Cool Again! Spin-Outs and the Rejuvenation of Old-Timers

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ABSTRACT

Building on the intuition that socialization leads to exploitation, this article focuses on corporate spin-outs as a strategy for desocialization that can rejuvenate the inventive efforts of old-timers—that is, inventors with a long tenure with the same company. Inventors that join in a spin-out may increase the extent of exploration in their inventive activities. Moreover, because these old-timers are more socialized than newcomers, they should benefit more than newcomers from the spin-out experience. Using data from a matched sample of inventors employed by Xerox Corporation and its spin-outs, this study offers evidence consistent with these predictions.

Keywords: Spin-out; Old-timers; Desocialization; Exploration; Exploitation

Introduction

This paper examines how and to what extent participation in a spin-out, defined as new ventures founded by employees with the support of their originating organization, can revamp inventive output at the individual level. The notion builds on March's (1991) original idea of socialization as a driving force of exploitation and thus ultimately inertia. That is, members of an organization over time grow more alike and align with the prevailing organizational code, which hinders their learning. The greater the socialization rate, the faster the inertial effect (March 1991). This process is of fundamental concern for established organizations that hope to remain continuously innovative and creative. To overcome the negative effects of socialization, this study proposes spin-outs as a *desocialization* strategy that attempts to rejuvenate the innovative potential of organizational members by removing them from the constraints imposed by their organizational code.

Spin-outs have become an increasingly common strategic choice for established innovative companies, including technological venture programs established by leading organizations such as Philips Electronics' New Business Initiative, Siemens's Technology Accelerator, and Shell's Game Changer program. However, extant literature mainly imagines corporate spin-outs as mechanisms for dealing with inventions that do not fit the parent organization's core strategy (e.g., Chesbrough 2002, 2003). In this case, parent organizations actively invest and transfer assets to a new independent organization to enter a new product market (e.g., Chesbrough 2003; Franco and Filson 2006), even as the spin-outs allow the parent organization to focus on its core business by redirecting its strategic resources to established innovation processes in traditional technological fields (e.g., McKendrick et al. 2009).

We propose that the spin-out experience also can rejuvenate the explorative efforts undertaken by inventors——especially experienced ones, whom we call old-timers to indicate their relatively long tenure with the same organization. Tenure tends to be associated with a reduced likelihood that the inventors contribute to progress in technological fields other than the organization's main fields of expertise; over time, they become exploitative. This tendency reflects their dependence on past experience and the convergence toward established knowledge and search heuristics, which are embedded in an established organizational code (March 1991; Nelson and Winter 1982). We contend that moving to a spin-out organization may provide inventors with an opportunity to detach from the organizational code and receive novel stimuli, which then should increase the likelihood that they explore new technological trajectories.

With a sample of inventors employed by Xerox Corporation and its spin-outs over 1975–2008, we show that inventors who join a spin-out company demonstrate greater exploration in their inventive activity, whereas comparable inventors who remain with the originating organization do not. Furthermore, this effect is stronger for inventors with a longer tenure with the originating organization. We measure exploration as the number of claims reported in patents generated after the spin-out decision that belong to new U.S. patent classes. That is, spin-out experience increases the mean of patent claims when inventors explore a new technological class. These results are robust to several econometric specifications that try to account for the endogeneity of the spin-out decision.

Ultimately, our findings thus enrich understanding of how established corporations can revamp the explorative activity of their inventors, as well as offer detailed theoretical and practical implications from the perspectives of corporate entrepreneurship, technology strategy, and organizational learning.

Background

As they grow, organizations tend to become inert and prefer the exploitation of old certainties to the exploration of new possibilities. Sorensen and Stuart (2000) show that a larger organizational size generally is associated with a stronger tendency to build and rely on previous innovative activities, as well as to refine and elaborate older areas of technology. More generally, Ahuja and Lampert (2001) describe how larger organizations tend to favor the familiar to the unfamiliar, the mature over the nascent, and solutions that are nearer existing knowledge and routines rather than de novo solutions.

Recent research also suggests this process is driven by a mutual positive feedback between experience and competence. Experience with a given technology leads to enhanced absorptive capacity and greater competence with it. Greater competence with a technology in turn fosters increased usage, which then again increases experience with the technology. In summary, the increased ease of learning and specific problem solving enabled by enhanced absorptive capacity and established organizational routines in known technological areas make the adoption of alternate directions of development less attractive (Cohen and Levinthal 1990; Levinthal and March 1993).

In his seminal paper, March (1991) thus proposed a model to formalize the process of mutual learning in knowledge development. In this model, firms consist of an "organizational code" of received truth, which represents their beliefs about (external) reality. Individual members modify their beliefs through their socialization into the organization by adapting to the code. The organizational code also could adapt to the beliefs of those members that offer a better representation of reality.

The organizational code thus plays a pivotal role in the learning process, in that individual beliefs do not affect other individual members directly but rather do so only by influencing the code. Improved knowledge thus results when the code mimics the beliefs of individuals and then individuals mimic the code. Yet this process implies that over time, individual members become more homogenous in their knowledge, and eventually equilibrium occurs, such that all members and the code reflect the same (not necessarily accurate) beliefs about reality. On the one hand, the resulting stable interactions allow colleagues to converge to shared understandings and experiences through their socialization (March 1991). On the other, they increase group-thinking behaviors and reduce the level of openness to the external environment (Katz and Allen 1982).

Socialization, or the process through which people learn from the organizational code, therefore reduces diversity and hinders learning, because individuals come to rely on stable, repetitive, socially accepted routines (March 1991; Nelson and Winter 1982). As a result, long-tenured members likely build new knowledge only within the organization's existing field of expertise. Even if such knowledge building is optimal in the short term, only organizations that can balance exploration and exploitation succeed in the long run (He and Wong 2004). Accordingly, socialization-induced inertia becomes a problem to overcome.

