WHO WILL SEIZE THE PROMISE OF THE NEW? ANTECEDENTS OF EXPLORATORY MOVES IN A POPULATION OF ORGANIZATIONS [1]

IE Working Paper WP06-04 12/01/2006

Pablo Martin de Holan

Instituto de Empresa and INCAE
Pinar 7, 1ª planta
Madrid, 28006 Spain
pmheh@ie.edu

Dimo Dimov

Instituto de Empresa
Pinar 7, Bajo
Madrid, 28006 Spain
dimo.dimov@ie.edu

Abstract

This paper studies the conditions that motivate firms to begin exploratory moves that lead to investing in an emerging industry. Using knowledge, institutional and population ecology theories, we capture contributing factors to these exploratory drives. We use a longitudinal census of the US Venture Capital industry since inception (>33 years, >4500 firms, >85000 transactions, 4 industries). Data are analyzed using a Cox proportional hazard model, setting clocks to track unfolding events. Predictions that size (positive), age (negative), knowledge specialization (negative), and interaction between age and prior experience (positive) have significant effects on exploratory drives are supported. Counterintuitive findings show that firms have recently explored are less likely to engage in further exploration, and that firms that have not explored in a long time are more likely to initiate exploration than their counterparts. Alternative theoretical explanations are presented for these findings.

[1] All errors remain ours

WHO WILL SEIZE THE PROMISE OF THE NEW?
ANTECEDENTS OF EXPLORATORY MOVES IN A POPULATION OF ORGANIZATIONS

Why, and under what circumstances organizations explore uncertain competitive landscapes or choose to exploit the ones they know well and forgo the risk and the opportunity of the uncertain? Since Jim March's seminal paper on the topic (March 1991), the dual notions of exploration and/or exploitation have become central for strategic organization scholars. In his paper, March theorized about tradeoffs that organizations needed to make when choosing between exploration and exploitation, but more specifically, about the difficulties that an organization could encounter when exploring the uncertain, versus exploiting what is already known to it (a theme that he contributed to develop in previous work, see in particular D. A. Levinthal & March, 1983). Yet, in spite of that early theoretical work and some encouraging recent research (see McGrath, 2001; see Sidhu, Volberda, & Commandeur, 2004), we still do not know very well the antecedents of exploration.

This paper seeks to distinguish between firms that do indeed seize the promise of the new and those that prefer to enjoy the certainty of the present. It does so by considering simultaneously the effect of population dynamics and firm attributes on the decisions to explore a technological frontier represented by a nascent industry. Specifically, we analyze how firm specific factors influence the propensity of a firm to enter a new and unproven industry space, and how prior entries into such space condition future entries. In so doing, we identify strong effects and contribute to the conversation about the different motivations that lead firms to embrace uncertain situations.

The empirical part of this paper uses a census of the US Venture Capital industry since its inception (>33 years, >4500 firms, > 85000 transactions, 4 emergent industries), and tracks their entry into several technological frontiers as they unfold. This census allows us to disentangle firm and population effects, and to track their interactions in a longitudinal way as different technologies are developed, adopted and leave the fringes to become part of the mainstream.

The remainder of the paper is divided in three main sections and a conclusion. The first section presents a brief literature review on subjects relevant to our study, drawn from the knowledge based view of the firm, from institutional theories and from population ecology. From this selective review we build hypotheses that are later tested on our empirical data. The second section describes our data, its components and the industry it represents, and concludes with a detailed description of the methodology used to test our hypotheses. The final section describes the main findings of our analysis. We conclude with some limitations of our study and suggestions for further research on the topic.

DETERMINANTS OF EXPLORATORY MOVES

The core theme of this paper discusses the organizational and environmental conditions that motivate a firm to begin exploratory moves that eventually lead it to invest in an emerging industry with uncertain a-priori potential. In such uncertain situations, the firm must make a double decision: it must decide if the new industry has sufficient potential to justify focusing its attention on it, or if it is simply a fad unworthy of attention (see, for example, Abrahamson, 1991). Then, it must evaluate if it possesses the knowledge to operate successfully in that space, and assess the probability of getting it timely and at a reasonable cost if it does not. Exploration, seen as the search for new business opportunities in novel areas (J.G. March, 1991), is related both to the potential seen in the new industry and the cost of acquisition of the new knowledge.

Firms usually behave according to their own peculiar reasons. Yet, we know that large populations of organizations have different dynamics. Specifically, in a population of organizations operating at a technological frontier, some may decide to face the uncertainty in spite of their lack of knowledge, particularly if the ignorance is widespread and if the firm sees significant first mover advantage. Ignorance, then, may not be a sufficient barrier to entry, especially if it is generalized in a given population. Indeed, it is precisely the low number of firms at the early stages of an industry that make it so vulnerable, but if enough firms enter the industry either simultaneously or in a rapid sequence, the legitimacy of the new industry increases and its uncertainty is reduced (see Michael T. Hannan & Freeman, 1989 for a full argument), creating strong institutional effects that may force other firms to enter it. Understanding then the antecedents of the decisions to enter a new and not yet proven industry space would enhance both our conception of exploration and contribute to the academic conversation about the gestation of the institutional momentum that has been repeatedly observed in large populations of organizations. Accordingly, in the following section we focus on the firm motivations that may drive the decision to enter an unproven industry space. Two main theoretical ideas inform our predictions. First, we view exploration as a reflection of how organizations develop and apply knowledge over time, both existing and new. Second, we view current exploration as a modified extension of prior exploration, as organizations become deft at exploring.

