TALES OF SERIAL EXPLORATION:
Knowledge Specialization, Repetitive Momentum, Early Conditioning, and Exploratory Drives in a Universe of Organizations[1]

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Abstract
In this paper, we examine the firm and ecological factors that affect the long-term sustainability of exploration. We analysed the investment decisions by US venture capital firms to enter new technological domains over a 43-year period. Our results suggest that in addition to the well studied effects of inertia and slack, exploration is affected by an organization's knowledge specialization, is conducive to repetitive momentum, and affects an organization's subsequent exploration when occurring early in an organization's life. We contribute to the literature on organizational learning by identifying some of the antecedents of exploration and its sustenance over time. In addition, we also resolve several theoretical tensions in the organizational learning and change literatures that could help push further theoretical development.

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TALES OF SERIAL EXPLORATION:
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Why, and under what circumstances organizations choose to explore uncertain competitive landscapes rather than exploit the ones they know well? 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 also 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 nor its sustainability over time.

Intuition and empirical evidence show that exploratory modes require considerable effort to be sustained over time, and it is suspected that constant exploration may be particularly difficult. Firms invest important resources as they zoom on particular opportunities (Dutta and Crossan, 2005), but the commitment needed to take advantage of that newly found opportunity may make renewed exploration efforts untenable. This is at the heart of the tension between exploration and exploitation: exploration is only useful if it eventually turns into exploitation, but excessive focus in exploitation may prevent future exploration.

In this paper, we are interested in the influence that knowledge specificity, prior exploratory efforts and early exploratory drives have on subsequent exploration activities. In so doing, we aim to resolve several theoretical tensions that prevail in the extant literature on the topic. First, while knowledge specialization increases the returns to exploitation and thus induces a commitment to it, it also makes the organization increasingly vulnerable to environmental change and, as a result, in need for exploration. Second, while exploration may help generate routines that enable repetitive momentum (Amburgey and Miner, 1992), it can also represent a quantum change (Miller, 1982) that, according to punctuated equilibria models (Tushman and Romanelli, 1985), can lead to long periods of stability where no further exploration is taken. Third, while organizational ageing creates inertia (Hannan and Freeman, 1984) and thus impedes change and exploration (Amburgey, Kelley, and Barnett, 1993), early exploration, if it becomes a vested interest during the organization's initial formation (Stinchcombe, 1965), could very well reverse this trend. Finally, while organizational slack enables exploration (March, 1991; Sidhu et al. 2004), engagement in exploration in periods of resource scarcity could lead to escalated commitment to the explored domain (Staw, Sandelands, and Dutton, 1981) and thus prevent future exploration.

The empirical part of this paper uses comprehensive data on the US Venture Capital industry since its inception (43 years, over 4400 firms, over 84000 transactions) and tracks, as they unfold, their investments into new high-technology domains. This longitudinal data allows us to examine how several firm and ecological processes affect exploration over time. The remainder of the paper is organized as follows. First, we discuss the determinants of exploration from organizational learning and change perspectives. Based on this, we develop specific hypotheses that reflect the theoretical tensions outlined above. The second section provides a brief overview of the US venture capital industry, describes our data and approach to measuring the constructs of interest, and concludes with a detailed description of the methodology used to test our hypotheses. We then describe the main findings of our analysis. In the final section, we discuss our findings and conclude with some limitations of our study and suggestions for further research on the topic.

DETERMINANTS OF EXPLORATION

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). While organizations are largely focused on exploiting their existing knowledge base, the continuously changing business environment and the organization's continuous quest for survival put pressure on the organization to create new knowledge, i.e. engage in exploration.

The core theme of this paper is the sustenance of exploratory moves that take firms beyond the uncertainty frontier, towards pursuing project with uncertain a-priori potential. Given the continuous tension between exploration and exploitation, when is a firm that has already engaged in exploration ready to do so again? 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, assimilation, and exploitation of the new knowledge. Therefore, while firms must evaluate if the new project has sufficient potential, they also must decide if they have the knowledge potential and expertise to operate successfully in that space as well as if they can create sufficient internal commitment to the new effort.