March (1991) notes the potential utility of maintaining a certain level of variety in the organization, perhaps through personnel turnover. Turnover introduces less socialized people into the firm, increases exploration, and thus improves aggregate knowledge. The resultant gains thus come from *diversity*, not necessarily superior capabilities. Inter alia, Rosenkopf and Almeida (2003) show that mobility is associated with interfirm knowledge flows, which might support the exploration of technologically distant knowledge (Song et al. 2003).

Diverse inputs are not necessarily associated only with turnover though. For example, recent research on open innovation (e.g., Chesbrough 2003, 2006) has stressed several different mechanisms that enable established organizations to maintain and enhance connections to the external environment, obtain different knowledge, and use it routinely to generate new ideas. The idea that external knowledge helps firms avoid inertial forces is well established in prior literature. Stuart and Podolny (1996) trace the technological trajectory of the ten largest Japanese semiconductor producers between 1982 and 1992 and show that only Matsushita was able to reposition itself technologically, by moving away from local search. This repositioning seemingly was accomplished through extensive alliances with other firms, which gave Matsushita access to different technologies. Furthermore, Rosenkopf and Nerkar (2001) find that inventive efforts that do not span organizational boundaries generate lower impacts on subsequent technological evolutions.

Finally, other streams of research have emphasized how companies might overcome the tendency to build and rely on previous innovative activities by making specific investments in new initiatives. Decades ago, Burgelman (1983) highlighted the role of internal corporate venturing in revitalizing established firms' innovative strategies; more recently Dushnitsky and Lenox (2005) have shown the contribution of corporate venture capital (CVC) investments to firm value, especially when firms explicitly pursue CVC to harness entrepreneurial inventions.

We focus on another tool available to established organizations to prevent inertia: spin-outs. We conceive of spin-outs as an instance of desocialization, which we define for this study simply as unlearning (e.g., Tsang and Zahra 2008) of previous normative expectations and roles, as are embodied into what March (1991) calls the organizational code. We thus argue that spin-outs enable old-timers to revamp their explorative activities.

From the Spin-Out Decision to Exploration

There are two main building blocks to our proposal. First, we consider how mobility affects exploration, as has been well established in prior literature. Second, we focus on the different effect of mobility through spin-outs on the explorative strategies of inventors with *different* levels of tenure with the parent organization (compared with a control group of inventors without spin-out experience). The first building block relies on literature on mobility (e.g., Trajtenberg 2005); the second builds on and extends organizational learning literature (e.g., March 1991).

Previous literature uses spin-off and spin-out mostly as synonyms. For example, Agarwal et al. (2004) define spin-outs as new ventures founded by former employees that enter the same industry and compete with the parent organization, which has no equity. Other studies define the same scenario as a spin-off (e.g., Klepper and Thompson 2007; McKendrick et al. 2009). Still other research (e.g., Chesbrough 2002, 2003) refers to either spin-outs or technology spin-offs as modes of entry into industries or technologies that are new to the parent organization.

For the purposes of this study, and following Chesbrough (2003), we define corporate spin-outs as the incorporation of a new independent organization composed of former employees, a unit, or a division of the parent organization. This definition clearly distinguishes corporate spin-outs from spin-offs. First, the parent organization voluntarily creates corporate spin-outs. Second, the parent organization invests equity in and transfers assets to this spin-out company, such that the spin-out is part of the parent organization (i.e., subsidiary or participating organization), which the parent eventually may decide to reintegrate or sell. Third, because the parent organization retains interest in the spin-out organization, it usually does not compete directly with the parent organization.

If they join the spin-out, employees change their formal affiliation (Hoisl 2007), though they do not necessarily engage in *geographic* mobility. Typically, this is the case when an entire unit or division is spun out and incorporated into a new, independent organization. For example, in 2002 Xerox PARC, an R&D unit of Xerox Corporation, was spun out into a new and independent subsidiary, PARC Inc.

The relationship between mobility (organizational and/or geographical) and inventive activity is certainly not a new idea. Turnover and mobility often introduce variety into organizations (e.g., Almeida and Kogut 1999; Miller et al. 2006; Rosenkopf and Almeida 2003), and Trajtenberg (2005) shows that mobile inventors are more likely to produce highly cited inventions and patents with greater economic value (Trajtenberg 1990). Yet there could be an issue of reverse causality: Does mobility spur productivity, or are more productive inventors better able to move? Hoisl (2007) explores the simultaneous correlation between inventor mobility and patenting productivity and shows that interfirm mobility actually enhances inventors' patenting productivity, thanks to the contact they gain with different sources of knowledge. Spin-outs reinforce this effect: They free organizational members from an environment that provides very few nonredundant stimuli (March 1991) and allow them to connect with different information. Therefore, we hypothesize:

Hypothesis 1. A spin-out increases the extent of exploration by organizational members who join it.

We next turn to a discussion of how different levels of tenure in the parent organization affect the relationship between spin-out participation and individual-level exploration. Although they maintain formal links with the parent organization, spin-outs allow former members of the originating organization to interact with new counterparts and detach from the established organizational code, which creates a basis for revamped innovative activity. The spin-out first prompts organizational members to unlearn roles and expectations of appropriate behavior, which grants them the opportunity to experiment with and receive new and different stimuli. We refer to such unlearning as an instance of desocialization. Similar to Siggelkow and Levinthal (2003), who argue that organizational decentralization enhances exploration at the business unit level, we posit that spin-outs enable individual members to diverge from the established organizational code, which in turn allows them to depart from their previous trajectories and explore again.

If spin-outs enable people to receive new stimuli, they also support a desocialization process through detachment from the former organizational code, which reinforces the effect of the diverse stimuli provided by mobility and turnover. Otherwise, companies could obtain the same result simply through job rotation, for instance.

The idea of innovation through desocialization also is consistent with recent work on entrepreneurship and start-ups, which identifies the role of tenure and pre-entry experience as crucial for understanding the innovative performance of new firms. For example, Klepper (2001) finds that industry tenure is a key explanatory factor for spin-off performance. The general idea is that industry-specific relevant experience is embodied in people, and founders transfer such knowledge when they join the spin-off. Thus spin-offs from incumbent firms seem to enjoy improved performance in various industries, including automobiles (Klepper 2002), disk drives (Agarwal et al. 2004), lasers

(Klepper and Sleeper 2005), and semiconductors (Balconi and Fontana 2011). Over time though, the effect of founders' embodied knowledge fades. Klepper (2001) shows that the impact of initial knowledge endowments tend to be very strong in the beginning, then decrease. This finding is consistent with the idea that over time in a new firm, socialization pressures crowd out diversity and reduce exploration.

