recognition that the amount of information learned from participation varies and that these variations are likely to influence the timing of entry decision and, as a result, not only individuals' performance but also the competitive structure of industries.

Vicarious Learning and Timing of Entry

Proposition 3: Ceteris paribus, the entrepreneur should expedite entry when the rate at which information learned vicariously (before entry) accumulates decreases (i.e., b is decreased).

A decrease in the marginal accumulation of information learned vicariously means that entrepreneurs will learn less quickly from the experience of others relative to

11. Proofs of all propositions are provided in the Appendix.

participation. This, in turn, encourages them to expedite entry. Heterogeneity in the rate of learning vicariously might be captured by industry velocity. In high-velocity industries, competitive advantage arises from rapidly creating and deploying new knowledge (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997). A high-velocity industry may indicate an environment where the opportunity to learn vicariously before entry is relatively low and therefore it is unlikely that an entrepreneur can benefit from delaying entry to learn vicariously and use that information to improve performance.

We further note that the rate b at which information learned vicariously (before entry) accumulates captures (in an aggregated manner) the fact that others can learn from the entrepreneur. That is, competitive forces are implicit and aggregated in our framework. As per proposition 3, if, ceteris paribus, others can learn from the entrepreneur faster (a relative diminution in b), then entry should be expedited in order to take advantage of first mover advantages (including higher profit potential).

> **Proposition 4:** Ceteris paribus, the entrepreneur should expedite entry when the amount of information learned vicariously at $t = 0$ is higher (i.e., B is high).

This proposition refers to situations in which the entrepreneur is able to acquire vicarious learning rapidly. If the entrepreneur accumulates upfront a good amount of information from the experience of others, she benefits from being an early participant in the industry. That is, when the amount of vicarious learning to be realized by the entrepreneur at the beginning of the industry life cycle is high, she should expedite entry in order to take advantage of her learning ability. It is important to recall that B (as is many of the parameters in our model) is individual specific and contributes to describing the entrepreneur's learning abilities. The discussion presented following proposition 2 applies to proposition 4 as well.

Hostility of the Learning Environment and Timing of Entry

Cohen and Levinthal (1989, 1990) found that a firm's ability to learn information depends on characteristics of the environment, which include the complexity of the information to be learned and the degree to which outside information is relevant to the needs and concerns of each specific firm. We expand their conceptualization to entrepreneurial learning and argue that the novelty component of entrepreneurial decisions elevates significantly the importance of the trade-off between learning directly or from others. Entrepreneurs operate under uncertainty and, when making decisions, rely significantly on environmental clues (Aldrich, 1999). This is particularly true in volatile, newer, or highly dynamic industries. Thus, useful insights about performance can be gained by investigating the learning captured by an entrepreneur before entry and after entry relative to the learning of later entrants. We argue that less "hostile" environments for entrepreneurial learning exist when (1) more information can be learned vicariously and from participation (and hence these environments yield a higher increment in entrepreneurial performance); and (2) when the information learned from the experiences of others is relatively more effective at increasing performance than is the information learned from participation.[12]

12. Our argument is consistent with Cohen and Levinthal (1989) who argue that learning-by-doing is more effective in more hostile learning environments.

Propositions 1–4 allow us to identify condition (1) above. The entrepreneur learns more when the amount of learning from participation to be obtained at $t = 0$ is augmented (i.e., C is increased), and/or its rate of decline (as entry is delayed) is diminished (i.e., c is decreased), and/or when the rate of accumulation of vicarious learning increases while she is waiting to enter (i.e., b is increased). These results from propositions 2, 1, and 3, respectively, suggest that increased learning produces incentives toward delaying entry. However, the entrepreneur also learns more when the amount of vicarious learning to be obtained at $t = 0$ is augmented (i.e., B is increased). The latter result from proposition 4 suggests that increased learning produces incentives toward expediting entry. Thus, in order to complete our analysis of timing of entry decisions (and identify condition (2) above), it is necessary to determine the relative contribution to performance provided by changes in learning from experience and by changes in learning from the experiences of others.