Firm knowledge and exploratory moves

Firms can be understood as repositories or bundles of knowledge (K. R. Conner, 1991; Kathleen R. Conner & Prahalad, 1996) which resides in their assets, rules (Levitt & March, 1988; M. Schulz, 1998; Martin Schulz, 2001), routines (Nelson & Winter, 1982), standard operating procedures (Cyert & March, 1963), and dominant logics (Bettis & Prahalad, 1995; Prahalad & Bettis, 1986). In essence, the existence of organizational knowledge is what makes collective action possible (Douglas, 1986), as it allows people in the organization to integrate their own knowledge into a complex collective action (e.g., a complex product or service).

Yet, these repositories of knowledge are finite, and the knowledge they store is not always adequate even if it is abundant. Often, then, organizations face new situations that do not fit well with their knowledge repertoire. In these cases, organizations reply in three generic ways: they ignore the misfit and act as though nothing had happened (Freeman, 1999; D. Miller, 1993, , 1994), in a sign of strong commitment to current firm strategies, even if they are failing (Staw, Sandelands, & Dutton, 1981). Alternatively, they apply an existing piece of knowledge to the new situation in spite of the misfit (Freeman, 1999; D Miller, 1990; D. Miller, 1993), or they strive to develop new knowledge (e.g., learn) that is adequate to the new situation. There is a consensus in the literature that learning by firms is very often initiated by the perception that a significant gap exists between present performance and potential future performance (Dosi & Marengo, 1994; Pisano, 1994; Von Hippel, 1988), but we also know that the initiation of the exploratory moves that lead eventually to learning is influenced by three main factors: firm size, age and its degree of ignorance about a particular situation, reflected in how specialized its knowledge base is. We explore these three factors below.

Firm size, slack and exploration. Learning is the process that leads to the creation of new knowledge (Argote, 1999; Crossan, Lane, & White, 1999; Dodgson, 1993; Easterby-Smith, Crossan, & Nicolini, 2000; Fiol & Lyles, 1985; Kogut & Zander, 1996; J.G. March, 1991; Miner & Mezias, 1996). Whenever an organization works at or near a technological frontier, it engages in exploration with the intention of learning and developing new knowledge in the process. However, exploration is not free, and the decision to explore involves allocating resources to it. In situations of scarcity, exploration and exploitation oppose themselves and the organization must make painful choices. This need not be always the case. For example, the existence of slack resources (Nohria & Gulati, 1996) allows the organization to avoid difficult choices, as slack is allocated to exploration, among other things by allowing top managers greater discretion to act (Finkelstein & Hambrick, 1990; D. Levinthal & March, 1981), and thereby leaving the resources allocated to exploitation intact. Recent empirical work has indeed upheld this positive association between slack resources and exploration (see Sidhu, Volberda, & Commandeur, 2004). Given that large organizations tend to have more slack resources than smaller ones, organizational size can play an important role on the decision to explore.

Hypothesis 1: The likelihood of exploration increases with the size of the organization.

Exploration and age. Organizations are often the victims of inertia (Michael T. Hannan & Freeman, 1984; D. Miller, 1994), and inertia can have deleterious consequences for their competitive advantage (D Miller, 1990; , 1993). One of the fundamental engines of inertia is organizational age. As they age, organizations develop well-entrenched routines and complex sets of rules that guide their everyday functioning and provide standard procedures to usual situations (James G. March, Schulz, & Xueguang, 2000; Nelson & Winter, 1982). While these rules and routines allow the organization to function effortlessly or so, this remains true as long as the response required is in the repertoire. As organizations age and develop more complex and more focused sets of routines, their flexibility decreases (M.T. Hannan & Freeman, 1977; , 1984). This is particularly noxious in circumstances when new knowledge is needed, as is the case with exploratory moves.

In addition to entrenching rules and ossifying routines, age tends to consolidate the worldview ("cosmogony") of the organization (Weick, 1994) around a dominant logic (Bettis & Prahalad, 1995) that becomes unquestioned even if the environment has changed, and the past becomes a justification for the future. Hence, we hypothesize that age will have a negative effect on the propensity to explore, both because of the inability to recognize good ideas and because of the inability to seize them even if recognized.

Hypothesis 2: The likelihood of exploration decreases with the age of the organization.

Degrees of ignorance and knowledge specialization. When an organization operates in one or several domains, it develops knowledge (e.g., core capabilities) that is both specific to them (Argote, Beckman, & Epple, 1990; Jensen & Meckling, 1992) and to the firm (Reed & DeFillippi, 1990). This specificity can serve as a platform for competitive advantage (Barney, 1991; Reed & DeFillippi, 1990), but also creates problems of its own, as is the case when core capabilities become core rigidities (Leonard-Barton, 1992). The specialization of knowledge can impede further innovation and learning, either from other firms (Lane & Lubatkin, 1998; Mowery, Oxley, & Silverman, 1996) or from different domains, particularly when they are clearly different from the one mastered by the firm.(Cohen & Levinthal, 1990; D. Miller, 1993). Knowledge specialization, then, facilitates the acquisition of knowledge in the domains where the organization operates, but renders learning more difficult in remote domains because the organization needs to forget the knowledge that is incompatible with the new domain before it can start to learn (Martin de Holan & Phillips, 2004), and because learning remote things is less intuitive for the organization.

Hypothesis 3: The likelihood of exploration decreases with the organization's knowledge specialization.