Understanding some of the factors that tip the internal resource balance towards or away from exploration 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. We view such decisions as enabled or restrained by the firm's current knowledge base. In addition, we also offer two main theoretical ideas related to the influence of prior explorations on future explorations. First, we view current exploration as affected by the momentum created by prior exploration. We provide two competing rationales for the nature of this momentum. On one hand, organizations become deft at exploring as they become more experienced with it, and are thus increasingly likely to do it. On the other hand, because of the commitment that exploration creates, organizations need to exploit the new terrain and generate returns before they engage in new exploratory efforts. Second, we view current exploration as a reflection of the institutional conditioning created by exploration occurring early in the life of the organization.

Knowledge Specialization and Exploration

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

The Momentum Generated by Prior Exploration

Exploratory drives are influenced not only by an organization's demographic characteristics, but also by its 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. Organizations develop routines to deal with recurring decisions (Cyert and March, 1963; Nelson & Winter, 1982). This notion underlies the logic of repetitive momentum: "as an organization takes actions over time it develops routines and competences which then become independent engines for further actions" (Amburgey and Miner, 1992: 336). Amburgey and colleagues further argue that the "occurrence of change makes the organization 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), having incorporated change routines in their repertoire of activities in lieu of treating it as an unusual and painful event. Yet, time tends to wear 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). In other words, if not used, routines may become stale and gradually forgotten. 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 2a: The likelihood of exploration increases with prior exploration.

Hypothesis 3a: The likelihood of exploration decreases with the time elapsed since the last exploration.

On the other hand, there are competing theoretical views in the literature that argue for the opposite effects. Organizational decision making is attention-driven: an organization shifts its attention to areas in which its performance is below its aspiration level (Cyert and March, 1963). We can portray the organizations aspiration level as achieving a particular rate of return on its assets or investments. As long as the new activity domain provides sufficient returns, the organization feels no pressure to look for new areas (Greve, 1998). In addition, as each decision to explore involves the commitment of resources that have been re-routed from alternative uses, organizations maintain their commitment to the new project in order to recover their opportunity costs. For example, an 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, yet, 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, 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) (Tushman and Romanelli, 1985).

Hypothesis 2b: The likelihood of exploration decreases with prior exploration.

The above logic also suggests that the time decay implied by hypothesis 3a is not automatic. Let's illustrate this with the folk imagery Amburgey et al. use for repetitive momentum: "If you know how to use a hammer, everything looks like a nail" (1993: 55). The logic of time decay suggests that the longer the hammer is not used the less everything looks like a nail. Yet, using the hammer in the first place is an adaptive response to a perceived problem at hand (in our case the need to look for new opportunities). In other words, one would see nails only when one perceives the situations as being conducive to finding nails. If one is currently preoccupied with putting wallpaper, knowing how to use a hammer would not propel him or her to actually use the hammer. This suggests that the exploration routines would be triggered only when the exploration problem (i.e. the need to identify new opportunities) reappears. A consequence of this is that if the problem is a recurring one the routine for handling it would be sustained and more likely to be activated as the problem becomes more acute. Given that the rates of return to current activities diminish with time and that the misfit between an organization and its environment gradually widens (Sorensen and Stuart, 2000), the more time elapses since last exploration the more acute the need for new exploration.

Hypothesis 3b: The likelihood of exploration increases with the time elapsed since the last exploration.

The Conditioning Effect of Early Exploration

Exploration is not free – the decision to explore involves allocating resources to it. As March clearly acknowledges, "Both exploration and exploitation are essential for organizations, but they compete for scarce resources" (1991: 71). 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.

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 4: The occurrence of exploration when an organization is small decreases the likelihood of engaging in further exploration.

Parallel with the effects of their (increasing) size and accumulating slack, organizations are also influenced by their ageing. Organizational ageing, through the sustained focus on maintaining reliability and accountability, drives structural inertia (Michael T. Hannan & Freeman, 1984; D. Miller, 1994), and inertia can have deleterious consequences for their competitive advantage (D Miller, 1990; D. Miller, 1993). 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; Michael T. Hannan & Freeman, 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.

Although 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 and 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.

Hypothesis5: 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 repeated exploration. The industry has originated in the U.S. in the late 1950s to facilitate the commercialisation of technological inventions emerging from Stanford's and MIT's research centres. In its development over the next 40 years, the VC industry has followed closely and participated extensively in the emergence and development of the high-technology industries.