We extend this line of reasoning on the strength of observations by Louis (1980) and March (1991) that the effects of turnover differ according to tenure in the organization. People with low turnover, such as old-timers, become well socialized in the organization, more so than newcomers. Their contribution to knowledge-generating activities thus declines; in March's terms, the slow learners (i.e., organizational members with the slowest rate of socialization) provide a relatively greater contribution in terms of new knowledge generation.

The theory underlying this argument is not knowledge obsolescence; what old-timers know can be of great utility, as literature on entrepreneurship has highlighted (e.g., Klepper 2001). Rather, the problem is that once old-timers' beliefs align completely with the organizational beliefs embodied in its code, there is no endogenous mechanism for learning. Consistent with Taylor and Greve (2006), according to whom experience may improve inventive output when inventors access new sources of knowledge, spin-outs can enable old-timers to leverage their knowledge and apply it to different contexts, even as they learn new roles and seek new logics. Experienced people even may be better than relatively junior organizational members at adapting their behaviors to novel knowledge environments, because a key distinction between expert problem solvers and novices is their ability to connect elements and build patterns, rather than describing situations in terms of specifics (e.g., Newell and Simon 1972). Accordingly, we hypothesize that spin-out experience benefits old-timers relatively more than newcomers, because they can apply their pattern-making skills to the novel situations that require them.

Hypothesis 2. The positive effect of spin-outs on the extent of exploration is stronger for old-timers than for newcomers.

Methods

Data

In this study, we aim to establish the effect of spin-outs on inventors' behavior. In particular, we contend that participating in spin-outs increases inventors' extent of exploration (H1), and this positive effect is stronger for old-timers (H2). To test these hypotheses, we use data pertaining to the patenting activities of a sample of inventors employed by the Xerox Corporation and its spin-outs. Xerox is a well-known example of an organization that has initiated many spin-outs in the past 30 years. Although Xerox has been widely studied (e.g., Chesbrough 2002, 2003), most investigations consider either its constraints in commercializing new technologies or the financial performance of its spin-offs. Focusing on Xerox thus facilitates the collection of reliable data about its spin-outs, while also automatically controlling for possible unobserved confounding factors at the parent level. This choice also is coherent with our theoretical framing: We are interested in understanding the extent to which desocialization, or unlearning of a specific "organizational code," enables inventors to revamp their innovative activities. Thus our sample and control group should be exposed to the same organizational code. Moreover, the theoretical point we attempt to substantiate relates to the extent of socialization and the ensuing lack of diversity (March 1991). We do not test for the outcomes of different organizational codes (i.e., more innovative vs. more conservative); Xerox itself is a highly innovative company and encourages its employees to devise new things. Thus it is meaningful to compare a sample of spun-out inventors with a sample of inventors who stayed with the originating company.

Empirically, in the computer and office equipment industry, patents constitute an effective and valuable way to appropriate returns from R&D (Arora et al. 2008), and they correlate well with new product or innovation counts (Hagedoorn and Cloodt 2003), so they provide a valid indicator of technological performance. This status is important because, as we explain subsequently, our measure of the extent of inventors' exploration is based on patent statistics.

We gathered information about spin-outs from several sources, including academic papers (Chesbrough 2003; Chesbrough and Rosenbloom 2002), teaching case studies (Chesbrough 1998), and news releases (e.g., Xerox press releases, spin-out press releases, news from Factiva). We identify corporate spin-outs according in four criteria (Chesbrough 2002):

1. A Xerox employee, unit, or division departs the parent organization and forms a new incorporated organization.
2. The organization is voluntarily released by Xerox to enter a new product market with a technology born and incubated within the parent organization.
3. The spun-out firm employs former Xerox inventors.
4. Xerox's ownership of the new independent firm varies from 0% (no equity) to 100% (wholly owned) of the spin-out's initial capital.

Eighteen companies fit these four selection criteria and have received patents from the U.S. Patent and Trademark Office (USPTO).

Insert Table 1 about here

From among these companies, we identified a sample of inventors using the recent data set built by Lai et al. (2009). We found inventors affiliated with a Xerox spin-out by searching the patent assignees (Almeida and Kogut 1999; Hoisl 2007). From among these inventors, we then noted those who patented with Xerox prior to the spin-out initiation date. Of the 18 spun-out companies, only 8 earned patents that were applied for by former Xerox inventors. Therefore, the final sample of inventors includes 136 individuals who generated or joined a spin-out and display patenting activities both before and after this spin-out event.

To support our comparisons, we built a control sample of Xerox inventors who did *not* move to a spin-out. This sample of 226 *co-inventors* of inventors that moved to a spin-out instead continued patenting with the parent organization. We selected the co-inventors precisely because they have been exposed to a similar knowledge environment and should display similar pre–spin-out output. To account for potential differences across the two groups, we collected additional data about the inventors' ages (from http://www.birthdetails.com) and patenting behavior. In Table 2, we summarize these variables for the three samples of inventors: those who moved to a spin-out, those in the control group, and other inventors in the parent organization. The control group is largely comparable to the group of treated inventors in terms of inventive productivity, breadth of knowledge, collaborative patterns, and seniority in the parent organization.

Insert Table 2 about here

An additional step for defining the sample pertains to the distinction between old-timers and newcomers. To ensure the robustness of results, we employ two alternative categorizations. To test H2, we define old-timers as inventors who had been working with the parent for at least five or ten years before they moved to a spin-out (for co-inventors, the measure referred to the time before his or her previous colleague moved to the spin-out). In contrast then, newcomers are inventors (co-inventors) who had been working with the parent company for at most four or nine years before moving to a spin-out (before his or her previous colleague moved to a spin-out). The timeline for inventors and organizations in the sample appears in Table 1, which shows that the sample encompasses spin-outs generated by former employees, units (e.g., more than one inventor), and divisions (e.g., Xerox PARC).