To this purpose, we synthesize changes in the model's parameters by assessing how difficult it is to learn in the entrepreneur's environment (i.e., satisfy (2) above). Specifically, we rely on ν, the effectiveness of participation in increasing profit, as well as on θ_{S1} and θ_{S2}, the effectiveness of participation in decreasing mortality risk for scenario 1 and scenario 2, respectively.

Proposition 5: Ceteris paribus, the entrepreneur should expedite entry when the effectiveness of learning from participation for both increasing profit and decreasing mortality risk increases (i.e., ν and θ_{S1} are decreased for scenario 1, whereas ν is decreased but θ_{S2} is increased for scenario 2).

We utilize propositions 1–5 to infer how the timing of industry entry in a more "hostile" environment for learning compares to that of a less "hostile" one. Table 2 provides a summary of our prescriptions (and thus of propositions 1–5).

If the learning environment is more hostile via a small ν and a small θ_{S1}, or via a small ν but a large θ_{S2}, then participation rather than vicarious learning provides relatively greater profit potential and reduction in mortality risk (although in more hostile environments both learning vicariously and from participation are diminished via a decrease in b, B, C and an increase in c). Expedited entry is then associated with an increased profit potential and a decreased risk from information learned that more than outweighs the direct costs of time on risk. However, if the learning environment is less hostile (both ν and θ_{S1} are large, and both learning vicariously and from participation are augmented via an increase in b, B, C and a decrease in c) then learning vicariously is relatively more important than via participation. Delayed entry increases the amount of information learned vicariously and therefore increases potential profit and decreases risk. This increase in the profit potential and the reduction in risk (from both delaying entry and increasing learning) outweighs the loss in profit potential resulting directly from delaying entry. Therefore, based on the results of the proposition stated above (and as illustrated in Table 2, second and third column) entry should be *expedited in more hostile learning environments* and *delayed in less hostile learning environments*.[13]

When conditions C2 and C3 for scenario 2 are violated, the conversion factor (ε) that transfers each risk unit into a dollar value is relatively large, and the entrepreneur

13. Noticeably, in our model, heterogeneous individuals (as well as different industries) can be easily characterized by altering the magnitude of the parameters. For example, everything else being the same, an individual who learns quickly from participation (e.g., C is large and/or c is small) but slowly vicariously (e.g., B and/or b is small) should delay entry in either scenario 1 or 2 (respectively, second and third columns in Table 2) compared with an individual able to accumulate information equally from both types of learning.

Table 2

Hostility of the Environment for Learning and Timing of Entry

	Entry timing				
	Additive utility function			Multiplicative utility function‡	
	Scenario 1	Scenario 2		Scenario 1	Scenario 2
		Low-risk cost (i.e., C1–C3 hold)	High-risk cost† (i.e., C1 holds, C2–C3 do not hold)	Profit potential p_0 of the pioneering entrepreneur is sufficiently large and, at the optimal entry time t^*, the ratio of change $\partial r_t/\partial t$ in mortality risk to survival risk $[1-r_t]$ is below a threshold	
More hostile environments are characterized by an *increase* in					
Rate at which information learned from participation decreases as entry is delayed (c is increased)	Expedite	Expedite	Delay	Expedite	Delay
Effectiveness of participation in increasing profit (v is decreased)	Expedite	Expedite	Expedite	Expedite	Expedite
Effectiveness of participation in decreasing risk (θ_{S1} is decreased or θ_{S2} is increased)	Expedite	Expedite	Expedite	Expedite	Delay
But a *decrease* in					
Information learned from participation at the time of entry for the pioneer (C is decreased)	Expedite	Expedite	Delay	Expedite	Delay
Rate at which information learned vicariously increases as entry is delayed (b is decreased)	Expedite	Expedite	Delay	Expedite	Delay
Information learned vicariously at the time of entry for the pioneer (B is decreased)	Delay	Delay	Expedite	Delay	Expedite

† The performance function must be concave on the planning time horizon $[0,F]$.
‡ The first and second order conditions for optimality are satisfied when the rate of change over time in profit potential and mortality risk are either both negative or both positive and, in the case of scenario 2, γ is sufficiently large or τ_{S2} is sufficiently small.

experiences a high-risk cost. If the objective function remains concave and, therefore, there exists a unique optimal entry timing, expediting entry in a hostile environment may no longer be the dominating strategy. Indeed, changes in the parameters as described in Table 2 (fourth column) then suggest an expedited industry entry for only half of these parameters. Changes as described in Table 2 for the other half of the parameters suggest, instead, a delayed industry entry.