A typical VC firm raises funds from various institutional investors to deploy them in privately held companies. It then strives to exit profitably from these investments within a set time period, typically 5 to 7 years. The success (i.e. rate of return) of a VC fund depends on the premium that mainstream (i.e. capital market or corporate) investors pay for the VC-backed company. In this regard, the timing of an entry into a new technological wave is an important part of the success of the VC firm – for an early entry, not only the return potential is bigger, but also there is a larger looming possibility of total loss. The dilemma of whether to invest early versus late in a newly forming industry thus represents well the tension between exploration and exploitation. By their very nature, VC firms are the financiers of choice for emerging technologies. However, while some VC firms invest in such technologies early, i.e. before new industries are created, other do so late. There is thus sufficient variability in exploration behavior across VC firms to allow us to conduct systematic analysis of it.

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. 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, to avoid multiple counts and given our research interest, we selected only the rounds in which a given VC firm invested in a given portfolio company for the first time. In its final form, the dataset contained 84,237 such first-time rounds transacted by 4,446 VC firms over the above 43-year period. For each transaction, we recorded the characteristics of both the VC firm and portfolio company, as detailed below.

In order to study not only in whether a VC firm invested in a given industry but also when it did so, we put the data in a survival analysis format. That is, we represented the investment history of each VC firm as a sequence of time periods (spells) ending with the occurrence (or lack thereof) of particular events (Morita, Lee, & Mowday, 1993). In our case, the event of interest was a VC firm's making an early investment in a newly emerging 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, i.e. there was no investment activity prior to the observation period.

Since we were also interested in how some time-varying characteristics (e.g. size, age, time since prior exploration) of the VC firms affected the likelihood of early investment, we had to "allow" these factors to vary over time. We did so by breaking the spells into smaller time intervals and recording these characteristics in each interval. 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. Using monthly (rather than daily) investment data also helped us avoid the problem of having various investments recorded on the same day, something that would prevent one from using continuous-time models for survival analysis. This new data structure yielded 57,475 firm-period observations.

The Exploration Events

In order to specify the *early* industry entries, we first time ordered all the investments by the VC firms into high tech industries. The *VenureXpert* database uses 5 main categories – communications and media, computer related, semiconductors and electronics, biotechnology, and medical and pharmaceutical – and 42 sub-categories for designating high-tech industries. We used the 42 sub-categories and recorded the order of each VC firm's investments in these industry sub-categories. We then selected the first investment made by each VC firm in each of these industries. We considered an investment *exploration* if it was among the first 50 investments in that particular industry sub-category. In order to check the robustness of our results, we also used an alternative cut-off point in our definition of exploration – if the VC firm's investment was among the first 20 investments in the particular industry. In order to verify that the so chosen cut-off points indeed captured the "embryo" period for each of the 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. For the 50th-investment cut-off, the average proportion was 6.5% (s.d. 11.3%) and 91% of the proportions were below 20%. Similarly, for the 20th-investment cut-off, the average proportion was 2.6% (s.d. 4.5%) and 98% of the proportions were below 20%. For each VC firm and investment period, we recorded the number of explorations made by the firm in that period. In this way, the exploration "event" occurred in a given period if there was a positive number of explorations made in that period.

Independent Variables

In determining the knowledge specialization of VC firms, we focused on two dimensions: industry 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 main 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.

We measured prior exploration as the number of explorations a VC firm has made prior to the particular investment period. We also constructed a clock to record the time elapsed since the previous exploration event. It started "ticking" after the first exploration event – i.e. it had a value of 0 until that event – and was then re-set to 0 at each subsequent exploration event. We measured the age of the VC firm for each investment period in months, calculated from the beginning of the year in which the VC firm made its very first investment and. VC firm size was also measured at each investment period by the cumulative total number of first-time investments made by the firm from its founding up to the beginning of the period. 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 addition, the cumulative number of portfolio companies is a reflection of the VC firm's ability to raise new investment funds and thus to sustain its investment activity. As attracting new fund investors is dependent upon the VC firm's prior investment successes, sustained investment activity (i.e. increasing size) is also a reflection of successful prior performance and is thus an appropriate proxy for accumulated slack resources.