Measures

Dependent variable

Our dependent variable is inventors' *extent of exploration*, which we measure for each inventor as the number of claims in patents successfully applied for in a *new* patent class in a given year. The patent classes established by the USPTO identify the technological areas to which the knowledge encompassed in the patent belongs (Fleming 2002). Such a count measure is common as a measure of exploration (e.g., Banerjee and Campbell 2009; Fleming 2002). Specifically, we identify whether an inventor *i* has applied for a patent in a new patent class in year *t*. If there are multiple classes, following Benner and Waldfogel (2008), we refer to the first class listed in the patent document.

Patents feature statements that differentiate their inventions from prior art in the same technological field. The number of claims therefore defines novel features of the patented invention and thus the technological distance between the protected invention and the prior art in that technological class (Lanjouw and Schankerman 2004). In this study, we consider both the number of claims and the novelty of technological classes, because together they provide a better appraisal of the extent of inventors' exploration by revealing whether the inventor's output is new with respect to the inventor and the parent organization, as well as the extent to which the invention output is new with respect to the world.

Independent and control variables

Our main independent variable, *spin-out*, captures inventors' affiliation at any moment in time. Specifically, it takes the value of 1 if the patents awarded to inventor *i* at time *t* are assigned to a spin-out, and 0 otherwise. In our sample, 1688 patents were awarded to Xerox inventors who moved to a spin-out, and 616 of them relate to the period in which inventors were affiliated with a spin-out.

We control for several variables that might influence inventors' extent of exploration. Previous literature (e.g., Banerjee and Campbell 2009; Fleming et al. 2007; Singh and Fleming 2010) suggests that individual inventive outcome depends on collaboration patterns, patenting experience, and knowledge background. We therefore include the following covariates at the inventor and organizational levels of analysis:

- *Team size*. Measured as the mean number of inventors listed on patents awarded to inventor *i* at year *t*, it provides a proxy for direct knowledge spillovers in team projects (e.g., Fleming et al. 2007).
- *Individual portfolio generality*. This variable measures the dispersion of patenting activity of inventor *i* prior to year *t* in different technological fields, such that it is a proxy for the extent to which the inventor might exploit past knowledge in new inventions (Banerjee and Campbell 2009; Hall et al. 2001). It is measured as a complement to a Herfindahl index, ranging from 0 (previous experience is concentrated in a single technological class) to 1 (highest dispersion of individual experience across different technological classes).
- *Solo patents*. This variable measures the proportion of patents awarded to inventor *i* in year *t* and in which inventor *i* is the sole inventor. It proxies for the propensity for collaboration, which Fleming et al. (2007) identify as a determinant of explorative inventions.
- *Patents*. This variable measures the total number of patents applied for by inventor *i* in year *t*.

- *Total patents.* This variable refers to the total number of patents applied for by inventor *i* by year *t*. Following Banerjee and Campbell (2009), this measure captures inventor productivity and tenure in the industry.
- *Seniority*. It refers to the number of years elapsed since the first patent by inventor *i*.
- *Parent patents*. This variable accounts for the total number of patents applied for by the parent organization in year *t*. It might help capture variance in individual inventive output, due to an organizational effect and possible knowledge spillovers.
- *Parent equity*. It measures the parent's ownership in inventor *i*'s spin-out. For observations with patents assigned to the parent organization, this variable equals 1. For observations with patents assigned to a spin-out, the variable is coded from 0 to 1, according to the percentage of the spin-out's equity owned by the parent organization at its foundation (i.e., from 1 for wholly owned to 0 for no parent equity).
- *PARC*. This dummy refers to inventors employed in Xerox PARC, the only spin-out in the sample that is a former division of Xerox. Because it does not imply geographical mobility and most old-timers with more than 10 years of tenure in the parent organization were affiliated with PARC Inc., we decided to include this variable to capture possible effects due to this specific affiliation.
- *Year dummies*.

Table 3 reports the summary statistic of the main variables of interest, as well as pairwise correlations.

Insert Table 3 about here

Empirical Strategy

Our basic specification estimates the following model:

$$\text{Extent of exploration}_{it} = f\,(\text{Spin-out}_{it}, X_{it}; \gamma, \beta), \qquad (1)$$

where X is a vector of control variables, and γ and β are vectors of parameters to be estimated. The dependent variable, extent of exploration, is a count variable that takes only non-negative integer values. Because it also reveals overdispersion, we use a negative binomial regression model

(Cameron and Trivedi, 1998). Exploiting the panel structure of our data, we include inventor fixed effects to account for time-invariant unobserved heterogeneity across individual inventors, which might influence their inventive performance.

Estimating the effect of spin-out on inventors' extent of exploration is potentially challenging because of the endogeneity of the decision of founding or joining a spin-out. In particular, spin-outs can be generated by the most explorative inventors in the parent organization, and/or the observed impact of the spin-out may relate to work actually carried out by the inventor when he or she was still employed by the parent organization. A greater extent of exploration therefore might be simply the result of a trend already in place. We try to minimize this potential bias in several ways.

First, because a plausible concern is that the spin-out is motivated by particularly explorative research carried out in the parent organization prior to inventors' spin-out, we exclude patents applied for in the first year of the spin-out's incorporation from our analysis. Of the 4,709 total inventor-year observations, 340 relate to patents applied for by inventors in the first year of the spin-out. By excluding them, we reduce the total sample size, including both inventors who moved to a spin-out and those who remained with Xerox, to 356. Second, we perform a difference-in-differences (DD) estimation. To identify the impact of a treatment on a group, the DD estimator computes (1) the difference in outcomes before and after the treatment for the treated group (i.e., for this study, inventors who moved to spin-outs), (2) the parallel difference for the control group (i.e., co-inventors who remained with Xerox), and (3) the difference between these differences, which offers evidence of the effect of the treatment. This procedure removes biases in second-period comparisons between the treatment and control group that could result from permanent differences between those groups, as well as biases from comparisons over time in the treatment group that could be the result of trends.