Although the timing of entry is sensitive to changes in the profit potential p_0 of the pioneering entrepreneur, the effect γ of industry age on mortality risk, and the exponential rate η at which that risk decreases, our qualitative results are not and, in fact, the assumption that potential profit declines at a fixed rate and the assumption that mortality risk declines at an exponential rate can both be relaxed. Also, the direct marginal loss of profit potential ρ due to delayed entry can be used to capture the per-period cost of learning vicariously. If this cost increases with the hostility of the learning environment, which makes good intuitive sense, then our results are robust and entry should be expedited in more hostile environments for learning. Learning from participation, however, does not have a cost in our baseline framework. Nevertheless, it is straightforward to verify that, if each period of participation involves a cost, our results hold if that cost increases with the hostility of the learning environment but does not exceed the per-period cost ρ of learning vicariously (which makes intuitive sense since otherwise it would not pay for the entrepreneur to be in the industry).

Finally, as formally shown in the Appendix, our results are robust even when performance is represented by a multiplicative function of profit and risk and equation 1 becomes $\underset{t \geq 0}{\mathrm{Max}}\{p_t[1-r_t]\}$, which functional form also captures the trade-off between risk and return highlighted by Schoemaker and Amit (1994).[14] This functional form is appealing because it is based on the computation of an expectation where potential profit is zero if the venture does not survive. In scenario 1, whereby increases in learning correspond to higher profit potential and lower mortality risk, reasonable conditions are sufficient for all of our propositions to hold true. These conditions are: (1) profit potential p_0 of the pioneering entrepreneur (not attributed to learning) is sufficiently large (which also keeps profit potential nonnegative and entry attractive); and (2) at the optimal entry time, the ratio of *change in mortality risk* to *survival risk* (i.e., $\left.\frac{\partial r_t/\partial t}{1-r_t}\right|_{t=t^*}$) is below a threshold. We then still recommend that entry be expedited in more hostile environments for learning, as summarized in Table 2 (fifth column). However, in scenario 2, where increases in learning correspond to higher profit potential but also higher mortality risk, we find that all but one of our sensitivity results are violated under conditions (1) and (2). As a result, changes in the parameters as described in Table 2 (sixth column) suggest an expedited entry for only two out of six of these parameters.

Conclusion

Learning scholars, such as Cohen and Levinthal (1989, 1990), have made a significant contribution to our knowledge of the relationship between learning and the environment,

14. We demonstrate in the Appendix that concavity is preserved is scenario 1, but in scenario 2 it requires that the effect of industry age on mortality risk (γ) be sufficiently large or, equivalently, that the marginal reduction in mortality risk from total learning (τ_{S2}) be sufficiently small.

i.e., that some environments enhance a firm's ability to learn while others diminish it. Given the novelty involved in entrepreneurial activity, we argue that learning from participation and learning from the experiences of others are particularly important factors in such entry decisions, especially in certain types of industries. The longer the entrepreneur waits the more she learns from others but by doing so she reduces her ability to learn directly and, therefore, to appropriate a comparative (possibly first mover) advantage. Thus, to help her decision, the entrepreneur considers whether she can improve her performance more by learning what others are doing and delaying entry or if, instead, she is better off by entering. We show that how long the entrepreneur should wait to enter the industry depends on the hostility of the environment. That is, on how much there is to learn to begin with (captured by propositions 2 and 4), on the speed at which she can learn new information directly and from others (captured by propositions 1 and 3), and on whether the information created by others is *relatively* more valuable for her performance than the information she can gain by entering (captured by proposition 5).