The priming effect of prior entry. Exploratory drives are influenced by organizational demographical characteristics, but also by the organization's history of dealing with change and uncertainty. Organizations that have embraced change in he past are more likely to embrace it again, and the ones that have rejected it will tend to be disturbed by it. Amburgey and colleagues, for example, found that the "occurrence of change makes the organization more temporarily more malleable", and that once organizations had overcome inertial forces, they became more deft at it and therefore more likely to implement change (Amburgey, Kelly, & Barnett, 1993: 70), having incorporated change routines in their repertoire of activities in lieu of treating it as an unusual and painful event. Yet, the same authors found that time wore off the ability to change that an organization had developed, probably because knowledge tends to dissipate rapidly and often involuntarily (Argote, 1999; Argote, Beckman, & Epple, 1990; Darr, Argote, & Epple, 1995; Martin de Holan & Phillips, 2004). Stated as a hypothesis, we can claim that organizations develop knowledge that enables them to explore new domains, but that these abilities deteriorate with time.

Hypothesis 4: The likelihood of exploration increases with prior exploration.

Hypothesis 5: The likelihood of exploration decreases with the time elapsed since the last exploration.

Interactions. Prior exposure to exploration facilitates the development of change routines, facilitating future exploratory drives. Yet, experience with exploration is likely to impact firms differently depending on firm size at the time of its first exploration: if an organization makes its first exploratory moves while still small, the lower availability of slack resources results in painful tradeoffs between their everyday operations and the exploratory activities. As a result, the opportunity cost of exploration increases, inducing higher levels of commitment to the industry explored, prone to even further escalation if the trade-off is of high symbolic value (Staw et al. 1981). A sustained commitment to the industry explored (rather than to exploration itself) in turn creates a prolonged focus on exploitation in order to recover and properly compensate these early costs, but fewer change routines. In these circumstances (e.g., significant tradeoffs at an early stage), organizations become inward-oriented and thus less likely to be on the look out for new exploration grounds.

Hypothesis 6: The occurrence of exploration when an organization is small increases the commitment to the industry explored and decreases the likelihood of engaging in further exploration in other industries.

Finally, even though organizational ageing ossifies the routines and narrows the dominant logics and worldviews of organizations, we can expect that the logic of exploration be incorporated in such routines and worldviews if the organization has engaged previously in exploratory activities. This is especially the case if the exploratory activities occur early on in the life of the organization. We know that early actions shape the development of routines (Levitt & March, 1988) and are thus influential in guiding the organization out of its “liability of newness”, as the relationships among the vested interests in the organization become more strongly shaped (Stinchcombe, 1965). The orientations and values that founders instil in the organization have a long-lasting influence on subsequent decision making processes within the organization (Boeker, 1989). Thus, early exposure to exploration is more likely to lead to the development of persistent flexibility,

Hypothesis 7: The early occurrence of exploration in the life of an organization increases the likelihood of engaging in further exploration.

METHOD

Overview of the venture capital industry

We chose the US venture capital (VC) industry to test our hypotheses, as several features of this industry make it well suited for studying exploration of technological frontiers. The industry has originated in the U.S. in the late 1950s as a means of commercialising Stanford's and MIT's technological inventions. Venture capital (VC) firms raise funds from various investors to deploy them in privately held companies and then strive to exit profitably from these investments within a set time period, typically 5 to 7 years. By their very nature, VC firms are the financiers of choice for emerging technologies. Because the success of a venture capital fund depends on the extent to which the companies it backs could subsequently attract more mainstream investors (capital market investors or corporate investors), the timing of an entry into a new technological wave is a crucial part of the success of the firm.

Sample

We collected data from the *VentureXpert* database published by Thomson Financial on all transactions executed by U.S. venture capital firms over the period 1962-2004. Full data were available on 186,073 transactions, but we excluded 988 transactions that pertained to investments in VC Partnerships and thus did not involve portfolio companies. Acting as a quasi-census, this database is the most comprehensive source on venture capital deals, stretching back to the origin of the industry.

From these deals, we selected only the first-time investments made by venture capital firms. It is common that VC firms disburse their investments in a given portfolio company over several "rounds," and each round is captured in the database as a separate transaction. Accordingly, and given our research interest, we only focused on the rounds at which a given VC firm invested in a given portfolio company for the first time. In its final form, the dataset contained 85,280 first-time rounds transacted by 4,511 VC firms over the above 33-year period.

Since we were interested not only in whether a VC firm invested in a given industry but also in when it did so, it was necessary to put the data in a survival analysis format (Morita, Lee, & Mowday, 1993). This involves recording the event history for each VC firm as a sequence of time periods, i.e. spells, signifying the time until a particular event occurs. In our case, the event of interest was a VC firm's making an investment in a not yet established industry. Firms that made no such investments by the end of the observation period were right-censored. Because the database we used covered the entire life span of the VC industry, our data did not suffer from left censoring.

Since we were also interested in how some time-varying characteristics (e.g. size, age, knowledge specialization) of the VC firms affected the likelihood of their industry entry, we had to allow these internal firm characteristics to vary over time. We did so by breaking the spells into smaller time intervals and measured the firm characteristics at them. We thus summarized the VC firms' investment activities on a monthly basis – there was an observation in the data for each month in which a given VC firm had made first-time investments. The observation reflected the total first-time investment activity in the particular month as well as in the life-to-date of the firm. We collected investment activity information in terms of the industry as well as the development stage (at the time of the particular VC firm's involvement) of the portfolio company. This new data structure yielded 57,900 firm-period observations.