Yet the DD estimates also might be biased in the case of endogeneity in the treatment (Bertrand et al. 2004). We therefore estimated another model based on matching (Imbens 2004) that assesses the effect of the spin-out event on inventors' extent of exploration. Matching estimators provide a possible solution to the fundamental problem of causal inference that arises when estimating a causal effect from nonexperimental data. Using formal notation, let Y_{i1} be the value of the outcome variable of interest (i.e., extent of exploration) when *i* is subject to the treatment; Y_{i0} is the value of the same variable when the unit is exposed to the control. In this study, the treatment entails moving to a spin-out, and the control units do not. The effect of spin-outs on inventor i is then $e_i = Y_{i1}–Y_{i0}$, and the "true" expected effect on the treated population (i.e., on inventors that join a spin-out) is:

$$e\,|_{T=1} = \mathrm{E}(Y_{i1}\,|\,T_i = 1) – \mathrm{E}(Y_{i0}\,|\,T_i = 1),$$

where $T = 1$ (= 0) if inventor i moved (did not move) to a spin-out. However, we cannot directly observe $\mathrm{E}(Y_{i0}\,|\,T_i = 1)$; we lack counterfactual evidence of what would have happened to inventor i if he or she had not moved to a spin-out, provided inventor i actually moved. If treated and untreated inventors systematically differ (i.e., the decision to move to a spin-out is not random), then $\mathrm{E}(Y_{i0}\,|\,T_i=0)$ is a biased estimator of $\mathrm{E}(Y_{i0}\,|\,T_i=1)$ (Heckman and Navarro-Lozano 2004). Matching estimators provide a possible solution to this problem by imputing the missing outcomes Y_{i0} of treated individuals using the outcome of individuals with *similar* values of relevant pre-treatment variables or covariates that were not exposed to treatment. A variable is relevant and appropriate to the extent that it affects the probability of being subject to treatment (Imbens 2004). Different matching estimators exist; we estimate that proposed by Abadie et al. (2004).

Results

This study explores the effect of spin-outs on inventors' inventive outcomes, relative to their level of tenure in the originating organization. We hypothesize that as inventors move to spin-outs, they increase the level of exploration in their inventive activity. In Figure 1 we provide the mean number of claims in new patent classes for the treated group and the control group. There is a substantial increase in the extent of exploration by inventors who moved to a spin-out, as confirmed by a t-test ($p < 0.001$). We do not observe the same pattern in the control group, which indicates a stable outcome over time.

Insert Figure 1 about here

However, the increase in the extent of exploration observed after the spin-out event may result from other factors at the individual or organizational levels. To account for these factors, we estimate Equation (1).

Insert Table 4 about here

In Column (1) in Table 4, we report the coefficients of the negative binomial regressions with inventors' extent of exploration as the dependent variable. The positive and significant parameter estimate for the spin-out variable ($p < 0.05$) indicates that spin-outs enhance individual efforts in technologies that are new with respect to the individual and organizational experience, as well as with respect to the state of the art in that specific technological field. We estimate the same model with a Poisson regression and ordinary least squares (OLS; log-linear specification). The results are robust to these different specifications and provide further support for Hypothesis 1.

In Hypothesis 2, we further predict that after the spin-out event, long-tenured inventors would increase the extent of their exploration more than newcomers. Venkatraman (1989) suggests that when researchers explore the different effects of certain strategies across different contexts, they should use subgroup analysis. Therefore, we first separated the sample into two groups, according to their tenure in the parent company before the spin-out date. As we explained in the previous section, for robustness we considered two alternative cut-offs and defined, in two different specifications, old-timers as inventors with a tenure of at least five or at least ten years, whereas newcomers were those with shorter tenures. We then generated two spin-out variables, one for each group, coded as 1 when a newcomer (old-timer) moves to a spin-out, and 0 otherwise. Finally, we ran an OLS regression for both groups and computed the test for equivalence between the coefficients related to newcomers' and old-timers' spin-out (Chow 1960).

The results of these estimations in Table 5 show that the effect of the spin-out variable on individual inventiveness is positive for old-timers. In the model presented in Column (4), we differentiate old-timers and newcomers according to the five-year tenure threshold. The parameter estimates show that the effects of spin-out for old-timers are higher in magnitude than those for newcomers, and the difference ($\Delta = 2.694$) is statistically significant. Moreover, the spin-out experience does not seem significant for newcomers with fewer than five years of tenure in the parent organization. When we differentiate old-timers and newcomers according to the ten-year tenure threshold (Column (5)), we confirm the higher magnitude effect for old-timers ($\Delta = 0.1911$), such that only the old-timers are affected significantly by the spin-out experience ($p < 0.05$). However, for the ten-year threshold, the difference among groups is less significant than in the previous specification. In summary, the results provide some evidence in support of Hypothesis 2.

Insert Table 5 about here

To ensure the robustness of our results for Hypothesis 1, we also performed several additional analyses. First, we performed a DD estimation of the impact of spin-out on the extent of individual exploration. The results in Table 6 confirm that the spin-out produces a positive and significant ($p < 0.05$) effect on the inventor's extent of exploration.

Insert Table 6 about here

To obtain consistent DD estimates, both groups must reveal the same trend for the dependent variable before the treatment period. As we discussed previously, inventors in the sample are homogeneous in several of their individual characteristics and their patent productivity in the period before spin-out incorporation. Figure 2 reveals the average extent of exploration by treated inventors and the control group; they are largely comparable before the spin-out event. Moreover, the DD estimates indicate no significant difference between the treated and control groups in the pre-treatment period.

Insert Figure 2 about here

To assess the effect of spin-outs further, we computed a matching estimator (Abadie et al. 2004), which requires two key decisions: how many comparison units to consider, and whether to match with replacement (i.e., are the same control units actually used as controls more than once?). Dehejia and Wahba (2002) discuss these issues thoroughly and suggest that matching with replacement is beneficial in terms of bias reduction, but matching without replacement could improve the precision of the estimates. By using more comparison units, we might increase the precision of the estimates, though at the cost of increased bias. Therefore for this study, we estimate a model with replacement and three comparison units. The results in Table 7 confirm the positive effect of spin-outs on inventors' extent of exploration.