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 and networking 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 in the description of the measure of stage concentration above and assigned to them the values from 1 to 6, to reflect the order of increasing degree of development.

Model and Analysis

In all 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. 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, **X** is a vector of predictors, and **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 and size, i.e. the hazard function was not of the same pattern across the different ages and sizes of the VC firms. In order to ensure that these violations did not lead to biased results, we conducted additional analyses by including VC firm age and size as time-varying covariates. We thus allowed the effects of age and size on the hazard rate to vary over time. The results (not reported here due to space limitations) revealed no change in the pattern and significance of the results.

In addition, because our data dealt with repeated events, we had to address the issue of conditional dependence. On one hand, we had no theoretical reasons to regard these events as conditionally dependent – i.e. we considered the process that generates a subsequent exploration independent of the one used to generate the previous exploration. Thus, our main 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. On the other hand, we checked the robustness of our results by conducting additional analyses with models based on conditional dependence. These used a conditional risk set method proposed by Prentice, Williams, and Peterson (1981), whereby we recorded the order number of each exploration event (whether 1st, 2nd, etc.) and stratified our analysis by this number. This assumes that to make a second exploration a VC firm needs to have made a first one. By stratifying the estimation by exploration number we allow for different baseline hazard functions to apply to the 1st, 2nd, 3rd, etc. explorations, while restricting the coefficients across the strata to be the same. The results (not reported here due to space limitations) revealed no change in the pattern and significance of the results.

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. The table is split in two parts, each part using a different definition of exploration. We ran our estimations in three steps: in the first we entered only the control variables (models 1 and 4), in the second we entered the main effects (models 2 and 5), and in the third we entered the interaction effects of firm age and size with prior exploration (models 3 and 6). As is evident from the table, the addition of both the main and interaction effects improved the fits of the models.

Hypothesis 1 predicted a negative effect of knowledge specialization on the likelihood of exploration. As shown in Table 2, the coefficients for both industry and stage specialization were negative and significant ($p < .001$) in all the models that included these variables. Thus, the more focused VC firms became on particular industries or development stages, the less likely they were to engage in further exploration. This relationship provides support for hypothesis 1. Hypotheses 2a and 2b represented competing rationales for the effect of prior exploration on the likelihood of subsequent exploration. The coefficients for prior exploration were positive and significant ($p < .001$) in all the models, suggesting support for the repetitive momentum rationale. This suggests that the more a firm has engaged in exploration in the past, the higher its capability to explore and thus the more likely it is to engage in exploration again. Hypotheses 3a and 3b gave competing arguments for the effect of time since prior exploration on the likelihood of subsequent exploration. In models 2 and 3, time since prior exploration had a negative and significant ($p < .001$) effect on the likelihood of future exploration. This result also supported the repetitive momentum rationale – capabilities, if unused, tend to wear off with time. However, the effect of time was not significant in models 5 and 6. This effect was thus sensitive to the applied definition of exploration, which limited the support for hypothesis 3a.

Based on hypothesis 4, we expected a negative interaction effect of firm size and prior exploration. This effect was indeed negative and significant ($p < .001$) in both models 3 and 6. The hypothesis thus received support – early exploration has a weaker effect on the likelihood of future exploration if it occurs when a firm is small. Finally, hypothesis 5 predicted a positive interaction effect of firm age and prior exploration. This effect was indeed positive, but it was only significant ($p < .05$) in model 3 and not in model 6. There was thus limited support for this hypothesis. Early exploration has a stronger effect on the likelihood of future exploration if it occurs when a firm is young.

DISCUSSION AND CONCLUSION

In this paper, we examine the firm and ecological factors that affect the long-term sustainability of exploration. We analysed the investment decisions by US venture capital firms to enter new technological domains over a 43-year period. Our results suggest that in addition to the well studied effects of inertia and slack, exploration is affected by an organization's knowledge specialization, is conducive to repetitive momentum, and affects an organization's subsequent exploration when occurring early in an organization's life. We contribute to the literature on organizational learning by identifying some of the antecedents of exploration and its sustenance over time, 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. In addition, we also resolve several theoretical tensions in the organizational learning and change literatures that could help push further theoretical development.