In determining the relevant 'entry' events, we resorted to historical accounts of the new technology space during the period of existence of the VC industry. The historians of technological development over the last 40 years (i.e. coinciding with the life of the venture capital industry) have identified 4 major technological waves, each marked by a seminal event, typically an Initial Public Offering (IPO) of one of the pioneering companies, that represents a significant motivating event for investors and entrepreneurs alike (Sorenson & Stuart, 2003) , fuelling the further establishment and, as a consequence, the consolidation of the industry. The first wave was related to semiconductors, marked by Intel's introduction of the first micro-processor in 1971 and with the introduction of the fourth-generation computers (sharing the same technology as computers today) in 1972. The second wave was related to the development of the personal computer and its associated hardware. It was marked by Apple Computer's spectacular IPO in December 1980. The third wave was biotechnology, with Genentech's IPO in October 1980, representing the first time the biotechnology industry received investor legitimacy. Finally, the fourth wave was related to the development and adoption of the internet. Although developed much earlier as part of the ARPAnet project, the internet was catapulted on the investors' map by Netscape's IPO in August 1995.

As each of these four technological waves represented the embryo of a new industry that VC firms could enter, our dependent variable of interest was whether and when a VC firm made its first investment in each of them by the time of the seminal event for each industry. To verify that with the so chosen cut-off dates we indeed captured the "embryo" period for each of the four industries, we examined the number of first-time investments by the cut-off date as a proportion of all first-time investments over the life of the industry. A low proportion would indicate not enough institutional momentum for the industry to be considered legitimate enough and thus entailing lower uncertainty. By the end of 1972 there were 78 investments in the semiconductor industry which represented 5% of all investments in that industry. Similarly, the 242 investments made in the computer hardware industry by December 1980 represented 16% of all investments in that industry. By October 1980, 54 investments in the biotechnology industry represented 5% of all investments. Finally, by August 1995, 239 investments in the internet industry represented 11% of all investments in that industry.

Independent variables

We constructed three duration clocks. The first simply recorded whether a VC firm made a first investment in one of the four industries by the specified cut-off time in the particular observation period. It thus had a value of 1 for the periods in which the first investments in these industries occurred and a value of 0 for the remaining periods. The second clock recorded the elapsed time since the previous industry entry, while the third one recorded the number of the entry which the VC firm was at a risk of experiencing in a particular period. It thus has a value of 1 until the first entry occurs, a value of 2 until the second entry occurs, etc. On the basis of this clock we created an indicator for whether prior entry has occurred.

We measured the age of the VC firm in months, calculated separately for each spell, i.e. at each month in which the VC firm made investments. We measured VC firm size be recording the cumulative total number of first-time investments made from its founding up to the beginning of the period in question. This essentially reflects the total number of companies in the VC firm's portfolio as of the beginning of a particular period. Although other studies of the venture capital industry have measured size in terms of total capital raised or invested, there is a close correspondence between the invested capital and the number of companies in the VC firm's portfolio.

In determining the knowledge concentration of VC firms, we focused on two dimensions: industry exposure and development stage. Since the investment strategies of VC firms typically involve selecting specific industries and development stages in which to operate, their portfolio composition provides an excellent indicator of the kind of expertise the firm has developed. We determined the VC firm's industry and stage knowledge concentration by recording the industries in which they invested using nine categories maintained by *VentureXpert*: (1) communications, (2) computer-related, (3) electronics, (4) biotechnology, (5) medical/pharmaceutical, (6) energy, (7) consumer related, (8) industrial/chemical, and (9) other manufacturing and services. We then counted the number of investments made in each category and in each of the months of investment activity as well as cumulatively, since the inception of the VC firm. Since we were interested in how current knowledge affected exploratory activity, we applied our knowledge concentration measures on the cumulative investment activity by a VC firm prior to a given month of investment activity. We measured industry knowledge concentration by calculating a Herfindahl Hirschman Index (HHI) on the industry distribution of the VC firm's investments. We used the following formula - $\sum p_i^2$ - where p_i represents the proportion of investments made in a particular industry category during the period from the founding of the VC firm up to the month in question. The HHI is commonly used in the economics and strategy literatures to measure industry concentration; in this case it reflects how concentrated the VC firm's investments are across industries (i.e. how much industry specialization there is). The index varies between 0 and 1, with a higher score representing higher concentration.

We used the same procedure to measure stage knowledge concentration. We used the following six stage categories used by *VenturExpert* - (1) seed stage, (2) start-up stage, (3) other early stage, (4) expansion stage, (5) later/acquisition stage, and (6) other – and calculated a stage HHI for the VC firm's investment activity for the period from the founding of the VC firm up to the month in question.

Control variables

We included several control variables. The first was an indicator for the type of VC firm. We used three categories – independent, corporate, and affiliates of financial institutions. The second, two indicator variables for location, controlled for the cluster effects that VC firms located in Massachussets or California might experience. Finally, we controlled for the average stage of the first-time investments that the VC firm had made prior to the current period. This variable accounts for the possibility that some VC firms may invest in companies in which other VC firms had already invested, an artefact of the staged nature of venture capital investments. To calculate the average stage, we used the stage categories specified above and assigned to them the values from 1 to 6, to reflect the order of increasing degree of development.

Model and analysis

We used a Cox proportional hazard model to test the hypotheses. The model has the following general form – $h(t) = h_0(t) \exp[\mathbf{BX}]$ – where h(t) is the hazard rate for a VC firm to enter a new industry at time t given that it hasn't done so previously, $h_0(t)$ is the baseline hazard function, $\mathbf{X}$ is a vector of predictors, and $\mathbf{B}$ is the vector of the coefficients that need to be estimated for these predictors. Because this is a semi-parametric model, it tends to be more empirically robust as it does not require specifying the functional form of the of the baseline hazard function. The applicability of this model does, however, depend on whether the proportional hazard assumption holds, i.e. that the hazard functions for all subjects and across time are of some constant multiples of the baseline hazard function. We checked this assumption by testing for nonzero slopes in a regression of the (scaled) Schoenfeld residuals on functions of time (Grambsch & Therneau, 1994). The test revealed that the assumption was violated for VC firm age, i.e. the hazard function was not of the same pattern across the different ages of the VC firms. In order to accommodate these non-proportional hazards related to age, we added an interaction between VC firm age and time to the model, thereby allowing the effect of age on the hazard rate to vary over time. The significance of this interaction term in the estimated model is another way of concluding that the hazards in respects to VC firm age are indeed non-proportional.