Overall, our results prove that delaying entry is more sensible the less hostile is the environment. Yet, the entrepreneur cannot wait forever. Our model shows that, under some pretty general conditions, it is possible to identify a unique optimal time of entry, and allows us to discuss specific situations in which multiple equilibria arise and a unique optimal time cannot be determined.[15] Our learning approach to the investigation of entry timing presents a number of relevant features. First, both sources of learning, and their trade-offs, are taken into consideration in making the timing of entry decision. Second, the role of the environment on the optimal time to enter an industry is investigated in terms of its impact on learning from participation and/or vicariously. Third, entry performance is determined by a combination of profitability and risk.

This study contributes to our understanding of how entrepreneurs learn and of the fact that learning varies from individual to individual and from industry to industry, which in turn suggests a strong tendency for earlier industry entry when one faces a more hostile environment for learning. It also contributes to the industrial economics literature (Cohen & Levinthal, 1989, 1990) by extending the concept of the hostility of an environment for learning. To complement this literature, we use a decision-theoretic approach to characterize the optimal timing of entry for an entrepreneur, and to assess how this entry time is influenced by changes in key model parameters, including those that characterize the hostility of the learning environment. We extend this concept of the hostility of an environment for learning to include the marginal accumulation of information learned from participation, the information learned from participation at the time of entry for the pioneering entrepreneur, the marginal accumulation of information learned vicariously, the information learned vicariously at the time of entry for the pioneering entrepreneur, and the effect on profit potential and risk of vicarious learning relative to learning from participation.

From a practical point of view, our model points out that one's level of industry expertise is significant when evaluating the hostility of the learning environment. For example, given a specific industry, let us compare an entrepreneur with many years of work experience in the industry—referred to as the "expert"—to one with a few years of work experience in that same industry—referred to as the "novice." Let us assume that both entrepreneurs have gone through similar education and, as a result, there is no

15. The actual specification of how long to wait and when to enter is beyond the scope of this paper and it requires the calculation of numerical values for all model parameters. Most of these parameters are specific to the entrepreneur while two of them (γ and η) are specific to her industry since they characterize the direct effect from delaying market entry on mortality risk (which declines with industry maturity).

obvious reason to believe that they would exhibit differences in the speed at which they can learn new information directly and from others. The novice would likely face a more hostile environment than the expert because, relative to the expert, the novice would have more to learn to begin with and the information created by others would be relatively less valuable for her performance. Thus, our model would suggest that the novice entrepreneur should be an early entrant as the gains from learning from participating in the industry would overcome the gains from learning from others.

Our investigation of entrepreneurial learning before entry provides a relatively simple model of the timing of entry decision. Although frameworks dealing with this type of issue are very difficult to operationalize, empirical testing could be addressed with the development of an economic experiment. Indeed, our decision-theoretic framework could be used to develop an experiment testing how long the entrepreneur would wait before entering. The experiment output could then be compared with what entrepreneurs actually do. By providing multiple decision scenarios, this experiment could also be used to test the behavior of decision makers with respect to the qualitative prescriptions in propositions 1–5. Of course, testing propositions from analytical models with real world data is often a challenge. Nevertheless, our model lends itself well to be tested empirically. For example, when considering proposition 2, data should be obtained that would allow proxy measures of (1) the date at which the industry started; (2) the date at which the entrepreneur entered the chosen industry; and (3) the amount of learning from participation to be realized by an entrepreneur at the beginning of the industry's life cycle. Market size and first sales could be used for (1) and (2), respectively. Consistent with existing literature on learning, the more complex learning potential of the entrepreneur, instead, could be approximated as a weighted average of the entrepreneur's experience in the chosen industry and her education as well as that industry's requirement for specialized expertise.