Still, Abadie and Imbens (2002) warn that matching estimators might be biased in finite samples with at least one continuous variable on which to match or, in general terms, when exact matching is not possible, such that they are generally not efficient. Hirano et al. (2003) show that weighting observations for the propensity score (i.e., probability to be subject to treatment) to create balance between the treated and control units result in the semiparametric efficiency bound. We therefore estimated the effect of spin-out using an inverse probability of the treated weighted estimation. The results of these estimations, with both a negative binomial and an OLS specification, are in Columns (2) and (3) of Table 4. They again provide evidence consistent with Hypothesis 1.

Insert Table 7 about here

Discussion and Conclusion

This study reveals that spin-outs rejuvenate old-timers' innovative strategies. Compared with a control group of similar inventors, old-timers who joined spun-out organizations patented broader ideas in novel technological classes. Hence, spin-outs increased the likelihood that these inventors would generate a significant technological development in a field that is new, compared with their prior experience. Moreover, our findings indicate that the spin-out effect was stronger for those with a long tenure in the originating organization.

We have argued that this evidence indicates that spin-outs act as a desocialization mechanism that allows inventors with a long tenure in the same organization to diverge from past behavior. In line with March's (1991) intuition about the impact of socialization rates on invention outcomes, our argument builds on two complementary explanations. First, spin-outs expose inventors to new sources of diverse knowledge and provide them with new stimuli to engage in explorative behaviors. Second, though old-timers might be expert decision makers, they are oversocialized in the organizational environment and aligned with the organization's established search heuristics (i.e., organizational code). Yet after the spin-out, these old-timers' superior experience favors their ability to exploit new stimuli, so they are likely to generate highly explorative strategies. Experience may provide an opportunity to produce significant technological progress in new fields if old-timers can increase the range and variety of external stimuli they receive. Spin-outs also provide old-timers simultaneously with the chance to break away from their oversocialization with the parent organization's code and gain exposure to new sources of knowledge through low social integration (e.g., Morrison 2002) with acquaintances that have expertise in different technological areas (e.g., Ahuja 2000).

Although we did our best to support our theoretical claims empirically, we acknowledge that we cannot rule out alternative explanations conclusively. First, the increase in the extent of exploration might be driven endogenously by the spin-out decision, because by definition spin-outs are devoted to entering new product markets with ideas largely explored by the parent organization. In this respect, we note that only a minority of Xerox spin-outs produced patents after their incorporation. Thus, though spin-outs serve as means to enter new product markets, they do not necessarily imply explorative activity or, to be more precise, any R&D activity that necessarily leads to patent applications. Second, we tried to correct for the endogeneity of the spin-out decision, both through our variable construction, which excluded patents applied for in the first year of spin-out incorporation, and econometrically, by using various specifications. Nonetheless, we realize that in our non-experimental context, we cannot indisputably prove causality.

At the same time, we lack direct evidence that desocialization is the actual process that leads to the observed effects of spin-outs. Although we cannot directly observe desocialization, we outline two additional empirical results (summarized here for conciseness) that indirectly support our theoretical argument. First, if spin-outs desocialize inventors due to the combined effects of desocialization and mobility, similar (but weaker) results should be produced by a sole inventor's mobility within the parent organization. Internal mobility then should enable old timers to gain access to novel sources of ideas, though within the bounds set by the organization code. Therefore, we coded inventors' mobility within Xerox using patent data regarding the inventor's location (Lai et al. 2009) and estimated the impact of intra-organizational mobility on the extent of exploration through a negative binomial regression. These results show that intra-organizational mobility has a positive and significant effect on the extent of exploration by the inventor (consistent with the idea that intra-organizational mobility enables inventors to access novel sources of ideas). However, if we regress our dependent variable on both intra-organizational mobility and spin-out, the effect of the former is no longer significantly different from zero. Interorganizational mobility through spin-out therefore appears related to desocialization from the established organizational code, which in turn is related to the greater effect on the extent of exploration shown by spin-out participation, compared with intra-organizational (i.e. intra-code) mobility.

Second, in line with March's (1991) argument about the relationship between socialization and organizational learning, we argue that desocialization might be proxied for by the extent to which inventors decrease self-citations to Xerox's patents, after they spin out. We thus estimated the effect of spin-out on the proportion of backward self-citations (to Xerox patents) using a fractional logistic regression (Papke and Wooldridge 2008). After they spin out, inventors reduce the proportion of their citations to their parent's patents, which we interpret as evidence that spin-outs desocialize them from the parent's organizational learning processes.

Beyond these results, our comparison of newcomers and old-timers shows that the latter exhibit a stronger positive effect of spin-outs, which is consistent with our theoretical explanation. If the simple exposure to new colleagues or different organizational incentives (e.g., due to the smaller size of the new organization) were responsible for increased exploration, this effect should not be any stronger for old-timers.

Even with these caveats, this study provides significant implications for extant literature. First, whereas previous literature (e.g., Chesbrough 2002, 2003) has analyzed spin-outs mainly as organizational choices driven by *previous* explorative efforts, whose results could not be exploited by the parent organization, we show that spin-outs can continue the pursuit of original patterns and revamp inventors' (especially old-timers') explorative behavior. Thus spin-outs are not only caused by exploration in product markets but may bring about exploration in novel technological fields by desocializing old-timers who previously belonged to the parent organization. We contribute to corporate entrepreneurship literature by suggesting spin-outs as another organizational tool to foster organizational search and exploration.

Our findings also relate to traditional literature on ambidexterity (e.g., Benner and Tushman 2003, O'Reilly and Tushman 2004), which suggests that novel technologies should be developed and engineered in structurally independent units, only loosely coupled with the existing management hierarchy. This literature stream has not presented large-sample results though, and to a large extent, it has not explored the *ex post* effects of this organizational choice.