In addition, because our data dealt with repeated events, we had to address the issue of conditional dependence. We regard our multiple entries as conditionally independent, as the process that generates a subsequent entry is independent of the one used to generate the previous entry. However, in order to account for the possibility that the conditional independence assumption may not hold, we also ran estimations using a conditional risk set model. Thus, our first estimation follows the method proposed by Anderson and Gill (1982), whereby the different entries are treated as indistinguishable and thus time to each entry is considered separately. Our second estimation uses a conditional risk set method proposed by Prentice, Williams, and Peterson (1981), whereby we recorded the number of each entry (whether 1st, 2nd, etc.) and stratified our analysis by entry number. This assumes that to make a second entry a VC firm needs to have made a first one. By stratifying the estimation by entry number we allow for different baseline hazard functions to apply to the 1st, 2nd, 3rd, and 4th entries, while restricting the coefficients across the strata to be the same. Because the prior entry variable had the same values over several of the strata, it was automatically dropped from the stratified estimation. In both estimations, taking into consideration the multiple observations per VC firm, we clustered the data by VC firm, thereby adjusting the standard errors for the non-independence of these observations.

RESULTS

Table 1 shows the descriptive statistics for the variables used in the analyses. The results of our survival analysis are shown in Table 2. We ran our estimations in three steps: in the first we entered only the control variables (model 1), in the second we entered the main effects from the presented hypotheses, and in the third we entered the interaction effects. For each of the estimations at steps 2 and 3, we ran two separate models: one with conditional independence (models 2 and 4) and one with conditional dependence (models 3 and 5). As is evident from the table, the addition of both the main and interaction effects improved the fit compared to the controls-only model. In addition, all the models yielded consisted results, suggesting that our estimation did not suffer from any material bias.

Hypothesis 1 predicted a positive effect of firm size on the firm exploration. The coefficients for firm size are positive and significant ($p < .001$) across all models, suggesting support for this hypothesis. Based on hypothesis 2, we expected a negative effect of firm age on exploration. The negative and significant ($p < .001$) coefficients for firm age across all models provide support for this hypothesis. Next, the coefficients for both industry and stage concentration were negative and significant ($p < .05$) across all models, supporting hypothesis 3. In regard to hypothesis 4, however, the estimated effect was contrary to the one predicted by it: prior entry was negatively (rather than positively) associated with exploration. This negative effect was significant ($p < .001$) across all models. Similarly, we found an effect for time since prior entry that was contrary to our expectation based on hypothesis 5. Although this positive effect was significant ($p < .001$) in three of the models (2,3, and 4), it was not significant in model 5.

The interaction effect of firm age and time, added to accommodate the non-proportionality of hazards in respect to age, was positive and significant ($p < .001$) across all models. This suggests that the suspected non-proportionality was indeed present. In addition, the sign of the effect implies that the effect of age increases with time. Of the two hypothesized interactions, the one between firm and prior entry was not significant although its negative sign was in the direction specified by hypothesis 6. The interaction effect of firm age and prior entry was positive and significant ($p < .001$), implying that for firms that have already entered a new industry space, the incremental effect of this prior entry is larger for older organizations. However, since age decreases the tendency to explore, the net effect of this increase is a higher propensity to explore for firms that have explored while they where younger. This interpretation follows the one provided by Amburgey et al. (2003) and provides support for hypothesis 7.

DISCUSSION AND CONCLUSION

In this paper we examine the simultaneously effects of population dynamics and firm attributes on their decision to explore a technological frontier represented by a nascent industry. While some of our results were consistent with the current wisdom of the field, others were puzzling and deserve close attention. We contribute to the literature on organizational learning by identifying some of the antecedents of exploration, not only in terms of firm characteristics that are well established in this literature, but also in terms of intervening ecological processes triggered by prior exploration. In this way we build a more nuanced, multi-level picture of what drives organizations into exploration. We also contribute to the population ecology and institutional theories by suggesting circumstances in which the well established duration-dependence effects may not hold.

As mentioned, size and age influence the propensity to explore, with a positive and negative sign respectively. Both hypotheses are standard fare in current organizational theory, so we will only give cursory treatment to them. Indeed, our data suggest that large firms explore more than otherwise, probably because of the presence of slack that can be either be explicitly allocated to exploration or diverted without being noticed. We can only hypothesize about the intentionality of the exploration, but according to some existing work in OT, we can speculate that at least some exploratory moves may be emergent rather than planned (Mintzberg & Waters, 1985), and illegitimate rather than authorized (Deborah Dougherty & Heller, 1994).