Far from closing the debate on this area of research, our study and model lend themselves to several other research extensions. For example, it should be pointed out that it is not clear how purposeful entrepreneurs might be about assessing their learning. Our model is perfectly compatible with this issue as it relies entirely on relative comparisons: The type of information necessary includes only whether or not entrepreneur X learns new information faster than entrepreneur Y; whether or not entrepreneur X learns faster from others than entrepreneur Y; whether or not entrepreneur X has to learn more (because e.g., she is a novice in the industry) than entrepreneur Y; and whether or not relative performance associated with the information created by others as compared with that gained by participating in the industry is (relatively) less valuable to entrepreneur X than to entrepreneur Y. Entrepreneurs, like all human beings, compare themselves to peers (and perhaps even to role models) and make assessments about their position with respect to others. Whether these comparisons are indeed implicit or explicit could be the subject of an interesting test for our model to be developed in a follow-up paper.

Finally, our framework of entrepreneurial learning and entry timing could be extended to allow for the explicit consideration of competitive forces and the resulting effect on industry structure. In this case, a simulation balancing real-world complexity with mathematical tractability could be used. A simulation model could be also used to study industry evolution. This would require modeling rivalry and reaction times, assuming some randomness, and alternative degrees of rationality and information (Nelson & Winter, 1982). Unlike our current framework, which focuses on individual decisions, such a model would be useful in studying industry structure and how the timing of entry of various participants influences the industry's convergence toward any particular type of equilibrium. Indeed, an appropriately modified version of our model could be used to study issues related to organization rather than individual learning along lines identified by Huber (1991) and Levitt and March (1988). Finally, the model can be used to analyze the possibility of competency traps in organizations. In other words, our model could be extended to study issues related to strategic entry timing in highly dynamic industries or unstable industry situations. This has clear policy implications since it could be applied to post-war and post-disaster economies, as well as high-tech industries.

Appendix: Mathematical Derivations

Entry Timing. The first and second order conditions for optimality are, respectively,

(A1)
$$\varepsilon\eta\gamma e^{-\eta t}-\rho+\frac{dP_t}{dt}\left(\frac{\partial f}{\partial P_t}-\varepsilon\frac{\partial g}{\partial P_t}\right)+\frac{dV_t}{dt}\left(\frac{\partial f}{\partial V_t}-\varepsilon\frac{\partial g}{\partial V_t}\right)=0$$

(A2)
$$\text{and } -\varepsilon\eta^2\gamma e^{-\eta t}+\left(\frac{d^2P_t}{dt^2}\right)\left(\frac{\partial f}{\partial P_t}-\varepsilon\frac{\partial g}{\partial P_t}\right)+\left(\frac{\partial P_t}{\partial t}\right)^2\left(\frac{\partial^2 f}{\partial P_t^2}-\varepsilon\frac{\partial^2 g}{\partial P_t^2}\right)+ \frac{d^2V_t}{dt^2}\left(\frac{\partial^2 f}{\partial V_t^2}-\varepsilon\frac{\partial^2 g}{\partial V_t^2}\right)<0.$$

A2 holds for any t in scenario 1. In scenario 2, if $n_1 = n_3$ and $\mu - \varepsilon\tau > 0$ then $[\partial f/\partial P_t] - \varepsilon[\partial g/\partial P_t] > 0$ and $[\partial^2 f/\partial P_t^2]-\varepsilon[\partial^2 g/\partial P_t^2]<0$, and if $n_2 = n_4$ and $\mu v - \varepsilon\tau\theta_{s2} > 0$ then $[\partial^2 f/\partial V_t^2]-\varepsilon[\partial^2 g/\partial V_t^2]<0$. Under these conditions, A2 also holds.

Proof of Propositions 1–5. Let $h_{tt}(t^*,\cdot)$ be the left-hand side of A2 evaluated at t^* and "$\cdot$" the parameter in question. For proposition 1, in scenarios 1 and 2, respectively, for any t

$$\frac{dt^*}{dc}=\left[\frac{-1}{h_{tt}(t^*,c)}\right]\cdot\Big\{-nt^{n-1}\left[\mu n_1[C-ct^n]^{n_1-1}+\varepsilon\tau n_3[C-ct^n]^{n_3-1}\right]- cnt^{2n-1}\left[\mu n_1[1-n_1][C-ct^n]^{n_1-2}+\varepsilon\tau_{S1}n_3[1-n_3][C-ct^n]^{n_3-2}\right]\Big\}<0$$

and

$$\frac{dt^*}{dc}=\left[\frac{-1}{h_{tt}(t^*,c)}\right]\cdot\left[-nt^{n-1}n_1[C-ct^n]^{n_1-1}+cnt^{2n-1}n_1[1-n_1][C-ct^n]^{n_1-2}\right]\cdot[\mu-\varepsilon\tau_{S2}]<0.$$