We found a negative effect of knowledge specialization on exploration. In some sense, this result is intuitive – as organizations specialize in one or few domains, they find it 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). On the other hand, the persistence of this effect over time suggests that an organization's narrowing vision as well as the dangers of competency traps (Levitt and March, 1988) are by themselves not enough to propel an organization toward exploration. Perhaps, to engage in the latter, organizations need shaking external events that negatively affect their performance and thus trigger corrective action.

We examined competing predictions for the effects of prior on future exploration. The repetitive momentum rationale (Amburgey and Miner, 1992) suggests that exploration is malleable into routines that make the organization more adept at engaging in further exploration. The alternative, punctuated equilibrium view holds that exploration, to the extent that it presents significant reorientation on the organization's part, is followed by a long, calm period of exploitation or convergence (Tushman and Romanelli, 1985). We found support for the former – exploration does create momentum to repeat itself. The lack of support for the punctuated equilibrium view could suggest that exploration, as conceptualized here and applied to the specific case of the VC industry, may not necessarily represent a significant reorientation for the VC firm. Investments in newly emerging industries need not be large and thus the firms making them may be fully prepared to lose their full amounts. This kind of experimentation may be a useful intelligence on the new trends and developments in the technology space.

On the other hand, we found some support that the repetitive momentum tended to dissipate with time if the exploration routines remained unused. This effect suggests that long periods of exploitation following exploration are indeed probable and reconciles the repetitive momentum and punctuated equilibrium views (Amburgey, Kelley, and Barnett, 1993). We also note here that the effect of time since exploration was not significant in the models using a more restricted definition of exploration. To the extent that this restricted view of exploration represents cases in which the VC firms undergo a more disruptive change to their normal investment routines, the firms' responses vary. Some of them do indeed settle down for period of exploitation while others seek new ground for exploration. The driver for these diverging behaviors could be whether the firm perceives the newly found ground as fertile enough to sustain prolonged exploitation. Perhaps when there are signs that the explored new domain may bring more immediate returns, the organization's attention shifts towards this domain and thus pushes subsequent exploration into the background. Alternatively, when such signs are lacking, the organization's exploratory search continues.

We show that the organization's size when it first engages in exploration matters for its subsequent exploration activities. There was a negative interaction between organization size and prior exploration. For firms that first engage in exploration when they are small the likelihood of further exploration decreases. Because small firms tend to have more scarce resources, commitment to uncertain course of action in such situations requires more painful tradeoffs that may create a strong negative resonance for the organization's future actions. An alternative explanation for this finding has to do with the fact that our measure of size (number of investments made to date) also captures the VC firm's cumulative experience. In situations of uncertain bets, experts receive the credit when things go right while novices receive the blame when things go wrong (Heath and Tversky, 1991). It is thus plausible that such asymmetric distribution of credit and blame discourages smaller (and thus less experienced) firms from making further investments in new domains.

While the likelihood of exploration decreases with the organization's age, we found some support for a positive interaction between age and prior exploration. This interaction suggests that when an organization first engages in exploration while still young the likelihood of subsequent exploration actually increases. 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. This latter view is 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). Similar to the finding on time since exploration, the interaction between age and prior exploration was not significant in the models using the restricted definition of exploration. This could imply that the disruption caused by these more drastic exploratory moves applies equally to both older and younger organizations.

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. This could be due to the fact that the interest by institutional investor in the US venture capital industry increased significantly following the coming into effect of a law in 1979 that allowed pensions funds to invest in private equity. While we have no evidence of systematic misses in the early observations of the industry, there are enough transactions from this early period to allow us to draw very robust generalizations. A second limitation pertains to the generalizability of our findings to other industries. Although the strategic decision making processes of VC firms share similarities with other industries, they also differ in important ways. On one hand, similar to other high-level corporate executives, VC firm managers need to anticipate new technological trends and market developments that would allow them to earn superior returns from their portfolio companies. Exploration for them is thus an important strategy for identifying and harnessing such trends. On the other hand, the need for VC firms to continuously renew themselves (by raising new funds) may make them particularly sensitive to achieving tangible results within a relative short period of time. In addition, VC firms are typical small in terms of manpower (20-30 people) and thus lack the structural complexity of other, more mainstream organizations. This may hold important implications for the nature of the tension between exploration and exploitation in VC vs. other firms. Finally, other than an indicator for the firms' state location, we did not control for the possible effects of a VC firm's social network on its decisions to engage in (further) exploration. The social network not only provides informational benefits (Burt, 1992) in regard to emerging technologies, but also serves as a conveyor of signals of the firm's perceived quality, the maintenance of which may propel VC firms away from uncertain investments (Podolny, 2001). It is therefore plausible that by accounting for such network effects we could gather further understanding of the exploration process.