Age negatively influences exploration and this effect gets even stronger with time. The literature suggests that firms ossify with time, making them both less willing and less capable of uncertain exploratory drives. Similarly intuitive are the results of hypothesis 3, which implies that higher knowledge concentration is associated with lower exploration. As organizations specialize in one domain, they find more difficult to understand and/or take advantage of other domains that require different bundles of knowledge that the firm does not possess or cannot get. This view is fully compatible with cognitive and behavioral views of learning, which state that existing knowledge can act as a strong impediment for the acquisition of new knowledge and even for the processing of new opportunities. (Leonard-Barton 1992)

The results of hypotheses 4 and 5 are rather puzzling. We find strong support for the idea that firms that have recently explored are less likely to engage in further exploration, and for the idea that firms that have not initiated exploratory moves in a long time are more, not less, likely to initiate exploration. We observed that the longer the time elapsed since prior entry in a new industry, the more likely the VC firm was to engage in new exploration. Both findings are counterintuitive, and opposed to what we had predicted. A possible ecological interpretation leads us to consider that entry into an emergent industry represents such a commitment for the VC firm that it reduces its propensity to enter another unproven industry until the industry life-cycle has moved away from its embryonic stage, and new opportunities become scarcer. Thus, munificence may prevent aggressive exploration, but, as the once-new industry becomes more mature and opportunities decline, the organization is prompted again to become alert to nascent opportunities beyond the realm of exploitation. Indeed, if an emergent industry is large enough (as the four industries studied were), it is plausible that organizations may chose long periods of exploitation after a successful exploration, a view that would be consistent with much of the literature on radical change, which predicts short bursts of rapid change (the exploratory drives) and long periods of calm (their fruitful exploitation). Although a standard disclaimer applies here for hypothesis 5, which is not significant in one of the full models, the robustness of the findings for hypothesis 4 (and the evidence in support of hypothesis 5) strongly suggest a line of inquiry for future research, particularly given that the radical change view is compatible with the "digestive" effects we are observing, both in terms of prior entry and delay since last entry.

An alternative line of inquiry for further theoretical elaboration of these surprising results comes from their joint consideration with the interaction effect for age and prior exploration. The latter suggests that the likelihood of subsequent exploration increases if the current exploration occurs early on in the organization's life. This implies that organizations are better able to assimilate current exploration efforts if their routines are still relatively fluid. For older organizations not used to exploration, engaging in it may be quite upsetting to their routines, so much so in fact that it may take a long time before they can become outward looking again, a view that would be consistent with interpretive and social constructionist views of innovation that argue that innovation in large, established organizations often is an illegitimate activity that creates so many disruptions for the organization that some large organizations chose to forgo innovations rather than face the difficulties inherent to it (Adams, Day, & Dougherty, 1998; D. Dougherty & Corse, 1995; Deborah Dougherty & Hardy, 1996; Deborah Dougherty & Heller, 1994). The positive effect of time since prior exploration on the likelihood of engaging in new exploration adds further credence to these ideas.

While the age of the organization at the time of its first exploration matters, we found no such effect for size. Although there was an indication that firms that engage in exploration when they are smaller may exhibit a reduced propensity for further exploration, this effect was not statistically significant. This may suggest that the imprint of first exploration matters much more for the establishment of routines than it does for the pattern of resource utilization within the firm.

Let's now review some limitations of our study. Although the *VentureXpert* database is the most comprehensive source on venture capital transactions, it is possible that the coverage prior to 1980 is incomplete, but we have no evidence of this. Incompleteness could be due to the fact that the public interest in the US venture capital industry significantly following a reform in 1979 that allowed pensions funds to invest in private equity. Nevertheless, there are enough transactions from this early period to allow us to draw very robust generalizations. A second limitation arises from the fact that for some of the four industries on which we focus, the periods in which organizations were at risk of entering their new technological frontiers overlap. This suggests that competing risks existed for organizations to engage in exploring one or the other industries. We did not account for such competing risks in our analysis, but we believe that doing so would further reinforce our findings rather than the opposite. Third, we did not account for the fact that while three of the industries in question – semiconductors, hardware, and internet – were germane to each other (they fall under what we refer today as ICT industries) and thus had a natural sequence of occurrence, biotechnology was not. While some part of this concern is mitigated by our usage of models based on conditional dependence, there still remains a possibility that hazard function of engaging in biotechnology exploration may be qualitatively different. Again, addressing this issue in future research would be an important extension to our work.

We would like to conclude with a cautionary tale. A considerable amount of organizational literature, both academic and practitioner-oriented, is devoted to examining the benefits of exploration, but little is known about its mechanisms and its antecedents. While it is commonplace to extol the benefits of learning, innovating, and initiating organizational change (all factors closely related to exploratory drives), many of the determinants of exploration still remain obscure, compromising the success of these endeavours even before they are initiated. Our findings strongly suggest that recommending exploitation to all organizations under all circumstances may not be a very wise piece of advice. Therefore, before suggesting that organizations engage ***corps et âme*** (with their soul and their hearts) in risky exploratory drives, it is necessary to understand what it takes for organizations to do so reasonably well, and assess the probability of success of these drives. In this paper, we have made the first step towards understanding the complexity of what drives organizations to leave the comfort of the familiar and seize the promise of the new.

TABLE 1: Descriptive Statistics and Correlations[a]

	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11
1 Firm age	108.58	101.47	1	511	1.00										
2 Firm size	50.98	89.50	0	1378	0.66	1.00									
3 Industry concentration	0.36	0.26	0	1	(0.30)	(0.23)	1.00								
4 Stage concentration	0.38	0.24	0	1	(0.20)	(0.17)	0.69	1.00							
5 Prior entry	0.33	0.47	0	1	0.60	0.46	(0.28)	(0.21)	1.00						
6 Time since prior entry	22.11	49.01	0	406	0.59	0.26	(0.21)	(0.14)	0.64	1.00					
7 Independent VC firm	0.63	0.48	0	1	0.00	0.05	0.00	(0.04)	0.03	(0.04)	1.00				
8 Corporate VC firm	0.09	0.29	0	1	(0.11)	(0.10)	0.15	0.05	(0.10)	(0.06)	(0.42)	1.00			
9 Financial VC firm	0.16	0.37	0	1	0.12	0.07	(0.09)	(0.01)	0.08	0.09	(0.57)	(0.14)	1.00		
10 Location California	0.29	0.45	0	1	0.02	0.05	0.05	(0.04)	0.08	0.03	0.11	0.00	(0.10)	1.00	
11 Location Massachussets	0.12	0.32	0	1	0.08	0.07	(0.03)	(0.04)	0.09	0.05	0.09	(0.05)	(0.05)	(0.23)	1.00
12 Average stage	3.36	1.31	0	6	0.24	0.10	0.25	0.48	0.13	0.12	(0.05)	(0.07)	0.13	(0.11)	0.02