The relationship between spin-outs and inventive activity also is relevant for research into the organizational determinants of technological performance. Motivated by early contributions by Schumpeter (1934, 1942), a vast body of empirical work considers the determinants of firms' propensity to produce innovative ideas. Yet we know little about the determinants of the quality and value of such inventions (Fleming 2002). Although producing new ideas and knowledge is a necessary condition to sustain superior performance, it is not sufficient: Not all inventions are equally useful and valuable (Gambardella et al. 2008). In this study, we provide evidence that spin-outs are associated with an increase in the claims of patents produced by inventors who move to a new organization. The number of claims defines the novel features of the invention and thus the technological distance between the protected invention and the prior art; claims also constitute very good indicators of inventions' economic value (Lanjouw and Schankerman 2004) and quality. Prior literature examining the drivers of the quality of inventions has stressed the importance of the resources available in the inventive process, and in particular the diversity of knowledge inputs available to inventors (e.g., Fleming 2001). However, it also notes the need for organizational incentives (e.g., Zenger 1994). Consistent with Kapoor and Lim (2007), we show that knowledge and incentive-based perspectives complement each other as explanations of technological performance. Not only do spin-outs increase the possibility that inventors receive new stimuli, but through desocialization, they also allow these inventors to interpret the stimuli through new lenses, unlike those suggested by the organizational code. Thus, we contribute to entrepreneurship literature that has identified founders' embodied knowledge as a leading determinant of the superior innovative performance of spin-offs from industry incumbents (e.g., Balconi and Fontana 2011; Klepper and Sleeper 2005; Klepper and Thompson 2007). Founders bring with them relevant, industry-specific knowledge, but their desocialization enables them to reinterpret it and enrich it in novel ways—hence the superior innovative performance of spin-offs founded by inventors with long tenures in industry incumbents that appears in many studies.

Furthermore, unlike prior studies, this study examines a different mechanism, desocialization, that might underlie the increase in explorative behavior. We thus contribute to organizational learning literature and provide an empirical test of one of March's (1991) key arguments. It is clear that exploitation and exploration should be balanced to achieve superior organizational performance (He and Wong 2004), but we still know relatively little about the actual mechanisms for stimulating exploration.

Our results also make a clear contribution to managerial practice. Rapid technological change and short product lifecycles have made continuous innovation critical to sustainable competitive advantage. From the perspective of a practicing manager, explaining a mechanism that allows old-timers to overcome inertia and increase their propensity to explore new technological paths is of great importance, especially considering the associated economic stakes. To provide a more complete picture of the economic outcomes of spin-outs, further studies should investigate the extent to which the parent organization can capture the value potentially created by the exploration of spin-out firms, as well as the factors that influence this process.

Much remains to be done to explain one of the most fundamental issues of strategy research—the drivers of organizational and individual change—yet with this study we believe we have contributed to the development of a stronger, more explicit link between empirical research on mobility and theoretical research on organizational learning and innovation.

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Table 1. Sample: Spin-Outs and Old-Timers

Spin-outs' assigned patents, 1975–2008	Year of spin-out incorporation	Inventors with patent records in both parent and spin-out organizations	Inventors with parent organization tenure > five years	Inventors with parent organization tenure > ten years
3COM Co.	1979	0	0	0
Optimem	1980	0	0	0
Sunrise Systems Inc.	1982	0	0	0
Filenet Co.	1982	0	0	0
Komag Inc.	1983	0	0	0
SDL Inc.	**1983**	**3**	**3**	**0**
Synoptis Communications	1985	0	0	0
Microlytics Inc.	**1985**	**1**	**0**	**0**
AMTX Inc.	**1988**	**1**	**1**	**0**
ParcPlace Systems Inc.	1988	0	0	0
Documentum Inc.	1990	0	0	0
Semaphore	1990	0	0	0
Placeware Inc.	**1996**	**3**	**2**	**1**
InXight Inc.	**1996**	**2**	**2**	**0**
DpiX LLC	**1996**	**5**	**4**	**3**
Gyricon Media Inc.	2000	0	0	0
ContentGuard Inc.	**2000**	**15**	**9**	**6**
PARC Inc.	**2002**	**106**	**69**	**51**
Total number of inventors in spin-outs group		**136**	**90**	**61**
Total number of co-inventors in parent group		**226**	**179**	**123**
Total patents granted to both groups by the		**5377**	**4865**	**4051**

Notes: Bold indicates that the sample includes both spin-outs and inventors.

Table 2. Inventors' Characteristics: Summary Statistics by Groups, Pre-Spin-Out

Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Age				
Treated group	42.48	8.32	18	68
Control group	44.62	10.18	20	83
Age at first patent				
Treated group	35.98	6.19	18	58
Control group	35.78	7.52	20	61
Mean number of team members				
Treated group	2.60	2.60	0	17.28
Control group	2.56	2.60	0	21
Knowledge generality				
Treated group	0.68	0.35	0	1
Control group	0.61	0.36	0	1
Patents by individuals per year				
Treated group	1.99	2.50	0	20
Control group	1.83	2.53	0	21

Table 3. Descriptive statistics and correlations

Variable	Mean	s.d.	min	max	Correlations 1	2	3	4	5	6	7	8	9	10
1. Extent of exploration	1.48	6.80	0	105										
2. Spin-out	0.10	0.30	0	1	.09									
3. Team size	2.57	2.57	0	21	.06	.11								
4. Individual portfolio generality	0.63	0.36	0	1	.05	.14	.16							
5. Solo patent	0.02	0.11	0	1	.06	-.01	-.08	-.11						
6. Patents in focal year	1.88	2.53	0	21	.21	.08	.44	.17	.02					
7. Total patents	16.37	20.08	1	158	.13	.13	.23	.21	-.10	.43				
8. Seniority	9.08	6.5	1	32	.02	.02	.09	.31	-.15	.10	.59			
9. Parent patents	1660	1504	0	4130	.10	.08	.67	.22	.00	.53	.28	.12		
10. Parent ownership	0.99	0.04	0.3	1	-.06	-.27	-.08	-.02	-.01	-.02	.01	.03	-.06	
11. PARC dummy	0.22	0.41	0	1	.00	.38	.02	.10	.00	.02	-.05	-.12	.07	.05

Notes: *n* = 4,709. All correlations above |.03| are significant at the .05 level.