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.

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TABLE 1: Descriptive Statistics and Correlations [a]

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Independent VC firm	0.61	0.49	1.00												
2 Corporate VC firm	0.09	0.29	-0.40	1.00											
3 Financial VC firm	0.16	0.37	-0.54	-0.14	1.00										
4 Location California	0.29	0.45	0.12	0.00	-0.11	1.00									
5 Location Massachussetts	0.12	0.33	0.07	-0.05	-0.05	-0.23	1.00								
6 Industry concentration	0.36	0.26	0.01	0.15	-0.09	0.05	-0.03	1.00							
7 Stage concentration	0.38	0.24	-0.03	0.05	-0.01	-0.04	-0.04	0.69	1.00						
8 Average stage	3.36	1.30	-0.06	-0.07	0.13	-0.11	0.02	0.26	0.48	1.00					
9 Firm age	108.49	101.52	-0.01	-0.11	0.12	0.03	0.08	-0.30	-0.20	0.23	1.00				
10 Firm size	50.04	86.78	0.05	-0.10	0.08	0.06	0.08	-0.23	-0.20	0.08	0.67	1.00			
11 Prior exploration	1.98	4.05	0.01	-0.10	0.13	0.02	0.07	-0.26	-0.18	0.08	0.64	0.70	1.00		
12 Time since prior exploration	25.92	52.09	-0.06	-0.05	0.07	-0.03	0.10	-0.20	-0.14	0.12	0.62	0.34	0.29	1.00	
13 Firm age X prior exploration	477.29	1,259.53	0.00	-0.09	0.13	0.03	0.06	-0.22	-0.16	0.06	0.68	0.77	0.93	0.32	1.00
14 Firm size X prior exploration	346.74	1,658.96	-0.02	-0.06	0.12	-0.01	0.03	-0.12	-0.10	0.02	0.42	0.81	0.70	0.13	0.80

[a] N = 57,475. All correlations with absolute value above 0.008 are significant at p < .05

TABLE 2: Survival Analysis of the Time to Exploration

	First 50 Industry Investments			First 20 Industry Investments		
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Independent VC firm	0.333 ***	0.187 *	0.141 +	0.382 ***	0.287 *	0.235 *
Corporate VC firm	-0.133	0.093	0.095	0.193	0.429 **	0.445 **
Financial VC firm	0.222 **	-0.045	-0.016	0.377 **	0.160	0.168
Location California	0.203 ***	0.276 ***	0.208 ***	0.015	0.153	0.113
Location Massachussetts	0.284 ***	0.187 *	0.113	0.157	0.072	0.014
Average stage	-0.128 ***	0.136 ***	0.116 ***	-0.108 ***	0.156 ***	0.133 ***
Industry concentration		-0.912 ***	-0.721 ***		-0.943 ***	-0.733 **
Stage concentration		-1.159 ***	-1.084 ***		-1.081 ***	-1.022 ***
Firm age		-0.006 ***	-0.008 ***		-0.007 ***	-0.009 ***
Firm size		0.005 ***	0.015 ***		0.007 ***	0.016 ***
Prior exploration		0.078 ***	0.064 ***		0.084 ***	0.089 ***
Time since prior exploration		-0.004 ***	-0.004 ***		0.000	-0.0001
Firm age X prior exploration			0.000 *			0.000
Firm size X prior exploration			-0.001 ***			-0.001 ***
LL	-9,576.15	-9,095.09	-9,023.09	-3,982.82	-3,770.47	-3,743.90
Chi-squared	154.21 ***	1,116.34 ***	1,260.34 ***	45.48 ***	470.18 ***	523.33 ***
D.f.	6	12	14	6	12	14
N	57,475	57,475	57,475	57,475	57,475	57,475
Number of firms	4,446	4,446	4,446	4,446	4,446	4,446
Number of events	1,602	1,602	1,602	712	712	712

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