[a] N = 57,900. All correlations with absolute value above 0.008 are significant at $p < .05$

TABLE 2: Survival analysis of the time to new industry entry

	Model 1	Model 2	Model 3	Model 4	Model 5
Independent VC firm	0.388 ***	0.387 ***	0.396 ***	0.404 ***	0.405 ***
Corporate VC firm	0.151	0.391 **	0.373 *	0.415 **	0.385 **
Financial VC firm	0.194	0.150	0.159	0.178	0.167
Location California	0.276 ***	0.412 ***	0.426 ***	0.409 ***	0.433 ***
Location Massachussetts	0.267 *	0.281 **	0.297 **	0.267 **	0.294 **
Average stage	-0.297 ***	0.080 *	0.088 **	0.090 **	0.108 **
Firm age		-0.023 ***	-0.025 ***	-0.025 ***	-0.030 ***
Firm size		0.011 ***	0.012 ***	0.013 ***	0.012 ***
Industry concentration		-0.805 **	-0.829 **	-0.704 **	-0.704 **
Stage concentration		-0.640 *	-0.790 **	-0.692 *	-0.851 **
Prior entry		-1.013 ***		-1.250 ***	
Time since prior entry		0.009 ***	0.009 ***	0.004 *	0.000
Age X time		0.000 ***	0.000 ***	0.000 ***	0.000 ***
Size X Prior entry				-0.005	-0.003
Age X Prior entry				0.007 **	0.014 ***
LL	-3,352.70	-3,163.90	-2,690.48	-3,159.48	-2,679.11
Chi-squared	198.71	520.06	448.05	571.67	440.48
D.f.	6	13	12	15	14
Number of events	590	590	590	590	590

***** p < .001, ** p < .01, *p < .05, + p < .10**

REFERENCES

Abrahamson, E. (1991). Managerial fads and fashions: the diffusion and rejection of innovations. *Academy of Management Review, 16*(586-612).

Adams, M. E., Day, G. S., & Dougherty, D. (1998). Enhancing new product development performance: An organizational learning perspective. *The Journal of Product Innovation Management, 15*(5), 403.

Amburgey, T. L., Kelly, D., & Barnett, W. P. (1993). Resetting the clock: The dynamics of organizational change. *Administrative Science Quarterly, 38*(1), 51.

Anderson, P. K., & Gill, R. D. (1982). Cox's regression model for counting processes: A large sample study. *Annals of Statistics, 10*, 1100-1120.

Argote, L. (1999). *Organizational learning : creating, retaining, and transferring knowledge*. Boston: Kluwer Academic.

Argote, L., Beckman, S. L., & Epple, D. (1990). The Persistence and Transfer of Learning in Industrial Settings. *Management Science, 36*(2), 140-155.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Bettis, R., & Prahalad, C. K. (1995). The Dominant Logic: Retrospective and Extension. *Strategic Management Journal*(16), 5-14.

Boeker, W. (1989). The Development and Institutionalization of Subunit Power in Organizations. *Administrative Science Quarterly, 34*, 388-410.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly., 35*(1 Mar), 125-152.

Conner, K. R. (1991). A Historical Comparison of Resource-Based theory and Five Schools of Thought within Industrial Organization Economics: Do We have a new Theory of the Firm? *Journal of Management*(17), 121-154.

Conner, K. R., & Prahalad, C. K. (1996). A resource-based theory of the firm: Knowledge versus opportunism. *Organization Science., 7*(5 Sept-Oct), 477-501.

Crossan, M., Lane, H., & White, R. E. (1999). An Organizational Learning Framework Organizational Learning: From Intuition to Institution. *Academy of Management Review, 24*(3), 522-537.

Cyert, R. M., & March, J. G. (1963). *A Behavioral Theory of the Firm*. Englewood Cliffs, N.J.: Prentice-Hall.

Darr, E., Argote, L., & Epple, D. (1995). The Acquisition, Transfer and Depreciation of Knowledge in Service Organizations: Productivity in Franchises. *Management Science, 41*(11), 1750-1762.

Dodgson, M. (1993). Organizational Learning: A Review of Some Literatures. *Organization Studies, 14*(3), 375-394.

Dosi, G., & Marengo, L. (Eds.). (1994). *Some elements of an evolutionary theory of organizational competences*. Ann Arbor: MI: University of Michigan Press.

Dougherty, D., & Corse, S. (1995). When it comes to product Innovation, What is So Bad About Bureaucracies? *Journal of High Technology Management Research, 6*, 55-76.

Dougherty, D., & Hardy, C. (1996, Oct). Sustained product innovation in large, mature organizations: Overcoming innovation-to-organization problems. *Academy of Management Journal, 39,* 1120-1153.

Dougherty, D., & Heller, T. (1994, May). The illegitimacy of successful product innovation in established firms. *Organization Science, 5,* 200.

Douglas, M. (1986). *How institutions think*. Syracuse, NY: Syracuse University Press.

Easterby-Smith, M., Crossan, M., & Nicolini, D. (2000). Organizational learning: Debates past, present and future. *The Journal of Management Studies, 37*(6), 783-796.