Table 4. Fixed Effects Panel Regressions (DV: Inventors' Extent of Exploration)

	Negative Binomial			*OLS*
	(fixed effects)	(f.e., weighted)		(f.e., weighted)
	(1)	*(2)*		*(3)*
Independent variable				
Spin-out	0.51* (0.23)	0.92* (0.44)		0.26** (0.09)
Controls				
Team size	0.01 (0.03)	-0.01 (0.06)		-0.02* (0.00)
Individual portfolio generality	1.14*** (0.26)	1.23* (0.55)		0.10 (0.06)
Solo patents	3.13*** (0.33)	2.98*** (0.67)		0.83*** (0.23)
Patents in focal year	0.13*** (0.01)	0.11** (0.03)		0.04*** (0.01)
Total patents	0.00* (0.00)	0.00 (0.00)		-0.00 (0.00)
Seniority	0.03 (0.02)	0.00 (0.05)		0.01 (0.01)
Parent patents	0.00* (0.00)	0.00 (0.00)		0.00** (0.00)
Parent ownership	1.16 (1.50)	1.95 (3.16)		-0.03 (0.51)
PARC dummy	-0.01 (0.22)	0.08 (0.43)		*(dropped)*
Year dummies	Included	Included		Included
Constant	-6.60*** (1.52)	-7.12* (3.20)		0.05 (0.60)
Log likelihood	-1,484.9	-381.7	F	4.80***
Wald chi^2	222.4***	55.5***	R^2 (between)	0.1346
n (w/o first year in spin-out)	2,482	2,135		3,744
Number of groups	165	145		303

Notes: Standard errors are in parentheses.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 5. Chow Test: Difference between Newcomers and Old-Timers

Independent variables	*OLS* (fixed effects, r. std err) *(4)*	*(5)*
Old-timer5 (as a 1 if tenure≥5 years; 0 otherwise)	*(dropped)*	
Spinout (newcomer5)	-0.07 (0.09)	
Spinout (old-timer5)	0.19* (0.08)	
Old-timer10 (as a 1 if tenure≥10 years; 0 otherwise)		*(dropped)*
Spinout (newcomer10)		0.04 (0.08)
Spinout (old-timer10)		0.23* (0.11)
Controls		Included
PARC dummy	*(dropped)*	*(dropped)*
Year dummies	Included	Included
Constant	0.55 (0.51)	0.45 (0.51)
F	5.13***	5.12***
R^2 (between)	0.1875	0.1841
n	4,369	4,369
Number of groups	356	356

Chow tests

Tenure threshold: 5 years

β(Spinout old-timer5) - β(Spinout newcomer5) = 2.694

H_0: β(Spinout old-timer5) - β(Spinout newcomer5) = 0

chi2 = 4.61
Prob > chi2 = 0.0318

Tenure threshold: 10 years

β(Spinout old-timer10) - β(Spinout newcomer10) = 0.1911

H_0: β(Spinout old-timer10) - β(Spinout newcomer10) = 0

chi2 = 1.96
Prob > chi2 = 0.1620

Notes: Standard errors are in parentheses.
* *p* < 0.05.
** *p* < 0.01.
** *p* < 0.001.

Table 6. Difference-in-Difference Estimation (DV: Inventors' Extent of Exploration)

	OLS (f.e., robust std err)
Independent variables	
Group (1 for treated group; 0 for control group)	*(dropped)*
Treatment period (1 for post-spinout; 0 for pre-spinout years)	-0.04 (0.07)
Group*Treatment period	0.17* (0.07)
Controls	Included
PARC dummy	*(dropped)*
Years dummy	Included
Constant	0.46 (0.50)
F	4.77***
R^2 (between)	0.1652
n	4,050
number of groups	356

Notes: Standard errors are in parentheses.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 7. Matching Estimation: Average Treatment Effect on the Mean of the Extent of Exploration in Three Years After the Spin-Out Incorporation

Matching estimator: Average Treatment Effect for the Treated (ATT)

Weighting matrix: inverse variance

Dependent variable: Mean number of "claims in new USpc classes" in the 3 years after the incorporation of spin-outs

	Coeff.	Std. Err.	Z	p
Sample average treatment effect (SATT)	1.75*	0.79	2.21	0.027
Number of inventors	294			
Number of matches	3			

Matching variables: inventor's age at first patent; number of team members; individual portfolio generality; patents in the focal year; inventor's seniority in the parent organization; firm's patents per year; parent's ownership; PARC dummy

* $p < 0.05$.

Figure 1. t-Test of Group Mean of Inventors' Extent of Exploration Pre- and Post-Spin-Out

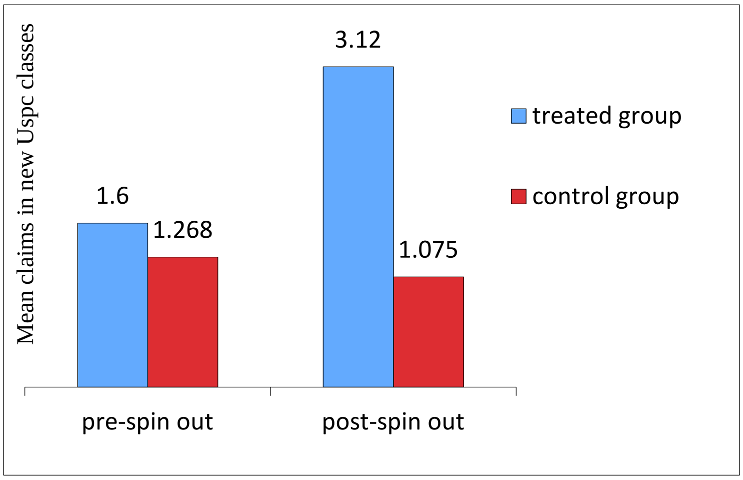

Figure 2. Group Mean Trend of Inventors' Extent of Exploration since Spin-Out Year