Similarly, for propositions 2, 3, and 4, respectively,

$$\frac{dt^*}{dC}=\left[\frac{-1}{h_{tt}(t^*,C)}\right]\cdot[cnt^{n-1}]\cdot\left[\mu n_1[1-n_1][C-ct^n]^{n_1-2}+\varepsilon\tau_{S1}n_3[1-n_3][C-ct^n]^{n_3-2}\right]>0$$

and $\displaystyle\frac{dt^*}{dC}=\left[\frac{-1}{h_{tt}(t^*,C)}\right]\cdot\left[cnt^{n-1}n_1[1-n_1][C-ct^n]^{n_1-2}\right]\cdot[\mu-\varepsilon\tau_{S2}]>0.$

and $$\frac{dt^*}{db}=\left[\frac{-1}{h_{tt}(t^*,b)}\right]\cdot\left\{\mu\nu n_2\left[B+bt^m\right]^{n_2-2}mt^{m-1}\left[B+bn_2t^m\right]+\right.$$
$$\left.\varepsilon\tau_{S1}\theta_{S1}n_4\left[B+bt^m\right]^{n_4-2}mt^{m-1}\left[B+bn_4t^m\right]\right\}>0$$

$$\frac{dt^*}{db}=\left[\frac{-1}{h_{tt}(t^*,b)}\right]\cdot\left[n_2\left[B+bt^m\right]^{n_2-2}mt^{m-1}\left[B+bn_2t^m\right]\right]\cdot\left[\mu\nu+\varepsilon\tau_{S2}\theta_{S2}\right].$$

$$\frac{dt^*}{dB}=-\left[\frac{-1}{h_{tt}(t^*,B)}\right]\cdot bmt^{m-1}\cdot\left\{\mu\nu n_2[1-n_2]\left[B+bt^m\right]^{n_2-2}+\right.$$
$$\left.\varepsilon\tau_{S1}\theta_{S1}n_4[1-n_4]\left[B+bt^m\right]^{n_4-2}\right\}<0$$

and $$\frac{dt^*}{dB}=-\left[\frac{-1}{h_{tt}(t^*,B)}\right]\cdot bmt^{m-1}\cdot\left[n_2[1-n_2]\left[B+bt^m\right]^{n_2-2}\right]\cdot\left[\mu\nu+\varepsilon\tau_{S2}\theta_{S2}\right]<0.$$

For proposition 5, for any t, $\frac{dt^*}{d\nu}=-\left[\frac{-1}{h_{tt}(t^*,\nu)}\right]\cdot bmt^{m-1}\mu n_2\left[B+bt^m\right]^{n_2-1}>0$. Furthermore,

$$\frac{dt^*}{d\theta_{S1}}=-\left[\frac{-1}{h_{tt}(t^*,\theta_{S1})}\right]\cdot bmt^{m-1}\varepsilon\tau_{S1}n_4\left[B+bt^m\right]^{n_4-1}>0$$

and $$\frac{dt^*}{d\theta_{S2}}=-\left[\frac{-1}{h_{tt}(t^*,\theta_{S2})}\right]\cdot bmt^{m-1}\varepsilon\tau_{S2}n_4\left[B+bt^m\right]^{n_4-1}>0.$$

Multiplicative Objective Function. The first and second order conditions for optimality are, respectively,

$$p_t\frac{\partial r_t}{\partial t}+\frac{\partial p_t}{\partial t}[1-r_t]=0 \text{ and } -2\frac{\partial p_t}{\partial t}\frac{\partial r_t}{\partial t}-p_t\frac{\partial^2 r_t}{\partial t^2}+\frac{\partial^2 p_t}{\partial t^2}[1-r_t]<0\cdot$$