Finkelstein, S., & Hambrick, D. C. (1990). Top-Management-Team Tenure and Organizational Outcomes: The. *Administrative Science Quarterly, 35*(3), 484-404.

Fiol, C., & Lyles, M. (1985). Organizational Learning. *Academy of Management Review, 10*(4), 803-813.

Freeman, S. (1999). Identity Maintenance and Adaptation: A Multilevel Analysis of Response to Loss. *Research in Organizational Behavior, 21*, 247-294.

Grambsch, P. M., & Therneau, T. M. (1994). Proportional hazards tests and diagnostics based on weighted residuals. *Biometrika, 81*, 515-526.

Hannan, M. T., & Freeman, J. (1977). The Population Ecology of Organizations. *American Journal of Sociology*(82), 929-964.

Hannan, M. T., & Freeman, J. (1984). Structural Inertia and Organizational Change. *American Sociological Review, 49*(April), 149-164.

Hannan, M. T., & Freeman, J. (1989). *Organizational Ecology*. Cambridge, MA: Harvard University Press.

Jensen, M. C., & Meckling, W. H. (1992). Specific and General Knowledge, and Organizational Structure. In L. Werin & H. Wijkander (Eds.), *Contract Economics*. Cambridge, MA: Blackwell.

Kogut, B., & Zander, U. (1996). What do Firms Do? Coordination, Identity, and Learning. *Organization Science, 7*(5), 502-518.

Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal., 19*(5 May), 461-477.

Leonard-Barton, D. (1992). Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. *Strategic Management Journal, 13*, 111.

Levinthal, D., & March, J. G. (1981). A model of adaptive organizational search. *Journal of Economic Behavior and Organization, 2*, 307-333.

Levinthal, D. A., & March, J. G. (1983). The myopia of learning. *Strategic Management Journal, 14*, 95.

Levitt, B., & March, J. G. (1988). Organizational Learning. *Annual Review of Sociology*(14), 319-340.

March, J. G. (1991). Exploration and Exploitation in Organizational Learning. *Organization Science, 2*(1), 71-87.

March, J. G., Schulz, M., & Xueguang, Z. (2000). *The Dynamics of Rules: Change in Written Organizational Codes*. Stanford: CA: Stanford University Press.

Martin de Holan, P., & Phillips, N. (2004). Remembrance of Things Past? The Dynamics of Organizational Forgetting. *Management Science, 50*(11), 1603-1613.

McGrath, R. G. (2001). Exploratory learning, innovative capacity, and managerial oversight. *Academy of Management Journal, 44*(1), 118.

Miller, D. (1990). *The Icarus Paradox*. New york:NY: Harper Business.

Miller, D. (1993). The architecture of simplicity. *Academy of Management Review, 18*(1), 116-138.

Miller, D. (1994). What happens after success: The Perils of Excellence. *Journal of Management Studies, 31*(3), 327-358.

Miner, A. S., & Mezias, S. J. (1996). Ugly duckling no more: Pasts and futures of organizational learning research. *Organization Science, 7*(1), 88:99.

Mintzberg, H., & Waters, J. A. (1985). Of strategies, deliberate and emergent. *Strategic Management Journal*(6), 257-272.

Morita, J. G., Lee, T. W., & Mowday, R. T. (1993). The regression-analog to survival analysis: A selected application to turnover research. *Academy of Management Journal, 36*(6), 1430-1465.

Mowery, D. C., Oxley, J. E., & Silverman, B. S. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal, 17*(Winter), 77-91.

Nelson, R. R., & Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Nohria, N., & Gulati, R. (1996). Is slack good or bad for innovation? *Academy of Management Journal, 39*(5), 1245-1265.

Pisano, G. (1994). Knowledge, integration, and the locus of learning: An empirical analysis of process development. *Strategic Management Journal, 15*(Winter), 85-100.

Prahalad, C. K., & Bettis, R. A. (1986). The dominant logic: A new linkage between diversity and performance. *Strategic Management Journal*(7), 485-502.

Prentice, R. L., Williams, B. J., & Peterson, A. V. (1981). On the regression analysis of multivariate failure time data. *Biometrika, 68*, 373-379.

Reed, R., & DeFillippi, R. J. (1990). Causal Ambiguity, Barriers to Imitation and Sustainable Competitive Advantage. *Academy of Management Review, 15*(1), 88-102.

Schulz, M. (1998). Limits to Bureaucratic Growth: The Density Dependence of Organizational Rules. *Administrative Science Quarterly, 43*(December), 845-876.

Schulz, M. (2001). The Uncertain Relevance of Newness: Organizational Learning and Knowledge Flows. *Academy of Management Journal, 44*(4), 661-681.

Sidhu, J., Volberda, H. W., & Commandeur, H. R. (2004). Exploring Exploration Orientation and its Determinants: Some Empirical Evidence. *Journal of Management Studies, 41*(6), 913-1013.

Sorenson, O., & Stuart, T. E. (2003). Liquidity events and the geographic distribution of entrepreneurial activity. *Administrative Science Quarterly, 48*(175-201).

Staw, B., Sandelands, L. E., & Dutton, J. (1981). THreat-rigidity effects in organizational behavior: a multilevel analysis. *Administrative Science Quarterly, 26*, 501-524.

Stinchcombe, A. (1965). Social Structure and Organizations. In J. G. March, Ed (Ed.), *Handbook of Organizations*. Chicago, IL: Rand McNally & Co.

Von Hippel, E. (1988). *The Sources of Innovation*. Cambridge:MA: MIT Press.

Weick, K. (1994). The Collapse Of Sensemaking In Organizations: The Mann Gulch Disaster. *Administrative Science Quarterly, 38*(4), 628-653.