If $p_t > 0$, one requires $\left.\frac{\partial p_t}{\partial t}\frac{\partial r_t}{\partial t}\right|_{t=t^*}>0$ for the former to hold. The latter holds for any t if $\partial^2p_t/\partial t^2 < 0$ and $\partial^2r_t/\partial t^2 > 0$. In scenarios 1 and 2, $\partial^2p_t/\partial t^2 < 0$ whereas $\partial^2r_t/\partial t^2 > 0$ unconditionally in scenario 1, but not in scenario 2 in which, however, it is sufficient that γ be sufficiently large or τ_{S2} sufficiently small. To characterize how a change in c affects t^*, we must identify the sign of

(A3) $$\left.-\frac{\partial p_t}{\partial c}\frac{\partial r_t}{\partial t}-p_t\frac{\partial^2 r_t}{\partial c\partial t}+\frac{\partial^2 p_t}{\partial c\partial t}[1-r_t]-\frac{\partial p_t}{\partial t}\frac{\partial r_t}{\partial c}\right|_{t=t^*}.$$

In scenario 1, $\partial p_t/\partial c < 0$ and $\partial r_t/\partial c > 0$ for any t. Also, $\partial^2r_t/\partial c\partial t < 0$ and $\partial^2p_t/\partial c\partial t > 0$ when $C > [2 - \min\{n_1,n_3\}]cF^n$. Hence, regardless of the sign of $\partial p_t/\partial t$, with $\left.\frac{\partial p_t}{\partial t}\frac{\partial r_t}{\partial t}\right|_{t=t^*}>0$, the sign of A3 is negative if p_0 is large enough. In scenario 2, similar derivations lead to a positive sign for A3. The same analysis allows us to verify that, under the conditions stated above, dt^*/dC and dt^*/db are positive in scenario 1 but negative in scenario 2, and that dt^*/dB is negative in scenario 1 but positive in scenario 2. However, since r_t is unaffected by ν,

$$\text{(A4)}\quad -\frac{\partial p_t}{\partial \nu}\frac{\partial r_t}{\partial t} - p_t\frac{\partial^2 r_t}{\partial \nu \partial t} + \frac{\partial^2 p_t}{\partial \nu \partial t}[1-r_t] - \frac{\partial p_t}{\partial t}\frac{\partial r_t}{\partial \nu}\bigg|_{t=t^*} = -\frac{\partial p_t}{\partial \nu}\frac{\partial r_t}{\partial t} + \frac{\partial^2 p_t}{\partial \nu \partial t}[1-r_t]\bigg|_{t=t^*}.$$

When $\partial p_t/\partial t > 0$, p_0 large enough is no longer sufficient to determine the sign of A4 and dt^*/dv. Instead, we require $\left.\frac{\partial r_t/\partial t}{1-r_t}\right|_{t=t^*} < \left.\frac{n_2 mb}{[B+bt^m]t^{1-m}}\right|_{t=t^*} < \frac{n_2 mb}{[B+bF^m]F^{1-m}}$, which is sufficient for $dt^*/dv > 0$ in both scenarios. Last, since p_t is unaffected by θ_{S1} or θ_{S2},

$$-\frac{\partial p_t}{\partial \theta}\frac{\partial r_t}{\partial t} - p_t\frac{\partial^2 r_t}{\partial \theta \partial t} + \frac{\partial^2 p_t}{\partial \theta \partial t}[1-r_t] - \frac{\partial p_t}{\partial t}\frac{\partial r_t}{\partial \theta}\bigg|_{t=t^*} = -p_t\frac{\partial^2 r_t}{\partial \theta \partial t} - \frac{\partial p_t}{\partial t}\frac{\partial r_t}{\partial \theta}\bigg|_{t=t^*},$$

which leads to $dt^*/d\theta > 0$ in scenario 1 but $dt^*/d\theta < 0$ in scenario 2 if p_0 is large enough.

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